ABUNDANCE OF *FRANKLINIELLA SCHULTZEI* (THYSANOPTERA: THRIPIDAE) IN FLOWERS ON MAJOR VEGETABLE CROPS OF SOUTH FLORIDA

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Abstract

The flower thrips, *Frankliniella schultzei* (Trybom), has only recently been recognized as a pest of vegetable crops in south Florida. Little is known about its abundance and impact on vegetable crops in this region. Therefore, a field experiment was conducted comparing *F. schultzei* abundance in blooms of the 5 key fruiting vegetable crops grown in south Florida, i.e., cucumber, pepper, snap bean, squash and tomato. Mean number of *F. schultzei* larvae was highest in cucumber flowers (78.1 larvae/5 flowers) and lowest in bean flowers (5.1 larvae/5 flowers). However, adults of *F. schultzei* were most numerous in tomato flowers (27.5 adults/5 flowers) and least numerous in snap bean flowers (3.5 adults/ 5 flowers). Neither larvae nor adults of *F. schultzei* were found in pepper flowers in the present study. The flower samples collected from 5 vegetable crops were also found to be infested with 3 other thrips species. Amongst these, *Thrips palmi* Karny was the second most abundant thrips species. *Frankliniella occidentalis* (Pergande) was found in low numbers on all crops except pepper, and *Frankliniella fusca* (Hinds) was found only on tomato. The above information should be useful in the development of monitoring programs, design of pest management strategies and in the timely application of preventive or suppressive measures in south Florida.

Key Words: Vegetable crops, *Frankliniella schultzei, Thrips palmi*, *Frankliniella occidentalis, Frankliniella fusca,* abundance

Resumen

El trips de las flores, *Frankliniella schultzei* (Trybom), ha sido reconocido recientemente como una plaga de cultivos de hortalizas en el sur de Florida. Poco se sabe de su impacto en los cultivos de hortalizas en el sur de Florida, o su abundancia relativa a otras especies de trips en estos cultivos. Por lo tanto, se evaluaron la incidencia y la abundancia de especies de trips durante la epoca de floración de 5 cultivos de vegetales fructíferos que siembran en el sur de la Florida: pepino, chile dulce, ejote, calabaza y tomate. *Frankliniella schultzei* fue la especie más abundante en flores de pepino, calabaza y tomate, seguido de *Thrips palmi* Karny en la calabaza y el pepino. *Thrips palmi* fue el trips más abundantes como adultos en ejote, pero se encontraron muy pocos en chile dulce. Se encontró *Frankliniella occidentalis* (Pergande) en pequeñas cantidades en todos los cultivos excepto en chile dulce, y sólo se encontró *F. fusca* en el tomate. Las larvas de *F. schultzei* fueron más abundantes en el pepino (15.6 larvas / flor) y menos abundante en ejote (1.02 larvas / planta). Ni las larvas ni los adultos de *F. schultzei* fueron encontrados en las flores de chile dulce. El número alto de larvas de *F. schultzei* en las flores de pepino sugirió que el pepino es un huésped preferido reproductivo de *F. schultzei*. Estos resultados deben ser útiles para el desarrollo de programas de monitoreo, el diseño de estrategias de manejo de plagas y en la aplicación oportuna de medidas preventivas o represivas en el sur de la Florida, y otros lugares donde se encuentran estas especies en cultivos de hortalizas fructíferas.

Thrips pests are ubiquitous because of their prominent dispersive behavior and ability to colonize many hosts in a wide range of habitats. The tropics and subtropics are the most suitable regions for thrips survival, although some thrips species also thrive in temperate regions (Mound

1997). Florida is especially vulnerable to thrips invasion and subsequent establishment, because of the State's diverse flora and year-round production of numerous fruit, ornamental and vegetable crops. While the majority of economically important thrips species are polyphagous in nature, some thrips species show preference for just a few host species on which they may reproduce and survive (Mound 2004). Several thrips species, including *Frankliniella occidentalis* (Pergande), the western flower thrips, have been reported to exhibit variability in host preferences in the same geographical region with time (Doederlein & Sites 1993). However, little information is presently available on host switching behavior of thrips.

Frankliniella schultzei (Trybom), also known as the common blossom thrips, is a polyphagous herbivore known to exploit more than 83 host species belonging to 35 different families of plants (Milne & Walter 2000; Palmer 1990). However, it is not an exclusively phytophagous pest, as it has been reported to feed on eggs of the two-spotted spidermite, *Tetranychus urticae* Koch, on cotton (*Gossypium hirsutum* L.; Malvales: Malvaceae) (Trichilo & Leigh 1986; Wilson et al. 1996). *Frankliniella schultzei* is one of the major pests of various ornamental and vegetable crops around the globe (Palmer 1990; Vierbergen & Mantel 1991; Milne et al. 1996). In Cuba and Brazil, it is one of the key pests of tomato (*Solanum lycopersicum* L.; Solanales: Solanaceae), and, accordingly, it is also known by the common name, the tomato thrips (Haji et al. 1998; Jones 2005). However, in Florida *F. schultzei* has been found to be associated more with flowers of ornamental plants (Funderburk et al. 2007) and cucumber (*Cucumis sativus* L.; Cucurbitales: Cucurbitaceae) (Kakkar et al. 2011).

