

Invasive Species Management Template with an Initial Emphasis on Thrips
Sept 18 2008 to Sept 16 2013
Final Report / Osborne & McKenzie

This final report serves to document research conducted under a specific cooperative agreement between ARS (Cindy McKenzie, ADODR) and Lance Osborne with the University of Florida (58-6618-8-118). Additional details of research can be found in the reports for the parent CRIS 6618-22320-002-02 Subtropical Insect Pests of Vegetables and Ornamental Plants. This report covers the fifth and final year of this agreement. However, over the life of this SCA, seven postdoctoral research associates were supported (Avery, Dickey, Dogramaci, Kumar, Hall, Wekesa, Xiao) and cooperators from the Universities of California, Georgia, and Florida, Texas A&M, Rutgers, and Cornell University have contributed to this project. Technology transfer resulting from this SCA including management plans and websites, as well as a presentation and publication summary (2008 to 2013) can be found at the end of this report.

The approach of this cooperative research project was to evaluate registered pesticides alone and in rotation on different floral and ornamental host plants for efficacy against chilli thrips (*Scirtothrips dorsalis*) and their impact on predatory mites, (*Amblyseius swirskii* and *Neoseiulus californicus*) for development of BMPs. In order to minimize reliance on spinosad and the attendant problems that this poses for western flower thrips (WFT) management, efficacy trials were conducted to find additional materials for chilli thrips control and their impact on beneficials. Bioassays were conducted to determine susceptibility baseline data for chilli thrips to the most important compounds. Data was used to develop robust IPM programs and BMPs for thrips control in general and *Scirtothrips dorsalis* in particular. Molecular genetic studies indicated that genetic diversity exists among chilli thrips, which suggests that there may be a species complex of chilli thrips. Differences could exist among chilli thrips in susceptibility to insecticides and the ability to develop resistance to insecticides. Robust marker development for *Scirtothrips dorsalis* is needed to address these issues and was currently underway. This project was extended to include whitefly and other exotic pests in 2010. Biological control has been touted as a method to reduce pesticide usage and avoid insect resistance. Banker plants were explored as a means of dispersing biological control agents for control of multiple pests (whitefly, thrips, two spotted spider mite) found in ornamental commercial greenhouses. The major benefits achieved will be a pest management system that greatly reduces continuous usage of high levels of pesticides in a concentrated area, reducing risk to both workers and consumers, and the environment.

Side effects on predatory mites resulting from pesticides sprayed to control pests

Pesticides are often effective against the prey used by the predatory mites we are interested in evaluating the side effects of pesticides on. One pesticide we are interested in using for ornamental IPM programs is called Sultan (cyflumetofen). The material is active on the two-spotted spider mite but not against whiteflies and thrips. The toxicity of cyflumetofen against *Phytoseiulus persimilis* and *Amblyseius swirskii*, two of the most commonly used biological control agents, was unknown. The acute toxicity of cyflumetofen against *P. persimilis* has been studied in the laboratory but not against *A. swirskii*. The residual toxicity of cyflumetofen against both predatory mite species is also unknown. This lack of information will hinder the practical

integration of cyflumetofen with biological control programs in floricultural production. Does cyflumetofen have acute or residual effect on the survival of *A. swirskii* and can it be safely integrated with existing whitefly and thrips biological control programs? Since cyflumetofen does not have translaminar or systemic activity, thorough coverage of the infested plants is required for effective spider mite management. If a grower does not achieve good coverage, can *P. persimilis* be used to ‘clean up’ the remaining or hidden colonies of spider mites? Can cyflumetofen be applied when biological control program is on-going (acute toxicity)? How many days after treatment with cyflumetofen can *P. persimilis* and *A. swirskii* be released (residual toxicity)? One issue we discovered when trying to evaluate the impact of pesticides on *A. swirskii* is that the pesticides had an impact on the whiteflies we were using to feed this predatory mite. We have developed two systems that will allow us to evaluate the impact of various pesticides in the future. The system being currently evaluated uses what we have learned concerning pepper banker plants. These plants, when in flower, are suitable for the maintenance/development of significant populations of *A. swirskii* even if no prey are present on the plant. We expose flowering Red Missile pepper plants to a source of the predatory mite. Once adequate numbers of the predators can be found on the test plants we count the numbers of individuals on a subsample of leaves, treat with the pesticide of interest. Populations are then monitored over time on the test plants. We utilize the maximum labeled rate of each pesticide being evaluated and compare to a water treated set of control plants in each experiment. To date we have run preliminary trials with Floramite, Avid and Sultan. We have observed significant reductions in the predatory mite populations but the populations are not eradicated. We will continue these studies over time to determine if the mites are able to rebound and develop populations large enough to manage thrips and whiteflies on the peppers and on other target crops if these treated peppers are used as banker plants.

Selecting an ornamental pepper banker plant for *Amblyseius swirskii* in floriculture crops

Four ornamental pepper (*Capsicum annuum* L.) plant cultivars, Red Missile (RM), Masquerade (MA), Explosive Ember (EE) and Black Pearl (BP), were selected based on previous greenhouse studies conducted at the University of Florida, Mid-Research and Education Center in Apopka, FL, to screen the suitable banker plant candidates for the survival and establishment of the phytoseiid mite, *A. swirskii* (Xiao et al. 2012). Ornamental peppers were chosen because the original work was aimed at finding an ornamental plant that could be planted in rose gardens to foster biological control of *S. dorsalis*. *Scirtothrips dorsalis*, a highly polyphagous pest is a new invasive thrips species in the United States. Since its introduction in 2005, *S. dorsalis* has emerged as a significant pest of nursery, landscape ornamental and a few economically important field crops in the region (Seal and Kumar 2010, Seal et al. 2010, Kumar et al. 2012a, b, 2013). Osborne (2009) has reported more than 50 different ornamental hosts of this pest in Florida. Use of chemical insecticide is considered a primary strategy for managing this pest. However, there are reports of resistance development in *S. dorsalis* to a wide range of chemical insecticides (Reddy et al. 1992; NPAG 2006; Kumar et al. 2012b). Thus, it is important to devise an alternate pest management strategy for regulation of this species. In previous studies, we reported efficacy of *A. swirskii* in regulating *S. dorsalis* (Arthurs et al. 2009), and here we chose to evaluate the factors supporting successful and long term establishment of phytoseiid mites in the presence and absence of pest population with the use of banker plants.

Before evaluating pepper cultivars (RM, MA, EE and BP) in this study, cultivars were pre-screened and found to be a poor host of the target pest (*S. dorsalis*). Black Pearl was chosen for comparative purposes because it has been tested as a banker plant in the greenhouse previously with the predator, *Orius insidiosus* (Say) (Hemiptera: Anthocoridae) (Pundt and Smith 2008), but not with *A. swirskii*. The objective of this study was to compare the oviposition preference of *A. swirskii* with the physical characteristics of each specific ornamental pepper banker plant cultivar during pre-bloom and flowering stages of the host.

Materials and methods

Plant cultivars: The four ornamental pepper plant cultivars MA, RM, EE and BP were grown in Premier Pro-mix General Purpose Growing Medium from seed in seedling trays and placed into a plastic screened cage (61 cm x 71 cm x 61 cm). Plants in seedling trays were transplanted at different growth times into either 10 cm x 10 cm, or 16 cm x 15.5 cm plastic pots depending on the experiment. Plants transplanted were placed back in screened plastic cages and watered as needed (~3 times a week) and fertilized with 50 mL / pot with Peter's Professional 20-10-20 (325 ppm) (Scotts Co., Marysville, OH) once a week at the ARS/USDA Horticultural Research Laboratory greenhouse, in Fort Pierce, FL. Temperature in the greenhouse ranged between 21.1 - 31.1 °C and the relative humidity from 42.0 - 99.5%.

Rearing of *Amblyseius swirskii*: The predatory mites, *A. swirskii* obtained in paper sachets (SWIRSKI-MITE PLUS®, Koppert USA, Romulus, MI) were reared at 24 - 25 °C on the lab bench until needed. Each rearing unit / colony was as follows: 2 wax-covered colored paper squares (~55 mm x 55 mm) grooved by a wire mesh (1 mm²) were placed on top of 3 stacked cotton rounds (75 mm diam) and placed inside a plastic square container (140 mm x 140 mm). Water was added to each plastic square container to provide a moat to prevent escapes and to moisten the cotton pads. Fresh peach pollen (stored at 0 °C for < 1 week) and cotton fibers (for oviposition) were placed on top of the upper most wax-covered paper square and then gravid females (mixed ages) were released on the top square.

Choice experiments between plant cultivars pre-bloom with and without pollen: Four seeds (one from each cultivar) were randomly chosen and planted in a 10 cm diam plastic pot using a template with all 4 cultivars equidistant from the center of the pot and each other. Plants were grown for 3-4 weeks (6-8 leaves/plant) and leaves of each cultivar were touching within the pot. A plastic Petri dish (60 x 15 mm) bottom containing peach pollen (13-15 mg) or no pollen (control) was placed in the center on the top of the soil between the plants (**Fig. 1a**). Four *A. swirskii* gravid female mites were gently removed from the rearing units using a moistened camel hair brush, and transferred to 1 of 4 randomly chosen leaves / cultivar. Each mite was allowed to walk off the brush onto the leaf surface. This procedure was repeated 4 times / cultivar for a total of 16 mites released per pot and there were 8 pots / experiment. Four out of 8 pots were randomly chosen and placed in separate plastic bowls set onto one of two separate trays in a randomized complete block design (**Fig. 1b**). Each tray was placed on a shelf in the growth chamber and soapy water was poured into it as a moat to prevent escapes. All pots were held at 25 °C, 75% RH under a 16 h L: 8 h D photoperiod for 7 days. After 7 days post-release of the mites, the plants were destructively sampled and the number of *A. swirskii* life stages for each plant cultivar was assessed using a binocular microscope (40X). Four leaves were randomly

chosen from each plant and the number of tuft domatia was determined per leaf. This experiment was repeated on 2 separate dates.

Fig. 1 a) Arrangement of the four different OP plants per pot for the choice test with and without pollen pre-bloom; **b)** layout of the OP pre-bloom choice tests in the growth chamber; **c)** arrangement of the three different OP flowering plants per pot for the choice test prior to being transferred to the growth chamber.



Choice experiments between flowering plant cultivars: The assessment for preference by the *A. swirskii* mites on flowering plants was conducted only with three cultivars RM, MA and EE because bud formation in these cultivars occurred 28 days after planting (DAP) whereas with BP it took > 68 DAP to flower. In preparation for the choice tests, each plant cultivar (RM, MA and EE) was grown in a seedling tray and placed in a screened plastic cage. Forty-five DAP, one plant of each cultivar was transplanted together into a single 3.78L black plastic pot (16 cm x 15.5 cm), staked, twist tied and then placed back into the screened plastic cage. A plant from one cultivar was planted close enough in each pot in order to touch the leaves of the other two cultivars. Twelve pots with three plants each were transported and placed in the growth chamber (RH 75%; 28 °C) at IRREC under a 12 h L: 12 h D photoperiod until plants flowered. Each pot was placed in a plastic dish (20 cm x 7 cm) to hold water or fertilizer and this dish was placed inside another dish (28 cm x 5 cm) filled with soapy water as a moat to prevent mite escapes (**Fig. 1c**). Five gravid female mites per plant cultivar were released on five different leaves per

plant cultivar using a camel hair brush as described above; total of 15 mites were released per pot. Pots were watered 3X a week (150-200 mL) and fertilized 1X a week (200-250 mL / pot). After 28 days post-release, the plants were destructively sampled, placed in resealable plastic boxes (21 cm x 15.5 cm x 10 cm) and stored at 4°C until assessed. The number of *A. swirskii* eggs, nymphs, adults for each plant cultivar / pot was assessed using a binocular scope (40X). This experiment was repeated on 2 separate dates.

Physical characteristics of plant cultivars: In a separate experiment, 100 leaves were randomly chosen from 10 plants / cultivar (75 DAP) and the number of tuft domatia was determined per leaf. The leaves were then photocopied, cut out using scissors; scanned using a LI-3100C Area Meter (LI-COR Biosciences, Lincoln, NE) to determine the surface area / cultivar leaf and the number of tuft domatia / mm² / leaf was calculated.

Statistical Analysis: Preference of *A. swirskii* between plant cultivars (treatments) using choice tests pre- and during bloom was determined based on the mean number of life stages observed. An ANOVA was conducted on the square root ($n + 0.01$) transformed data with a mean separation between treatments using a LSD test ($P < 0.05$). The treatment effect of pollen (present or absent) in the amount of eggs deposited or motiles (nymph + adult) present on each cultivar was determined after conducting a *t*-test ($P < 0.05$) in the pre-bloom studies. Also, in the pre-bloom studies, a correlation analysis was conducted using CORR PROC to determine if there was any significant ($P < 0.05$) relationship between the number of tuft domatia / leaf and the number of eggs + motiles / plant cultivar when pollen was available. Significant differences in plant characteristics per cultivar: number of leaves, flowers, tuft domatia / per mm² / leaf was determined using an ANOVA ($\alpha = 0.05$) and LSD test on square root ($n + 0.01$) transformed data. Preference of *A. swirskii* for a banker plant cultivar during bloom was based on the difference in the mean number of eggs, nymphs, adults, and motiles present between cultivars. All statistical analyses were conducted using SAS Proc GLM procedures and executed on a WIN_PRO platform (SAS Version 9.2 2002-2008).

Results

Choice experiments between plant cultivars pre-bloom with and without pollen: In the choice tests pre-bloom, the mean number of tuft domatia / leaf on RM was significantly higher ($F = 37.07$; $df = 3, 31$; $P < 0.001$) than the other cultivars (**Table 1**). The mean number of leaves / plant did not vary significantly amongst the cultivars. After 7 days post-release, when pollen was present, the mean number of motiles counted per plant was significantly higher ($F = 3.78$; $df = 3, 7$; $P = 0.0258$) for cultivar RM; whereas no significant difference was observed in motile counts among the other cultivars. No differences were apparent between cultivars when pollen was absent ($F = 0.03$; $df = 2, 7$; $P = 0.968$); however, no motiles were found on cultivar EE. When comparing the effect of pollen being present or absent on the same cultivar, a significantly higher mean number of motiles was found on cultivars RM ($t = -2.96$; $df = 1, 14$; $P = 0.0104$), and MA ($t = -2.21$; $df = 1, 14$; $P = 0.0444$) when pollen was present. The mean number of motiles recorded for cultivar BP was similar regardless of whether pollen was present or absent. A positive correlation ($R^2 = 0.8309$; $P = 0.0884$; $y = 0.885x - 0.4434$) was reported between the number of tuft domatia and the number of eggs + motiles / plant cultivar (**Fig. 2**).

Table 1. Plant characteristics and preference of *Amblyseius swirskii* motiles (nymphs and adults) for four different candidate banker plant ornamental pepper cultivars / pot with and without pollen in choice tests pre-bloom^a.

Cultivar ^c	Mean number \pm SEM ^b			
	tuft domatia / leaf ^d	leaves / plant	pollen	motiles / plant without pollen
RM	5.1 \pm 0.3d	12.2 \pm 0.5a	4.0 \pm 1.2bB	0.4 \pm 0.2A
MA	3.8 \pm 0.3c	12.3 \pm 0.7a	1.9 \pm 1.0aB	0.4 \pm 0.3A
EE	1.9 \pm 0.3b	11.7 \pm 1.0a	1.1 \pm 0.4a	0
BP	1.0 \pm 0.2a	12.5 \pm 1.0a	0.8 \pm 0.3aA	1.3 \pm 1.3A

^aFour cultivars were planted in a single pot prior to releasing 4 *A. swirskii* on each. Plants were destructively sampled 7 days post-release ($n = 8$ pots).

^bData was square root ($n + 0.01$) transformed before analysis by ANOVA and LSD tests ($P < 0.05$). Untransformed data is presented. Mean numbers in a column with letters that are not the same are significantly different. Mean numbers with different capital letters across columns are significantly different (t test, $P < 0.05$).

RM = Red Missile; MA = Masquerade; EE = Explosive Ember; BP = Black Pearl

^dResults from 4 randomly selected leaves per plant / pot ($n = 32$ leaves / cultivar).