Frantz & Fasulo (1997) reported the presence of *F. schultzei* in cucurbit and tomato fields in Florida. Although this pest has not subsequently been reported in Florida, we found it infesting field crops in Miami-Dade County in 2008. Considering the paucity of information on *F. schultzei* and the potential host plants at risk in Miami-Dade County, a major producer of fresh winter vegetables, this study was conducted to evaluate the abundance of *F. schultzei* in the flowers of each of 5 major vegetable crops in this County, i.e., snap bean, (*Phaseolus vulgaris* L.; Fabales: Fabaceae), squash (*Cucurbita pepo* L.; Cucurbitales: Cucurbitaceae), cucumber, tomato, and pepper (*Capsicum* spp.; Solanales: Solanaceae). The results from this study should prove helpful in determining which of these crops are most vulnerable to attack by *F. schultzei* in this region. In addition, we report on the thrips species complex inhabiting the flowers of each of these 5 vegetable crops infested with *F. schultzei*.

Materials and Methods

Abundances of *F. schultzei* was studied on cucumber (*C. sativus* L. cv 'Vlaspek'), pepper (*C. annum* L. cv 'King Arthur'), snap bean (*Phaseolus vulgaris* L. cv 'Opus'), squash (*C. pepo* L. cv 'Straightneck') and tomato (*S. lycopersicum* cv 'Flora-Dade'). The study was conducted in a field at the University of Florida, Tropical Research and Education Center (TREC), Homestead, Florida during the fall of 2009. The 5 vegetable crops selected for this study were planted in their respective plots adjacent to each other in the same field. Each plot had 10 planted rows where each row represented a data point. A 9-m wide fallow buffer area separated adjacent crops. Soil type was Krome gravelly loam (loamy-skeletal, carbonatic hyperthermic lithic Udorthents), which consists of about 33% soil and 67% limestone pebbles (>2 mm). Fields were prepared using standard commercial practices (Olson & Santos 2010).

Crop Management

'Vlaspek' cucumber seeds were sown on 17-VIII, 15.2 cm apart within the row and 91.4 cm between rows on flat ground. Each plot measured 251 m^2 consisting of ten 30 m long rows. At planting, 8-16-16 (N-P-K) was applied at 908 kg/ha in a furrow 20 cm apart from the seed row. Halosulfuron methyl (Sandea®, Gowan Company LLC., Yuma, Arizona) at 55 gm/ha was used as a pre-emergence herbicide to control weeds. Copper hydroxide (Kocide® 3000, BASF Ag Products, Research Triangle Park, North Carolina) at 0.8 L/ha and chlorothalonil (Bravo®, Syngenta Crop Protection, Inc., Greensboro, North Carolina) at 1.75 L/ha were used in rotation at 2-wk intervals to prevent fungal disease. Crops were irrigated twice a wk with 3 cm of water using overhead sprinklers. Fertilizer 4-0-8 (N-P-K) at 236 L/ha/wk was applied as an in-furrow band in the field to provide 2.4 kg-N/ha/wk beginning 3 wk after planting.

'Opus' snap beans were direct-seeded 7.5 cm apart within the row on flat ground on 18-VIII. Plot characteristics and cultural practices were the same as described above. 'Straightneck' squash was directly seeded at 21 cm within the row spacing on 2-IX to compensate for earlier onset of flowering, and thus ensure that all the plant species had equal chances of being infested by *F. schultzei*. Otherwise plot dimensions and horticultural practices were the same as described above. 'King Arthur' pepper transplants were planted 17-VIII, 25 cm apart within row on raised beds 91 cm wide, 15 cm high, and 182 cm between centers. Beds were covered with 1.5 ml black polyethylene mulch. Each plot consisted of 10 raised beds each 30 m long making a plot of ~500 m^2. Management of each crop including use of fertilizers, herbicides

and fungicides was as described for cucumber. 'Flora-Dade' tomato seedlings were transplanted 30 cm apart within row on raised beds as for pepper on 18-VIII. The crop was drip irrigated twice a week. Fertilizer 4-0-8 (N-P-K) was applied at 236 L/ha once a week beginning 3 wk after planting through the drip lines to provide 2.4 kg-N/ha. *Bacillus thuringiensis* Berliner (Bacillales: Bacillaceae) based insecticides, Dipel DF® (*B. t.* var. *kurstaki*) at 1.1 kg/ha and Xentari DF® (*B. t.* var. *aizawai*) at 1.2 L/ha (Valent Biosciences Corporation, Libertyville, Illinois) were used to control lepidopteran pests in all the experimental crops except snap bean.