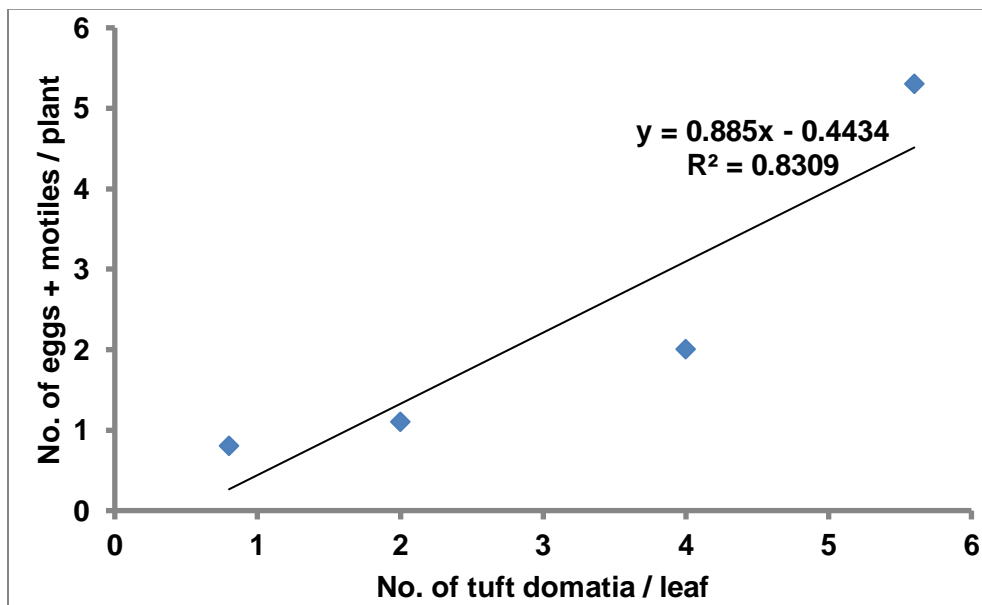


Fig. 2 Correlation between the number of tuft domatia / leaf and its effect on the number of *Amblyseius swirskii* eggs + motiles present pre-bloom for all the different ornamental pepper plant cultivars when incubated at 25 ± 0.5 °C with ~ 100 RH under a 16 h L:8 h D photoperiod regime. Each data point represents the mean number of eggs + mites (nymphs and adults) from 8 plants sampled per cultivar with pollen present.

Choice experiments between flowering plant cultivars: There were no significant differences in the mean number of eggs deposited by the gravid female *A. swirskii* mites among the different cultivars (**Table 2**). However, a significant preference was apparent for cultivars RM and MA in the mean number of nymphs ($F = 5.54$; $df = 2, 29$; $P = 0.0149$), adults ($F = 6.35$; $df = 2, 29$; $P = 0.0094$) and motiles ($F = 6.40$; $df = 2, 29$; $P = 0.0091$) per plant, compared to EE. The mean number of motiles / plant for cultivars RM, MA and EE was 314, 254 and 173, respectively.

Physical characteristics of different plant cultivars: The mean number of tuft domatia / leaf on RM was significantly higher ($F = 7.14$; $df = 2, 99$; $P = 0.0010$) compared to the other cultivars; however the number per mm² was highest ($F = 20.30$; $df = 2, 99$; $P < 0.0001$) for EE (Table 2). The number of leaves / plant was significantly higher ($F = 4.10$; $df = 2, 9$; $P = 0.0342$) on RM than MA; however, the mean number of flowers / plant did not differ significantly among the different cultivars.

Table 2. Plant characteristics of different candidate banker plant ornamental pepper cultivars and mean number of *Amblyseius swirskii* life stages found on cultivars in choice tests during bloom 28 days post-release^a.

Cultiva rc	Mean number \pm SEM ^b /							
	leaf		plant					
	tuft domatia	Tuft Domatia / mm ²	leaves	flowers	eggs	nymphs (n)	adults (a)	motiles (n + a)
	4.6 \pm	0.4 \pm					185 \pm	314 \pm
RM	0.2b	0.1ad	198 \pm 14b	27 \pm 3a	51 \pm 14b	129 \pm 14b	35b	44b
		0.4 \pm					138 \pm	254 \pm
MA	3.5 \pm 0.2a	0.1a	153 \pm 12a	28 \pm 3a	52 \pm 14b	116 \pm 14b	29b	39b
		0.8 \pm	180 \pm					173 \pm
EE	3.9 \pm 0.2a	0.1b	12ab	24 \pm 5a	53 \pm 14b	84 \pm 17a	89 \pm 17a	32a

^aThree cultivars were transplanted in a single pot and allowed to flower prior to releasing 5 *A. swirskii* gravid females on each. Plants were destructively sampled ($n = 10$ pots).

^bData was log transformed before analysis by ANOVA and LSD tests ($P < 0.05$). Untransformed data is presented. Mean numbers in a column with letters that are not the same are significantly different.

^cRM = Red Missile; MA = Masquerade; EE = Explosive Ember

^d10 leaves randomly chosen from 10 plants / cultivar at 40 days after planting ($n = 100$ leaves / cultivar)

Discussion

We demonstrated in another similar experiment that after release of *A. swirskii* reared on the banker plants, they effectively suppressed both the population of *B. tabaci* and mixed thrips on green bean plants (Xiao et al. 2012). Such an effective suppression of these pests through this established banker plant system could provide a long-lasting and sustainable way of managing multiple pests under economically damaging levels in floriculture crops. Therefore, selection of the preferred ornamental pepper banker plant host(s) by *A. swirskii* was evaluated.

In the current study, female mites laid more eggs when pollen was provided as a food source in the pre-bloom studies. This finding is corroborated by other researchers concerning the effect of pollen on the mite reproductive capacity. Nomikou et al. (2010) and Park et al. (2010) indicated that the control of whiteflies and tomato russet mite by *A. swirskii* can be improved by supplementing the predators with pollen, respectively. In addition, van Rijn and Tanigoshi (1999) and Rugusa et al. (2009) found pollen sustains the reproduction and development of the predatory mite, *Iphiseius degenerans* and generalist mite, *Cydnodromus californicus*, respectively. Without pollen available as a supplementary food source in these studies, the number of eggs deposited decreased and the population of mites was significantly lower compared to those same cultivars when pollen was provided.

In a concurrent study, when Kumar et al. (2013) studied the effect of the pollen of four ornamental pepper cultivars (RM, MA, EE and BP) on development and reproduction of *A. swirskii*, they reported there was no significant difference in longevity and reproductive capacity of phytoseiid mite when fed solely on a pollen source. However, numerically, higher egg deposition was reported on treatment containing RM followed by MA, EE and BP. This result suggests that *A. swirskii* can successfully survive, develop and oviposit on all four ornamental pepper cultivars in the absence of prey when pollen is available as a source of nutrition. Therefore, an important aspect for selecting a particular cultivar as a suitable banker plant would be the time required for it to flower and produce pollen as an alternative source of food for the predator when being used early in the cropping season as a preventive measure for suppressing pest populations. In such a scenario, use of cultivars RM, MA and EE are preferred to cultivar BP which takes > 68 DAP to flower, compared to 28 DAP for the other three cultivars.

In the current study, inside the domatia of the leaf, the non-glandular trichomes (tuft) present provided a place for the egg(s) to be attached and for the adult to inhabit. Some eggs were observed attached to the apex of the trichome which extended several millimeters above the leaf surface or underneath several trichomes in or near the domatia. In the choice plant tests pre-bloom between all four cultivars growing in a single pot supplemented with pollen and leaves touching, cultivar RM had the highest mean number of eggs deposited and tuft domatia per leaf, followed by MA, EE and lastly BP with the lowest egg numbers and least tuft domatia per leaf. The presence of tuft domatia have been shown to have a positive influence on the abundance of predatory phytoseiid mites (Pemberton and Turner 1989; Grostal and O'Dowd 1994; Agrawal 1997; Roda et al. 2000; Romero and Benson 2005; Loughner et al. 2008, 2010). Our results further support the idea that tuft domatia are preferred for increasing oviposition.

These experiments have indicated that the plant characteristics, especially the number of tuft domatia and availability of pollen as a supplemental food source are some of the key aspects that

can influence the selectivity and host preference of *A. swirskii* for an ornamental pepper banker plant cultivar. Based on our plant studies, *A. swirskii* demonstrated a preference for cultivar RM (pre-bloom) when supplemented with pollen and both RM and MA when flowering. In IPM programs, if the grower wants to utilize these ornamental pepper banker plants pre-bloom when no prey is available, it will be important to supplement *A. swirskii* released with some pollen, such as dusting on the leaves in order to sustain the population until plants begin to flower. Also, by growing all three cultivars in the same pot as in our study, using three RM or MA cultivars or a combination and then releasing the predatory mites during flowering, this strategy potentially may increase the carrying capacity of the banker plant system as well as the efficacy for suppressing the target pest. This hypothesis offers much promise, but needs to be tested under varying greenhouse and landscape conditions.

In conclusion, the three pepper varieties RM, MA and EE post-bloom, all supported a high number of the predator *A. swirskii* for suppressing populations of pestiferous insects in cropping systems. Further studies are needed to evaluate the dispersal and efficacy of *A. swirskii* on this banker plant cultivar system for managing various pestiferous arthropods found in floriculture production and landscapes.

Efficacy of an entomopathogenic fungus, *Isaria fumosorosea* and an insect growth regulator against the rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae)

Aleurodicus rugioperculatus Martin, commonly known as gumbo limbo or rugose spiraling whitefly (RSWF) is new emerging pest of ornamental and landscape plants in Florida. It is a newly introduced pest of Central American origin, reported first time in Florida from Miami-Dade County in 2009. Since then, its distribution range is increasing and now it has been reported causing damage to ornamental plant hosts in at least 10 counties of Florida. Feeding damage caused by this pest not only brings its host under stress, but the massive production of wax and honeydew promoting the growth of fungus sooty mold, is causing a nuisance for homeowners and property managers in the infested region. Experiments were initiated in June 2013 at a residential site in Stuart to evaluate the effectiveness of a biological insecticide named Talus® (insect growth regulator) against RSWF. The insecticide was found effective in regulating the RSWF population till four weeks after application of insecticide. Progress is being monitored by weekly site visits. In addition, more than 100 RSWF infested plants were surveyed for the presence of biological control agents associated with this pest. *Nephaspis oculatus* is most frequently encountered natural enemy observed on the RSWF infested plants in this region.

Laboratory and greenhouse studies are being conducted in order to evaluate the effect of an entomopathogen *Isaria fumosorosea* (PFR 97), a chitin synthesis inhibitor (Talus) and their combination against RSWF. In the preliminary study conducted to assess the compatibility of the two products, both the insecticides were found to be compatible. Six different concentrations of Talus (0, 3, 4.5, 6, 7.5 and 9 oz/100 gallon) was mixed with the PDA media, on which the radial growth and germination of the spores of the PFR was tested. Although a little low germination of spores ranging between 79-84% was reported in the treatment dishes compared to control (92%), but the growth of the spores was found to be higher in all the treatments than control.

Fungal Endophytes

Researchers with the University of Florida and the USDA are investigating possible prophylactic effects of commercial microbial pesticides on the behavior of whiteflies and subsequent plant protection. Preliminary results suggest that both commercial entomopathogenic fungi, PFR-97 and botanigard, can establish as endophytes in lima bean plants. Possible benefits this establishment could confer to the plants continue to be explored.

Functional response of predatory mites (*Amblyseius swirskii*) to chilli thrips.

Different nutritional resources were investigated to determine which artificial diets (peach, cattail, ornamental, and prey) are optimal for mite predation on thrips.

Materials and methods

The modified standard Petri dish assay methods was employed to examine the predation capacity of *A. swirskii* reared on different pollens. The functional responses of single female adult of *A. swirskii* (2-4 day old) reared on the different diets (peach, cattail, ornamental pepper, and other prey) to chilli thrips were determined using leaf disks (1 cm) infested with different prey densities (5, 10, 20, 30, 40, 50, and 60 chilli thrips per disk), each with 5 replications. The densities were prepared in advance by placing chilli thrips on new non-infested leaf disks. The numbers of chilli thrips killed were recorded daily for 48 h using a stereo microscope. To maintain appropriate chilli thrips densities in the arenas, dead chilli thrips were replaced with live ones daily. The type of functional response was determined by performing a binomial logistic regression analysis of proportion of prey consumed as a function of prey density and is represented by the equation: $(N_e / N = a + bN + cN^2 + dN^3 + e)$, or directing from the curve of the predation with densities. This analysis has been described in detail by several authors (Juliano, 2001; Xiao and Fadamiro, 2010). Data on maximum mean number of prey killed / female / day (number of prey killed at the density at which the highest prey consumption is recorded) was analyzed with repeated measures analysis of variance (ANOVA) using SAS GLM procedure followed by Tukey's honestly significant difference (HSD) test to determine significant differences in maximum number of prey consumed among different diets ($P < 0.05$). This study provided information as to whether predatory mites have the same or similar predation rate on chilli thrips irrespective of the pre-exposure diet.

Results

The predatory mite, *A. swirskii*, reared on different diets was equally effective against chilli thrips nymphs. The chart curve suggested Type II (convex) functional responses of the predatory mite species. Among the four different diets, *A. swirskii* had the almost same predation on chilli thrips, the maximum daily predation was 35-43 nymphs of chilli thrips / day by a *A. swirskii* female reared from peach, cattail, ornamental pepper, and other prey, there was no significant difference in maximum daily predation among the different diets. The findings from this study could help to develop better artificial diet for the biological control agent to be employed against multiple pests in vegetable productions.

Chilli Thrips Barcoding Efforts

Chilli thrips, *Scirtothrips dorsalis* is a globally invasive species that was first established in Florida in 2005. ARS researchers in Fort Pierce, Florida have sequenced a portion of mitochondrial gene from populations in four Florida counties feeding on ten hosts as well as populations in China, Vietnam, Japan, India, Israel, Thailand, and Singapore and found more than 90 distinct haplotypes. There is 14% sequence divergence between Japan and U.S. populations, 14% sequence divergence between China and U.S. populations, and 7% sequence divergence between Japan and China populations of chilli thrips. The common Florida haplotype is identical in sequence to samples from Thailand and Singapore.

Due to the difficulty sequencing the barcoding region of diverse chilli thrips populations, 12 new primers have been designed to sequence previously unavailable samples. Some of these primers amplify the boundary between the ribosomal large subunit gene and the mitochondrial CO1 gene. Numts, or mitochondrial pseudogenes present in the nuclear genome have been demonstrated to be problematic in chilli thrips but this problem can be mitigated by validating sequences with more than one flanking pair of PCR primers. The large number of haplotypes sequenced to date suggest that chilli thrips invasive in Israel may have originated in India and that chilli thrips invasive in the U.S. may have originated in Thailand. We continue to pursue chilli thrips populations from other endemic regions, especially, Australia and South Africa, to allow us to fully resolve the phylogenetic relationships among chilli thrips groups with highly divergent DNA sequences.

Next Generation Sequencing in Search of a Better Barcode

ARS researchers in Fort Pierce, Florida are conducting next-generation DNA sequencing of the invasive chilli thrips and have sequenced more than 1 billion nucleotides of the chilli thrips metagenome. Because of their high sequence divergence and national importance, one DNA sample each from Japan and Florida were sequenced for genomic and metagenomic comparison. Raw sequencing reads were assembled into larger contigs -501,640 from Japan and 615,073 from Florida. Bioinformatic analyses of these contigs uncovered sequences from more than 170 different bacterial genera. Gammaproteobacteria, such as *Pseudomonas sp.*, are of particular interest and may be important components of the microbiomes of thrips making them possible targets for future control methods. Researchers were also able to construct large portions of the mitochondrial genomes of both Florida and Japan chilli thrips.

Distribution of *Bemisia tabaci* (Hemiptera: Aleyrodidae) Biotypes in North America following the Q Invasion.