Sampling

Samples were collected and processed independently for each of the plant hosts during the fifth, sixth and seventh wk after planting. Five flowers (1 flower/plant) were randomly collected from each row of the planted plot. All flower samples belonging to each row were placed in a separate ziplock® bag (17 × 22 cm) marked with date of collection, row number and host type. Samples were transported to the laboratory and placed individually in a 1-qt (0.946 L) plastic cup with 75% ethanol for 30 min to dislodge various life stages of thrips. Plant material was carefully removed from the cup leaving the thrips in the alcohol. The contents in the alcohol were sieved using a 25-µm grating, USA Standard Testing Sieve (W. S. Tyler, Inc., Mentor, Ohio) as per Seal & Baranowski (1992). The residue in the sieve was washed with 75% alcohol into a Petri dish.

Samples were sorted under a dissecting microscope at 12X according to the following characteristics. Female adults of *F. schultzei* and *F. fusca* (Hinds) are dark brown and measure less than 1.5 mm in length (Figs. 1a and b). *Thrips palmi* and *F. occidentalis* adults are comparatively lighter in color with body lengths ranging from 0.8-1.0 mm (Capinera 2000) and 1.5-1.66 mm, respectively (De Kogel et al. 1999) (Figs. 1c and d). Samples were stored in 75% ethanol for later identification using taxonomic traits illustrated by Hoddle (2009). The ocellar setae on head are one of the important features for identifying thrips at the species level. All 4 thrips species possesses 3 pairs of ocellar setae on head. The third pair, also known as interocellar setae, arises between the anterior ends of the 2 hind ocelli in *F. schultzei and F. occidentalis* (Figs. 2a and c). However, in *F. fusca and T. palmi* the third pair originates above the 2 hind ocelli (Figs. 2b and d). In *F. fusca*, each ocellar seta arises away from the anterior margin of the 2 hind ocellus (Fig. 2b) and in *T. palmi*, it arises from a region closer to the posterior end of the apical ocellus (Fig. 2d). The postocular setae on head of *F. schultzei*, *F. fusca* and *T. palmi* are shorter than the interocellar setae; unlike *F. occidentalis* in which the postocular and interocellar setae are of equal size. The posteromarginal comb on the eighth abdominal segment was the main characteristic used for thrips identification (Fig. 3). The comb on abdominal segment of *F. schultzei* is not fully developed; it is incomplete medially and bears short microtrichia on either end (Fig. 3a). However, the comb on the eighth abdominal segment of *F. occidentalis* and *T. palmi* is fully developed and bears a complete row of microtrichia. The comb is absent on *F. fusca* (Fig. 3b).

In the collected flower samples larvae of *T. palmi* were recognized by their characteristic reddish yellow color and slow movement (D. R. Seal, personal communication). We assumed other larvae to be *F. schultzei*. They were similar to each other, and adults of *F. occidentalis* and *F. fusca* were rare in flowers.

Statistical Analysis

Each row of a planted plot represented a data point, thus, 10 samples were collected from each of the plots during a sampling. Data on the abundance of *F. schultzei* larvae and adults on each crop (except pepper) were averaged for all samplings The mean numbers of larvae and adults on each crop were compared separately using one way analysis of variance (ANOVA) (PROC GLM, SAS Institute Inc. 2003). Data were analyzed independently for larvae and adults. Data were transformed by $\log_{10}(x+1)$ before analysis. Untransformed means and standard errors are reported in the Table 1 and Fig. 4. Means of larvae and adult on various crops were separated using Tukey's HSD (Honestly Significant Difference) procedure ($P < 0.05$).

Results

Flowers of 4 of the 5 putative hosts were found to be infested with *F. schultzei* adults. Abundance of *F. schultzei* adults in tomato flowers was not different from that in squash and cucumber flowers (Tukey's HSD test, $P < 0.005$) (Fig. 4). The least number of *F. schultzei* adults was captured in flowers of snap bean and none was found in pepper flowers. The number of *F. schultzei* adults in flowers of tomato and squash was significantly greater than in snap bean ($F = 4.28$; df = 3, 36; $P < 0.0001$) (Fig. 4).

Mean number of *F. schultzei* larvae was highest in cucumber flowers (Fig. 4). The infestation level in cucumber flowers was numerically higher than in flowers of the other 4 hosts ($F = 30.35$; df = 3, 36; $P < 0.0001$). Not a single *F. schultzei* larva was found in pepper flowers. There were no significant differences in the numbers of larvae sampled from squash, tomato and snap bean (Tukey's HSD test, $\alpha = 0.05$).

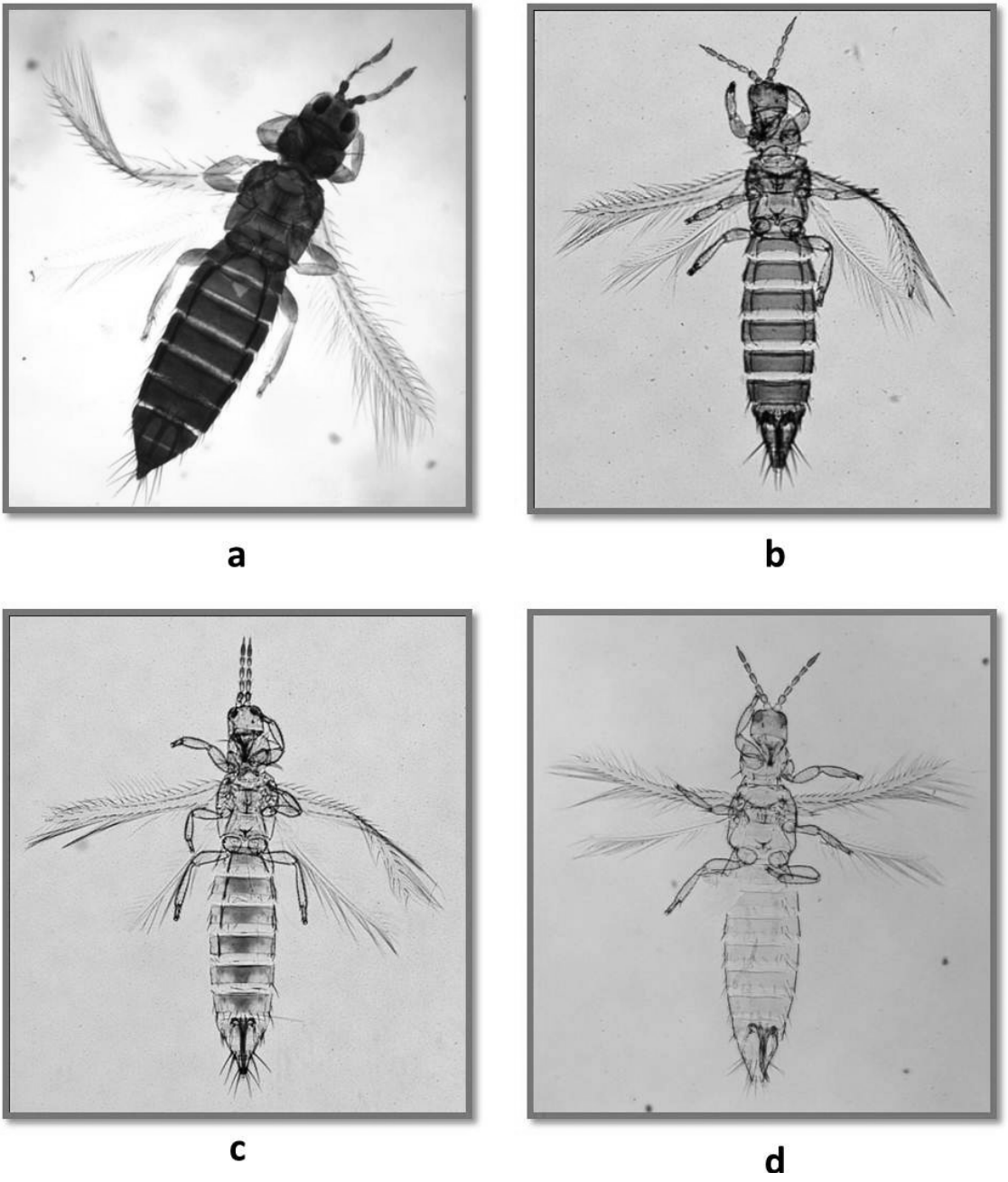

Fig. 1. Slide mount of female adults of a) *Frankliniella schultzei*, b) *Frankliniella fusca*, c) *Frankliniella occidentalis*, and d) *Thrips palmi.*

In the course of sampling 5 vegetable crops, other thrips species were also encountered. By comparing the count of different thrips species (Table 1), it is apparent that the average number of *F. schultzei* in flowers was several folds greater than the other species. The predominant species sampled from the 5 crops besides *F. schultzei* was *T. palmi* Karny, followed by *F. occidentalis* and *F. fusca* (Table 1). The average number of *T. palmi* adults in flowers of cucumber ($F = 38.71$; df = 2, 27; $P < 0.0001$) and squash ($F = 6.10$; df = 2, 27; $P = 0.006$) was significantly lower than *F. schultzei* (Tukey's HSD test, $\alpha = 0.05$). The highest number of *T. palmi* was found in snap bean flowers with an average of ~1 adult per flower, followed by squash, and cucumber. The number of *T. palmi*