The following research is the culmination of a very large collaborative effort between the ADODR/PI and sub award recipients from this SCA and a previous related SCA plus many growers, industry, state and federal agencies too many to mention. A short summary is provided and the full report can be found in:

McKenzie, Cindy L., James A. Bethke, Frank J. Byrne, Joseph R. Chamberlin, Timothy J. Dennehy, Aaron M. Dickey, Dan Gilrein, *Paula M. Hall*, Scott Ludwig, Ronald D. Oetting,

Lance S. Osborne, Lin Schmale, Robert G. Shatters, Jr. 2012. Distribution of *Bemisia tabaci* (Hemiptera: Aleyrodidae) Biotypes in North America following the Q Invasion. J Econ Entomol 105(3): 753-766. DOI: <http://dx.doi.org/10.1603/EC11337>

After the 2004 discovery of the *Bemisia tabaci* (Gennadius) Q biotype in the U.S., there was a vital need to determine its distribution and its interaction with the resident B biotype because of its innate ability to rapidly develop high level insecticide resistance that does not revert back to susceptibility in the absence of exposure. Associated with the appearance of biotype Q in the U.S. in 2004 were reports from ornamental growers of increasing problems in controlling whitefly infestations due to the increased proclivity of the Q biotype to rapidly develop insecticide resistance in comparison to the resident B biotype. As a result, there was great concern over the possibility of the development of a B-Q hybrid whitefly that would have high insecticide resistance of the Q biotype with the more aggressive and invasive characteristics of the B biotype. As part of an APHIS coordinated multi-state, multi-agency and multi-institutional Q biotype task force initiative with the cooperation of growers, industry, state, and federal agencies, a coordinated whole country survey was conducted across North America from Jan 2005 to Dec 2010 including the islands of Bermuda and Hawaii (big island of Hawaii and Oahu), Canada and Mexico with the primary objective to monitor the introduction of the Q biotype and distribution of all *Bemisia* biotypes, including B, Q and New World. The biotype status of submitted *B. tabaci* samples was determined by PCR amplification and sequencing of a mitochondrial cytochrome oxidase I small subunit (mtCOI) gene fragment, characterization of two biotype discriminating microsatellite markers and esterase zymogram analysis. Host plants were split between ornamental and herb (67%) and vegetable and field (33%) commodities. Five collections from tomato in Mexico (2) and Texas (3) were 100% New World biotype. To our knowledge this is the first report of the New World biotype in the United States since its rapid displacement in the late 1980s after the introduction of biotype B. Seventy-one percent of all collections contained at least one biotype B individual and 53% of all collections contained only biotype B whiteflies. In this report, biotype Q was detected in 23 states in the U. S., Canada (British Columbia and Ontario territories), Bermuda, and Mexico. Forty-five percent of all collections were found to contain biotype Q in samples from ornamentals, herbs and a single collection from tomato transplants located in protected commercial horticultural greenhouses with no Q detections in open agriculture (field crops). Ten of the 15 collections (67%) from Canada and a single collection from Bermuda contained biotype Q which represents the first report of biotype Q for both countries. Three populations of *B. tabaci* biotype Q whiteflies were detected in North America which differentiated from one another at both mitochondrial and nuclear loci. Our data is consistent with the inference of independent invasions from at least three different locations. Of the 4,849 individuals analyzed from 468 collections which include data from McKenzie et al. 2009, only 16 individuals contained genetic/zymogram signatures that suggested possible hybridization of the Q and B biotypes and there was no evidence that rare hybrid B-Q marker co-occurrences persisted in any populations. Our results suggest that, unlike other countries where the Q biotype has invaded field crops, in the U.S. rapid detection and implementation of improved control strategies targeting the Q biotype has prevented the establishment of this pest beyond greenhouse production.

Population genetics of invasive *Bemisia tabaci* cryptic species in the United States based on microsatellite markers.

As a result of the North American distribution research, a limited loci microsatellite population genetics study was conducted. A short summary is provided and the full report can be found in:

Dickey, Aaron, Lance S. Osborne, Robert G. Shatters, Jr., Paula Hall, and Cindy L. McKenzie. 2013. Population genetics of invasive *Bemisia tabaci* cryptic species in the United States based on microsatellite markers. J Econ Entomol. 106(3):1355-1364. : <http://dx.doi.org/10.1603/EC12512>

The *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) cryptic species complex of Whiteflies contains two species, MEAM1 (biotype B) and MED (biotype Q), that are highly invasive in supportive climates the world over. In the United States, MEAM1 occurs both in the field and in the greenhouse, but MED is only found in the greenhouse. To make inferences about the population structure of both species, and the origin and recent spread of MED within the United States, 987 MEAM1 whiteflies and 340 MED whiteflies were genotyped at six and seven microsatellite loci, respectively, for population genetic analyses. Major results of the study are 1) MED exhibits more population structure and genetic differentiation than MEAM1, 2) nuclear microsatellite markers exhibit a high degree of concordance with mitochondrial markers used in the North American distribution survey recovering a major east-west phylogeographic break within MED, 3) both eastern and western MED are found throughout the continental United States and eastern MED is present in Hawaii, and 4) MEAM1 contains two greenhouse U.S. populations significantly differentiated from other U.S. MEAM1. The results suggest that ***MED was introduced into the United States on at least three occasions and rapidly spread throughout the United States***, showing no discernible differentiation across 7,000 km. The results further suggest that there is an enhanced role of the protected agricultural environment in promoting genetic differentiation in both invasive *B. tabaci* cryptic species.

LAMP: a technique for biotype discrimination in *Bemisia tabaci*.

A single temperature DNA amplification technique is being pursued as a means to discriminate between two invasive whiteflies, *Bemisia tabaci* biotypes B and Q, in high-value greenhouse ornamental crops. At present growers and other stakeholders send whiteflies to forensics labs for “biotyping” in order to manage pesticide resistance and to track the continental spread of biotype Q. An assay was developed that amplifies target DNA from biotype B whiteflies in 30 minutes with results based on color change in the reaction tube. This assay is much faster and easier to carry out and interpret than other biotyping assays. The combination of speed and simplicity make this assay more amenable to deployment in the greenhouse for real-time pest management decisions. Once additional barriers to field deployment are overcome, this assay will provide this real-time data to ornamentals growers and other stakeholders. Furthermore, once proof-of-concept is established, this DNA amplification technique is amenable to help solve other pest/pathogen diagnostics problems in agriculture.

Management Plans, Technology Transfer, Websites, Training Workshops

National Whitefly Management Plan for Ornamental Plants -

http://www.mrec.ifas.ufl.edu/LSO/bemisia/WhiteflyManagementProgram_2011.pdf

National Thrips Management Plan for Ornamental Horticulture –

<http://mrec.ifas.ufl.edu/iso/DOCUMENTS/ThripsManagementProgram-February%202011-FINAL.pdf>

Thrips Management Program for Plants for Planting

Efficacy trials from Florida and Texas expanded the list of effective pesticides for chilli thrips control to 26 with 11 different modes of action. As a result, a thrips management program for plants for planting was developed and is available at the chilli thrips website:

http://mrec.ifas.ufl.edu/iso/DOCUMENTS/ThripsManagementProgram_100308.pdf.

Technology Transfer via Websites:

Two whitefly websites: (<http://www.mrec.ifas.ufl.edu/LSO/bemisia/bemisia.htm> and <http://www.q-biotypewhiteflies.com/>) have been developed and are maintained for disseminating whitefly (biotypes B and Q) information.

Two banker plant websites:<http://www.mrec.ifas.ufl.edu/iso/banker/banker.htm>

<http://www.mrec.ifas.ufl.edu/iso/banker/media/>



Chilli thrips website is maintained by Dr. Lance Osborne (University of Florida) for dissemination of educational and research materials to growers, researchers and the general public.

<http://www.mrec.ifas.ufl.edu/iso/thripslinks.htm>

From 2008 to 2013, the chilli thrips website had a total of 64,931 page loads from 41,167 unique visitors, 36,554 first time visitors and 4,613 returning visitors.