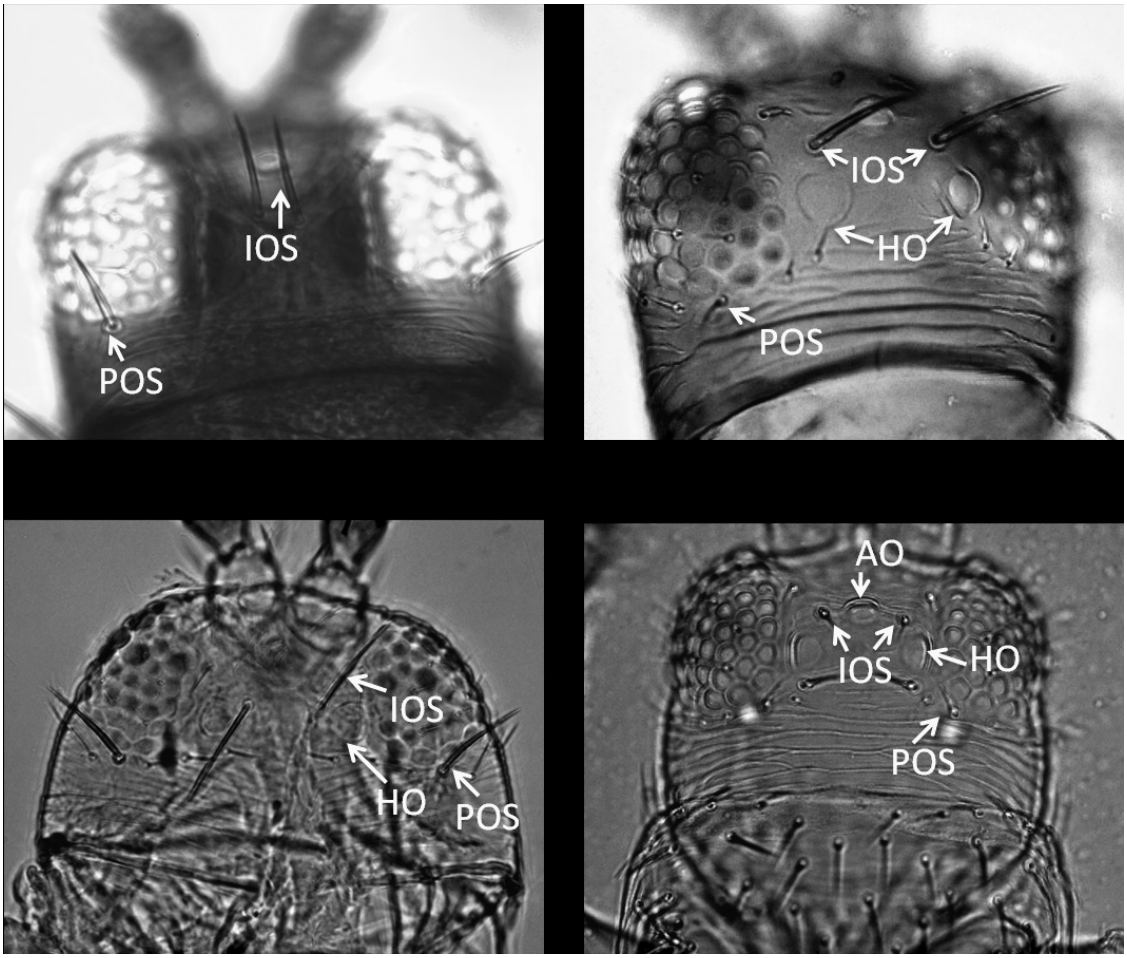

Fig. 2. Head of each of 4 thrips species a) *Frankliniella schultzei*, b) *Frankliniella fusca*, c) *Frankliniella occidentalis*, d) *Thrips palmi*. Note the interocellar setae (IOS), postocular setae (POS), a pair of hind ocelli (HO) and apical ocelli (AO).

collected from flowers of these crops was the least from pepper and none in tomato. *Frankliniella bispinosa* (Morgan), Florida flower thrips was found on bean flowers (data not shown) but the number was fewer than 4 specimens in the total number of thrips adults collected from various crops during the study. *Frankliniella occidentalis* was collected from squash, tomato, cucumber and bean flowers, with the number of adults ranging between 0.2-1.0 per 5 flowers sampled from various hosts in the study. *Frankliniella fusca* was collected from tomato flowers with an average number of 0.6 adults per 5 flowers.

Discussion

The study demonstrated that the flowers of 5 major winter fresh market vegetable crops in Miami-Dade County were infested with at least 4 different thrips species: *F. schultzei, F. fusca*, *F. occidentalis* and *T. palmi*. The density of individual thrips species other than *F. schultzei* encountered in flowers of sampled crops was small. The low density could be due to various factors including: 1) unsuitability of these crops as hosts of these thrips species, 2) naturally low abundance of thrips species in the area of study, for example *F. fusca*, 3) the flower being the plant part least preferred by some of these thrips species, for example *T. palmi*, and (4) competition from *F. schultzei*.

Frankliniella schultzei was reported as a pest of several ornamental and vegetable crops (Jiménez et al. 2006). In the present study, the densities of *F. schultzei* adults in the flowers of various plant species were consistently similar for the 3 most preferred hosts, i.e., tomato, squash and cucumber. The high density of *F. schultzei* in tomato flowers was in agreement with the findings of Jiménez et al. (2006), Mon-

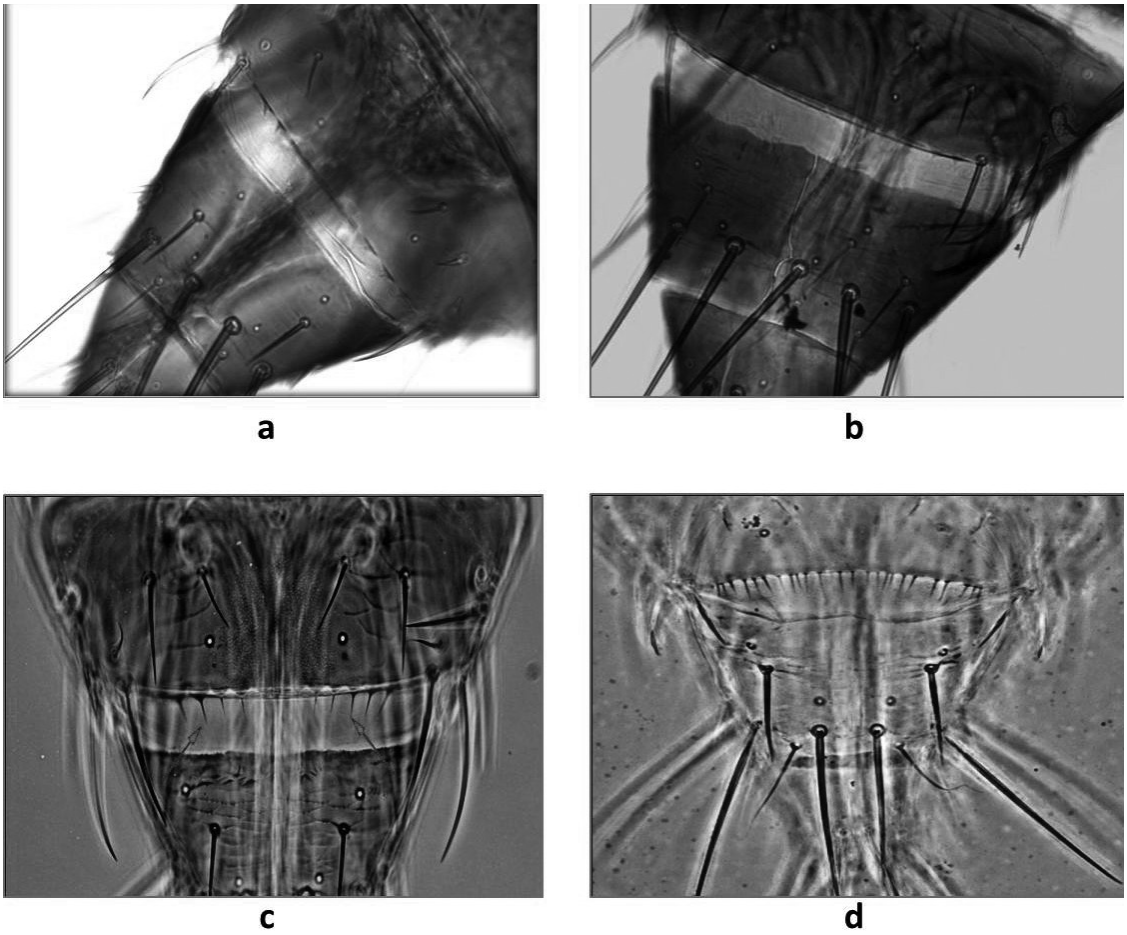

Fig. 3. Eighth abdominal segment of each of 4 thrips species, i.e., a) *Frankliniella schultzei*, b) *Frankliniella fusca*, c) *Frankliniella occidentalis*, d) *Thrips palmi*

teiro et al. (2001) and Sakurai (2004), who reported tomato as one of several vegetable hosts of *F. schultzei* in Cuba, Brazil and Paraguay, respectively.

There is an essential difference between a primary and a secondary host of thrips. While species of thrips may forage on a wide range of plant species, a primary host fully supports the reproduction of the thrips species and adequately provides it with food and shelter. However, a provisional or secondary host is usually exploited temporarily for food and shelter, and does not provide an adequate substrate for reproduction (Mound 2005). Thus, it is important to distinguish between primary (reproductive) hosts, and secondary (provisional) hosts of a thrips species

Based on the larval densities in the flowers of the 5 major vegetable crops in Miami-Dade County, we found that squash, tomato, bean and cucumber were capable of supporting reproduction of *F. schultzei*. However when these plant species were ranked for the host status based on larval density, a striking pattern was observed. Only in cucumber flowers did the number of *F. schultzei* larvae exceed the adults, suggesting that cucumber is potentially a major reproductive host of this pest. The larval counts were lower than adult counts on the other 4 hosts (bean, pepper, squash, and tomato), and thus these crops can be regarded as secondary reproductive hosts of this pest in south Florida.