First Detector Training Workshops

A chilli thrips on-line eLearning training module complete with CEUs was developed with the National Plant Diagnostic Network (NPDN) for training first detectors and is available on the NPDN training website at: <http://chc.at.ufl.edu/>

News Media Coverage of Banker Plants:

1. This Old House episode: <http://www.thisoldhouse.com/toh/tv/ask-toh/video/0,,20665197,00.html>
2. News University of Florida in USA: <http://news.ufl.edu/2011/06/29/banker-plants/>
3. Southeast farm press in USA: <http://southeastfarmpress.com/vegetables/papaya-plants-play-keyrole-greenhouse-whitefly-control> ;
4. News in Physorg.com in USA: <http://www.physorg.com/news/2011-06-papaya-pesticides-tomatoes-florida.html>
5. <http://agriculture.einnews.com/search.php?keywords=Papaya+plants+reduce+the+need+for+pesticides+on+tomatoes+in+Florida%2C+new+UF+study+finds&makesearch=yes>
6. China scientific news: <http://paper.sciencenet.cn/htmlpaper/20117714293897417937.shtm>
7. The Philippine crop protection association: <http://cpap.ph/news?start=30>
8. Labspaces: http://www.labspaces.net/123346/Researchers_use_banker_plants_to_help_battle_whitefly_pests
9. Seedquest: http://www.seedquest.com/news.php?type=news&id_article=29774&id_region=&id_category=&id_crop
10. The Grower: <http://www.thegrower.com/news/Plants-help-bank-beneficial-insects-in-greenhouses-169190216.html>
11. Seed Daily: http://www.seeddaily.com/reports/Researchers_Use_Banker_Plants_to_Help_Battle_Whitefly_Pests_999.html
12. Agrotimes: http://www.agrotimes.com/research/Researchers_use_banker_plants_to_help_battle_whitefly_pests.asp
13. Western Farm Press: <http://westernfarmpress.com/management/banker-plants-battle-whiteflies>
14. Growing Produce: <http://www.growingproduce.com/article/31258/study-backs-benefits-of-banker-plants>

Honors and Awards Received

2009 Lance Osborne / Alex Laurie Award – Society of American Florists presents this very prestigious award for “Research, Education and Outstanding Services and Contributions to Floriculture & Ornamental Horticulture”.

2009 McKenzie & Osborne / Outstanding Achievement Award for Research Teams, “Investigating the Q invasion of *Bemisia tabaci* in Florida”, Florida Entomological Society.

2011 Cindy McKenzie / Entomologist of the Year Award for “Outstanding Contributions to the Genomics and Management of Whitefly Pests”, Florida Entomological Society.

2012 Lance Osborne / Extension Entomologist of the Year Award for “Outstanding Achievement for Extension”, Florida Entomological Society.

Publications and Presentations
Life of the Project Summary 2008 – 2013
Alphabetical by year / *italicized authors* are postdoctoral research associates

2008

Publications

- Bethke, James A., Frank J. Byrne, Greg S. Hodges, Cindy L. McKenzie, and Robert G. Shatters, Jr. 2008. First report of the Q biotype of *Bemisia tabaci* (Gennadius) in Guatemala. *Phytoparasitica* 37:61-64.
- Bethke, James, Luis Canas, Joe Chamberlin, Ray Cloyd, Jeff Dobbs, Richard Fletcher, Dave Fujino, Dan Gilrein, Richard Lindquist, Scott Ludwig, Cindy McKenzie, Ron Oetting, Lance Osborne, Cristi Palmer, and John Sanderson. 2008. Whiteflies. Society of American Florists, Proceedings of the 24th Annual Conference on Pest and Disease Management in Ornamentals. XXIV: 32-50. (Proceedings).
- Bethke, J. A. and F. J. Byrne. 2008. Invasive biotype: the quest for a quick answer. CAPCA Advisor. April 2008 Vol. XI (2): 26-29.
- Bethke, J. A., F. J. Byrne, and V, J Mellano. 2008. Effective use of the neonicotinoids. Final report to the California Cut Flower Commission. 5-12-08
- Bethke, J. A. 2008. Efficacy of selected insecticides against the sweetpotato whitefly, *Bemisia tabaci*, Q biotype on poinsettias under greenhouse conditions. IR4. 5-12-2008.
- Bethke, J. A. 2008. Efficacy of the neonicotinoids against the sweetpotato whitefly, *Bemisia tabaci*, Q biotype on poinsettias under greenhouse conditions. IR4. 2-10-2008.
- Bethke, J. A. and R. A. Redak. 2008. Control of adult sweetpotato whitefly, *Bemisia tabaci* B & Q biotype, on poinsettia using Endeavor (pymetrozine) under laboratory conditions. IR4. 2-10-2008.
- Bethke, J. A. and R. A. Redak. 2008. Efficacy trial conducted against nymphs of *Bemisia tabaci*, Q-Biotype (Poinsettia '04), within the Quarantine Facility at UC Riverside. IR4. 2-10-2008.
- Bethke, J. A. and R. A. Redak. 2008. Control of silverleaf whitefly B & Q biotype on poinsettia under laboratory conditions using the Potter Spray Tower. IR4. 2-10-2008.
- Ludwig, S. 2008. New insecticides for old pests. *American Nurseryman*. 208(10): 8-9.
- Ludwig, S. 2008. Look for these pests in 2008. *Greenhouse Management and Production (GMPRO)*. 27(2): 37-39.

- McKenzie, C. L., Robert G. Shatters, Jr, J. A. Bethke, F. J. Byrne, and G. S. Hodges. 2008. Guatemala mitochondrial whitefly (*Bemisia tabaci*) biotyping dataset: 6 *mtCO1* sequences. GenBank Acc. Nos. EU881708 through EU881713, National Center for Biotechnology Information (NCBI). <http://www.ncbi.nlm.nih.gov/> (Public Database).
- McKenzie, Cindy and Robert G. Shatters, Jr. 2008. Florida mitochondrial whitefly (*Bemisia tabaci*) biotyping dataset: 203 *mtCO1* sequences. GenBank Acc. Nos. FJ188480 through FJ188501, FJ188503, FJ188505 through FJ188609, FJ188611 through FJ188642, FJ188644 through FJ188678, and FJ188680 through FJ188687, National Center for Biotechnology Information (NCBI). <http://www.ncbi.nlm.nih.gov/> (Public Database).
- Osborne, L.S., Z. Landa, A. Bohatá, and C. McKenzie. 2008. Potential of entomopathogenic fungus, *Isaria fumosorosea* to protect potted ornamental plants against *Bemisia tabaci* during shipping. IOBC/WPRS Bulletin 32, 159-165.
- Osborne, Lance, Joe Chamberlin and Cindy McKenzie. 2008. Managing the Invasive Species Risk. Society of American Florists, Proceedings of the 24th Annual Conference on Pest and Disease Management in Ornamentals. XXIV: 80-81. (Proceedings).
- Osborne, L. S. 2008. Invasion and response: Impacts of *Bemisia* on worldwide agriculture. Journal of Insect Science 8: 37-38.
- Osborne, L. S., G. J. Hochmuth, R. C. Hochmuth, and D. Sprenkel. 2008. Managing *Bemisia* on organically grown herbs. Journal of Insect Science 8: 38-38.
- Osborne, L. S., Cuda, J. P. & Thompson, M. O. 2008. "Invasive Arthropod Working Group." MREC-Server: University of Florida. (<http://mrec.ifas.ufl.edu/Iso/IAWG/default.asp>). (Website).
- Osborne, L. S., Cuda, J. P., Jacoby, C. A., Langeland, K. A., Johnson, S. A. & Thompson, M. O. 2008. "University of Florida Invasive Species Coordinating Council Website." MREC-server: University of Florida. (<http://mrec.ifas.ufl.edu/Iso/Isc/>). (Website).
- Stansly, P.A. and C. L. McKenzie. 2008. Fourth International *Bemisia* Workshop International Whitefly Genomics Workshop. 53 pp. Journal of Insect Science 8:04, available online: www.insectscience.org/8.04. (Book of Abstracts).

Presentations

- Bethke, J. A. 2008. Optimizing the use of the neonicotinoid insecticides in floriculture. International Cut Flower Growers 2008 Annual Meeting, Mission Valley Resort, San Diego, CA. 4-12-08.
- Bethke, J. A. 2008. Battling Invasive Pests and Diseases: Quarantine regulations for invasive pests: Three recent examples. Lion's Park, Carpenteria, CA.