Variations in host plant preferences of pests inhabiting different geographical regions have been reported for other thrips species, for example canistel (*Pouteria campechiana* (Kunth) Baehni), which has never been reported as a host of *Scirtothrips dorsalis* Hood (chilli thrips) was preferred by it over mango (*Mangifera indica* L.) and other hosts in Florida (Kumar et al. 2012). Probable reasons for such plasticity in behavior have been suggested to be genetic and/or environmental (Jaenike 1990), although there is little published evidence for the role of genetic variation in host preference. Environmentally induced variation is

Table 1. Abundance of thrips adults per 5 blooms in 5 vegetable crop species in South Florida.

Thrips species	Mean ± SE number of adults/5 flowers				
	Cucumber	Pepper*	Snap bean	Squash	Tomato
F. schultzei	15.8 ± 2.1 a	—	3.5 ± 0.6 b	22 ± 6.7 a	27.5 ± 3.2 a
T. palmi	4.5 ± 0.6 b	4.1 ± 0.9	6.1 ± 0.5 a	5.1 ± 1 b	—
F. occidentalis	0.3 ± 0.1 b	—	0.2 ± 0.1 c	1.2 ± 0.3 b	1 ± 0.2 b
F. fusca	—	—	—	—	0.6 ± 0.2 b

Mean numbers of thrips in each column followed by the same letter are not significantly different (Tukey's HSD, $P < 0.05$).
*No thrips species except *Thrips palmi* was found.

known to cause differences in host preferences for a species in different regions. Jaenike (1990) postulated that the abundance of the most preferred host in a region can result in higher thresholds of attraction to secondary host plants, which tend to be disregarded by the pest in such circumstances. Absence of this preferred host in another geographic region changes the herbivore's threshold of attraction and thus the preference level for secondary host plants. Tomato is one of the important hosts of *F. schultzei* in the area of their origin (South America). Preference of *F. schultzei* for cucumber over tomato in this study, where the pest was given free choice contradicts the concept of threshold of attraction.

Flower thrips belonging to genus *Frankliniella* use visual and olfactory cues to find hosts (Terry 1997), and the bright yellow flowers of tomato play an important role in attracting adults of *Frankliniella* spp. (Reitz 2005). However, the inability of the commercially grown tomato to serve as reproductive hosts for flower thrips may restrict the rate of population increase of this genus on tomato (Reitz 2005). While these are assumptions to understand host preferences of *F. schultzei*, the study helped in determining the reproductive host range of *F. schultzei* in south Florida. Further studies on the seasonal abundance of *F. schultzei* on these hosts will refine our knowledge of dispersive behavior, population dynamics, damage potential and interaction between *F. schultzei* and its hosts; such information is needed as a foundation of an effective thrips management program.

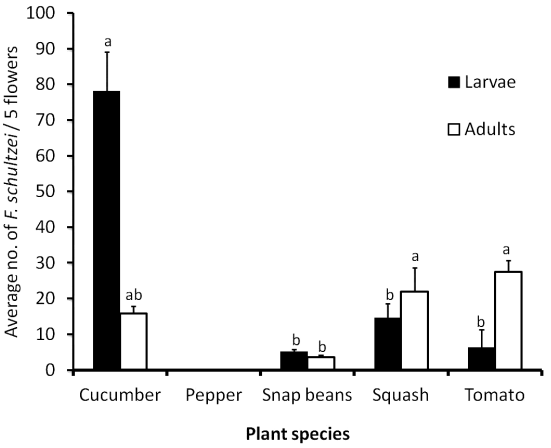

Fig. 4. Numbers of *Frankliniella schultzei* larvae and adults (Mean ± SEM) on flowers of 5 host plants sampled during the fall of 2009. Means with the same letter are not significantly different (P > 0.05, Tukey's HSD test).

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References Cited

Capinera, J. L. 2000. *Thrips palmi* Karny. Entomol. Nematol. Dept., IFAS, Univ. Florida. http://entnemdept.ufl.edu/creatures/veg/melon_thrips.htm

De Kogel, W. J., Bosco, D., Van Der Hoek, M., and Mollema, C. 1999. Effects of host plant on body size of *Frankliniella occidentalis* (Thysanoptera: Thripidae) and its correlation with reproductive capacity. European J. Entomol. 96: 365-368.

Doederlein, T. A., and Sites, R. W. 1993. Host plant preferences of Frankliniella occidentalis and Thrips tabaci (Thysanoptera: Thripidae) of onions and associated weeds on the southern high plains. J. Econ. Entomol. 86: 1706-1713.

Frantz, G., and Fasulo, T. R. 1997. Thrips: A Knowledgebase of Vegetable Thrips. Glades Crop Care. http://www.gladescropcare.com/GCC_software.html (11August 2011).

Funderburk, J., Diffie, S., Sharma, J., Hodges, A., and Osborne, L. 2007. Thrips of ornamentals in the southeastern US., Florida Coop. Ext. Serv., Entomol. Nematol. Dept., IFAS, Univ. Florida. http://edis.ifas.ufl.edu/in754

Haji, F. N. P., Alencar, De J. A., and Prezotti, L. 1998. Principal pest of tomato and alternatives for control, pp. 50 In Empresa Brasileira de pesquisa Agropecuaria, Centro de Pesquisa Agropeucuaria do Tropico Semi-Arido, Brazil.

Hoddle, M. S., Mound, L. A., and Paris, D. L. 2009. http://keys.lucidcentral.org/keys/v3/thrips_of_california/Thrips_of_California.html (Accessed XII 2 2011)

Jaenike J. 1990. Host specialization in phytophagous insects. Annu. Rev. Ecol. Syst. 21: 243-273.

Jiménez Jiménez, S. F. Pérez López, L., Toro, M., Granda, C., Mateo, A. Sariol, H., Rodríguez, E., Pérez, R., Jiménez, R, Pérez-Alejo, A., and Vázquez, R. 2006. Dispersión, distribución actual y nuevos reservorios de *Frankliniella schultzei* Trybom (Thysanoptera: Thripidae) en Cuba. Fitosanidad 10: 273-278.

Jones, D. R. 2005. Plant viruses transmitted by thrips. European J. Plant Pathol. 113: 119-157.

Kakkar, G., Seal, D. R., and Kumar, V. 2011. Assessing abundance and distribution of an invasive thrips *Frankliniella schultzei (*Trybom) (Thysanoptera: Thripidae) in South Florida. Bull. Entomol. Res. DOI: 10.1017/S0007485311000599.

Kumar, V., Seal, D. R., Kakkar, G., McKenzie, C., and Osborne, L. S. 2012. New tropical fruit hosts of *Scirtothrips dorsalis* (Thysanoptera: Thripidae) and its relative abundance on them in south Florida. Fla. Entomol. 95: 205-207.

Milne, M., and Walter, G. H. 2000. Feeding and breeding across host plants within a locality by the widespread thrips *Frankliniella schultzei*, and the invasive potential of polyphagous herbivores. Divers. and Distri. 6: 243-257.

Monteiro, R. C, Mound, L. A., and Zucchi, R. A. 2001. Espécies de *Frankliniella* (Thysanoptera: Thripidae) de importância agrícola no Brasil. Neotrop. Entomol. 1: 65-71.

Mound, L. A. 1997. Biological diversity, pp. 197-215 *In* T. Lewis [ed.], Thrips as Crop Pests. CAB International, Wallingford, UK.

Mound, L. A. 2004. Australian Thysanoptera-biological diversity and a diversity of studies. Aust. J. Entomol. 43: 248-257.

Mound, L. A. 2005. Thysanoptera: Diversity and Interactions. Annu. Rev. Entomol. 50: 247-269.

Olson, S. M., and Santos, B. 2010. Vegetable production handbook for Florida 2010-2011. EDIS, Florida Coop.Ext. http://edis.ifas.ufl.edu/features/handbooks/vegetableguide.html .

Palmer, J. M. 1990. Identification of the common thrips of tropical Africa (Thysanoptera: Insecta). Trop. Pest Mgmt. 36: 27-49.

Reitz, S. R. 2005. Biology and ecology of flower thrips in relation to Tomato spotted wilt virus. Acta Hort. 695: 75-84.

Sakurai, T. 2004. Transmission of tomato spotted wilt virus by the dark form of *Frankliniella schultzei* (Thysanoptera: Thripidae) originating in tomato fields in Paraguay. Appl. Entomol. Zool. 39: 189-194.

Seal, D. R., and Baranowski, R. M. 1992. Effectiveness of different insecticides for the control of melon thrips, *Thrips palmi* Karny (Thysanoptera: Thripidae). Proc. Florida. State Hort. Soc. 105: 315-319.

Terry, L. I. 1997. Host selection, communication and reproductive behavior. pp. 65-118 *In* T. Lewis [ed.], Thrips as Crop Pests, CAB International, New York.

Trichilo, P. J., and Leigh, T. F. 1986. Predation on spider mite eggs by the western flower thrips, *Frankliniella occidentalis* (Thysanoptera: Thripidae), an opportunist in a cotton agroecosystem. Environ. Entomol. 15: 821-825.

Vierbergen, G., and Mantel, W. P. 1991. Contribution to the knowledge of *Frankliniella schultzei* (Thysanoptera: Thripidae). Entomol. Ber. (Amsterdam) 51: 7-12.

Wilson, L. J., Bauer, L. R., and Walter, G. H. 1996. 'Phytophagous' thrips are predators of twospotted spider mites (Acari: Tetranychidae) on cotton in Australia. Bull. Entomol. Res. 86: 297-205.