- Bethke, J. A. 2008. Invasive Pests and Regulations. Plug and Cutting Conference, GrowerTalks and Ohio florists Association, Rosen Plaza Hotel, Orlando FL. 9-29-08.
- Bethke, J. A. 2008. Invasive species and regulations affecting San Diego. Laws and Regs Seminar, CAPCA San Diego Chapter, San Diego Farm Bureau, Escondido, CA. 12-10-08
- Bethke, J. A. 2008. Invasive pests in greenhouse foliage crops. Greenhouse Seminar and Tour, Southern California Chapter and UCCE Orange County, Kallisto Greenhouse, Fontana, CA. 12-5-08
- Bethke, J. A. 2008. Invasive pests: What to do? San Diego CAPCA's Nursery Greenhouse Seminar 2008. The Windmill, Carlsbad, CA. 6-5-08
- Leibee, Gary L., Lance S. Osborne, Moh Leng Kok-Yokomi, Cindy L. McKenzie, and Robert Shatters, Jr. 2008. Toxicity of Selected Insecticides to a Strain of *Bemisia tabaci* Biotype Q from Florida. 4th Pan Pacific Conference on Pesticide Science, Honolulu, HI, 2 Jun 08.
- Gilrein, Dan. 2008. ID & Management of Insects & Mites of Greenhouse and Outdoor Ornamentals. Hudson Valley Nursery and Greenhouse Growers School. New Paltz, NY. January 15, 2008. 120 attendees.
- Gilrein, Dan. 2008. Managing Greenhouse Arthropods: Back to the Basics. Capital District Bedding Plant Conference and Trade Show. Latham, NY. January 16, 2008. 120 attendees.
- Gilrein, Dan. 2008.. Insects and Mites – Current Problems and Fixes. Long Island Greenhouse and Floriculture Conference. January 22, 2008. 60 attendees.
- Gilrein, Dan. 2008. 2008 Integrated Pest Management & Insect and Mite Problems of Ornamental Plants. Long Island Horticulture Training School. Riverhead, NY. February 19, 2008. 30 attendees.
- Gilrein, Dan. 2008. Field Reports, Results of Efficacy Trials, New Products and Current Issues. Entomological Society of America, Eastern Branch, Annual Meeting. Syracuse, NY. March 10, 2008. 50 attendees.
- Gilrein, Dan. 2008. Introduction to Insects. Urban Horticulture and Ecology Training Program. Cornell Cooperative Extension, Manhattan. March 19, 2008. 45 attendees.
- Gilrein, Dan. 2008. Entomology Research at the LIHREC. Long Island Horticultural Research and Extension Center Plant Science Day. July 8, 2008. 60 attendees.
- Gilrein, Dan. 2008. Pest Control Products and Strategies: What's Working and What's Not Working in the Real World. New England Greenhouse Conference. Integrated Pest Management for Propagation. 120 attendees.

- Leibee, G.L., L. S. Osborne, M. Leng Kok-Yokomi, C. L. McKenzie & R. Shatters, Jr. 2008. Toxicity of selected insecticides to a strain of *Bemisia tabaci* Type Q from Florida. Annual meeting Entomological Society of America. November, 2008 Reno, NV.
- Ludwig, S. 2008. Managing new and old ornamental insect pests. Spring Pest Management Seminar. Richardson, TX. (February 2008).
- Ludwig, S. 2008. New insecticides and pests - What really works. Southeast Greenhouse Conference. Greenville, SC. (June 2008).
- Ludwig, S. 2008. Managing whiteflies and thrips. Southeast Greenhouse Conference. Greenville, SC. (June 2008).
- Ludwig, S. 2008. New insecticides for ornamental pest management. University of Hawaii Cooperative Extension Service. Pearl City, HI. (June 2008).
- Ludwig, S. 2008. East Texas Nursery and Greenhouse IPM Program update. Northeast Texas Nursery Growers Association Monthly Meeting. Overton, TX. (July 2008).
- Ludwig, S. 2008. Entomology update & fire ant management. Pesticide Recertification Training #1. Overton, TX.
- Ludwig, S. 2008. Entomology update & fire ant management. Pesticide Recertification Training #2. Overton, TX.
- Ludwig, S. 2008. Grower's guide to what is new in insect pest control. BWI Expo. Shreveport, LA. (September 2008)
- Ludwig, S. 2008. Whiteflies in US floriculture. Global Workshop on Stewardship of Neonicotinoid Insecticides. Honolulu, HI, 4 Jun 08.
- Ludwig, S., L. Osborne, C. McKenzie, O. El-Lissy, & L. Schmale. 2008. The coordinated response of industry, regulatory, research, and extension to *Bemisia tabaci* Biotype Q. Southeastern Branch Meeting of the Entomological Society of America. Jacksonville, FL.
- Ludwig, S., L. Osborne, O. El-Lissy, D. Schuble, and L. Schmale. 2008. Q-Tac and Chilli thrips Task Force – USDA. Entomological Society of American Annual Meeting. Reno, NV.
- Ludwig, S. 2008. IPM update. East Texas Nursery and Greenhouse Conference. Tyler. TX.
- Ludwig, S. 2008. Sustainable IPM of insect pests. GrowerTalks Sustainability Conference. Frisco, TX.
- McKenzie, C. L., L. Boykin, R.G. Shatters, Jr., G. Hodges, L.S. Osborne, and F. Byrne. 2008. Extensive Survey of *Bemisia tabaci* Biotypes in Florida – Investigating the “Q” Invasion. Florida Entomological Society Annual Mtg, Jupiter, FL, 16 Jul 08.

- McKenzie, C. L., L. Boykin, R.G. Shatters, Jr., G. Hodges, L.S. Osborne, and F. Byrne. 2008. Extensive Survey of *Bemisia tabaci* Biotypes in Florida – Investigating the “Q” Invasion. Faunistics, Systematics, and Ecology, 3rd European Whitefly Symposium, Almeria, Spain, 21 Oct 2008.
- McKenzie, C. L., Boykin, R. G. Shatters, Jr., G. Hodges, L. S. Osborne, & F. Byrne. Extensive survey of *Bemisia tabaci* biotypes in Florida – investigating the “Q” invasion. . Annual meeting Entomological Society of America. November, 2008 Reno, NV.
- Osborne, L.S., Z. Landa, A. Bohatá, and C. McKenzie. 2008. Invited Keynote Speaker. Potential of entomopathogenic fungus, *Isaria fumosorosea* to protect potted ornamental plants against *Bemisia tabaci* during shipping. IOBC/WPRS Working Group "Integrated Control in Protected Crops, Temperate Climate", Sint Michielsgestel, April 21-25, 2008.
- Osborne, L. S. and S. Ludwig. 2008. "Invited" "Q-Tac and Chilli Thrips -USDA." Entomology Without Borders - The Next Stage in Resistance Management, Symposium. Annual meeting Entomological Society of America. November, 2008 Reno Nevada.
- Osborne, Lance, Joe Chamberlin and Cindy McKenzie. 2008. Managing the Invasive Species Risk. Society of American Florists, Proceedings of the 24th Annual Conference on Pest and Disease Management in Ornamentals. Atlanta Georgia February 2008.
- Osborne, L.S. 2008. Annual CARET Meeting. Tours and presentations on Pest Management in Protected Culture. August, 2008.
- Osborne, L.S. 2008. Tours and Talk on “Pest Management in Greenhouses” Annual Plug Conference and Young Plant Health Committee. September 27, 2008.
- Osborne, L.S. 2008. “IR-4 and Their Role in the Management of Invasive Species”. The IR-4 5 Year Planning Meeting. Washington D.C, December 8-11, 2008.
- Osborne, L. S. 2008. "Invited" "The potential of banker plants in protected culture.". Symposium: Recent and Current Events in Biocontrol of Arthropods and Weeds in Florida, 2008 Annual meeting of the Florida Entomological Society. July 2008.
- Osborne, L. S. 2008. "Pest Management Update for Ornamental Growers" CEU Day Pierson, Florida. June 17, 2008.
- Osborne, L. S. 2008. “Banker Plants and Biological Control”. Multi-County Master Gardener Meeting. MREC-Apopka, Florida. September 9, 2008.

2009

Publications

- Arthurs, Steven, Cindy McKenzie, Jianjun Chen, *Mahmut Dogramaci*, Mary Brennan, Katherine Houben, and Lance S. Osborne. 2009. Evaluation of *Neoseiulus cucumeris* and *Amblyseius swirskii* (Acari: Phytoseiidae) as biological control agents of Chilli thrips, *Scirtothrips dorsalis* (Thysanoptera: Thripidae) on pepper. *Biological Control* 49(1):91-96.
- McKenzie, C. L., Greg Hodges, Lance S. Osborne, Frank J. Byrne and Robert G. Shatters, Jr. 2009. Distribution of *Bemisia tabaci* (Hemiptera: Aleyrodidae) biotypes in Florida – Investigating the “Q” invasion. *J Econ Entomol* 102(2):670-676.
- Shatters, Robert G. Jr., Charles A. Powell, Laura M. Boykin, *He Lian Sheng*, and C. L. McKenzie. 2009. Improved DNA barcoding method for *Bemisia tabaci* and related Aleyrodidae: Development of universal and *Bemisa tabaci* biotype-specific mitochondrial cytochrome c oxidase I polymerase chain reaction primers. *J Econ Entomol* 102(2):750-758.

Presentations

- Bethke, J. A. 2009. Invading Pests: What to do? San Diego CAPCA’s Nursery Greenhouse Seminar 2009. The Windmill, Carlsbad, CA. June 4, 2009
- Bethke, J. A. 2009. Invasive Species Update. Annual Winter Workshop Series Ontario Workshop, Target Specialty Products, Doubletree Hotel, Ontario, CA. 10-22-09
- Bethke, J. A. 2009. Pest Management in Ornamental Production. Western Regional Meeting of the International Plant Propagators’ Society, San Diego CA. 10-3-09.
- Byrne, F. J., R. A. Oetting, J. A. Bethke, C. and J. Chamberlin. 2009. Understanding the dynamics of neonicotinoid activity in the management of *Bemisia tabaci* whiteflies on poinsettias. 93rd Annual Meeting of the Pacific Branch of the Entomological Society of America. Bahia Resort Hotel, San Diego Ca. March29-April 1, 2009.
- Gilrein, Dan. 2009. Pest Management Update. Long Island Floriculture Conference, January 20, 2009. 80 attendees.
- Gilrein, Dan. 2009. The Entomology Program. Cornell Cooperative Extension of Suffolk County, Agriculture Advisory Committee. Riverhead, NY. 12 attendees.
- Gilrein, Dan. 2009. Pest Posse: Insect Diagnoses on Floriculture Crops Long Island Floriculture Field Day. LIHREC, Riverhead. July 8 – 9, 2009. 20 attendees.
- Gilrein, Dan. 2009. Long Island Horticultural Research and Extension Center Plant Science Day, September 10, 2009. 120 attendees.

- Ludwig, S. 2009. IPM update. East Texas Nursery and Greenhouse Conference. Tyler, TX. Organizer and Presenter. Tyler, TX.
- Ludwig, S. W. 2009. New invasive insects in Texas. Texas Tree Conference. Texas Chapter, International Society of Arboriculture. Oct 1, 2009.
- Ludwig, S. W. 2009. IPM update. East Texas Nursery and Greenhouse Conference. Tyler, TX. Organizer and Presenter. Tyler, TX. Oct 28, 2009.
- Ludwig, S. W. 2009. Natural insecticides in the landscape. Sustainable Landscape Pest Management Conference. Houston, TX. Dec 10, 2009.
- Ludwig, S. 2009. IPM Program update. Joint meeting of the Northeast Texas Nursery Growers Association and Texas Nursery and Landscape Association Region 3. Tyler, TX.
- Ludwig, S. 2009. Strategies for resistance management: Thrips and others. SAF Pest Management Conference. Presenter and Meeting Organizer. San Jose, CA.
- Ludwig, S. 2009. Insect control on greenhouse and nursery crops. East Texas Nursery and Greenhouse IPM Program. 5 meetings: Ft. Worth, Houston, Jacksonville, Canton, and McKinney, TX.
- McKenzie, Cindy. 2009. Biotype Q Whitefly and Chilli Thrips Status in Florida. Agriculture Industry Liaison Committee, U.S. Horticultural Research Laboratory, Fort Pierce, FL May 4, 2009.
- Oetting, Ron. 2009. '*Bemisia tabaci* 'Q' Biotype Management and Susceptibility to Key Insecticides', 5th International *Bemisia* Workshop, Guangzhou, PR China, Nov 9-12, 2009.
- Osborne, L.S. C. Palmer, L. Schmale, S. Ludwig, D. Schuble and C.L. McKenzie. 2009. Managing Invasive Arthropods. 25th Annual Pest Management Conference. February 19-22, 2009. San Jose, California.
- Osborne, L.S. C. 2009. Banker Plants. 25th Annual Pest Management Conference. February 19-22, 2009. San Jose, California.
- Osborne, L.S. and C.L. McKenzie. 2009. Responding to Invasive Species that Threaten Existing IPM Systems (Whitefly as a Model). Third ARS Floriculture and Nursery Review Meeting. October 12-17, 2009. Cleveland, Ohio.
- Osborne, L.S. Banker Plants and Biological Control. Annual Meeting of Zoo Horticulturists. September 30, 2009. Jacksonville, Florida.
- Osborne, L.S. 2009. Extensions' response to unknown or potentially regulated pests. Entomological Society of America, Annual Meeting, December 13-16, 2009. Indianapolis, Indiana.

- Osborne, L.S. 2009. Banker Plant Concepts. In-Service Training for Extension Agents. March 20, 2009. Apopka, Florida.
- Osborne, L.S., S.E. Webb and W. L. Laughlin. 2009. IPM and Biological Control..Given 16 times. Advanced Topics In Hydroponics. November 13-14, 2009 Live Oak, Florida.
- Webb, S.E., L.S. Osborne, and W. L. Laughlin. 2009. Common Vegetable Pests: Identification and Morphology. Given 16 times..Advanced Topics In Hydroponics. November 13-14, 2009 Live Oak, Florida.

2010

Publications

- Bethke, J., J. Chamberlin, J. Dobbs, M. Faver, K. Heinz, R. Lindquist, S. Ludwig, **C. McKenzie**, G. Murphy, R. Oetting, L. Osborne, C. Palmer, M. Parrella, N. Rechcigl, R. Yates. 2010. Thrips Management Program for Plants for Planting. 2 pp.
http://mrec.ifas.ufl.edu/Iso/DOCUMENTS/ThripsManagementProgram_100308.pdf (Public Database).
- Byrne, F.J., R.D. Oetting, J.A. Bethke, C Green, and J. Chamberlin. 2010. Understanding the dynamics of neonicotinoid activity in the management of *Bemisia tabaci* whiteflies on poinsettias. *Crop Protection* 29 (2010) 260-266.
- McKenzie, Cindy and Cristi Palmer. 2010. Whitefly Management. Society of American Florists, Proceedings of the 26th Annual Pest and Production Management Conference. XXVI: 40-49. (Proceedings).
- McKenzie, Cindy, Greg Hodges, Lance S. Osborne, Frank J. Byrne, and Robert G. Shatters, Jr. 2010. Florida Tomato Research Institute Proceedings. Investigating the “Q” invasion into Florida – Status and Update. *PRO* 53:17-19. (Proceedings).
- Ludwig, Scott and Lance Osborne. 2010. Thrips Management. Proceedings of the 26th Annual Pest and Production Management Conference. XXVE: 50-53. (Proceedings).
- Oetting, R. 2010. *Bemisia tabaci* ‘Q’ biotype management and susceptibility to key insecticides. The 5th International *Bemisia* Workshop. Nov. 9-12 Guangzhou China (Proceeding Abstract).
- Osborne, L.S. 2010. Banker Plants Explained. Society of American Florists, Proceedings of the 26th Annual Pest and Production Management Conference XXVI: 50-53. (Proceedings).
- Popenoe, Juanita and Lance Osborne. 2010. Rose nursery banker plants. *Proc of the Florida Horticultural Society* 123: 296-297.
- Vander Mey, B. and J. A. Bethke. 2010. Efficacy of selected insecticides against the sweetpotato whitefly, *Bemisia tabaci* B biotype, on gerbera under greenhouse conditions (Technical Report).

Presentations

Avery, Pasco B., Vitalis W. Wekesa, Wayne B. Hunter, David G. Hall, Cindy L. McKenzie, Lance L. Osborne, Charles A. Powell, and Michael E. Rogers. 2010. *Invited* "Multitrophic interactions of *Isaria fumosorosea*: to reduce the spread of citrus disease, Huanglongbing". Symposium on Multitrophic Interactions: Concepts and Applications Jupiter, FL July 27, 2010.

Gilrein, Dan. 2010. Entomology Update: Managing thrips and other arthropod pests Capital District Bedding Plant Conference, January 7, 2010. 84 attendees.

Gilrein, Dan. 2010. Nursery and Greenhouse Crops Insect Update. Hudson Valley Nursery and Greenhouse Growers' School, January 8, 2010. 64 attendees.

Gilrein, Dan. 2010. Current Pest and Pest Management Issues for Greenhouse Growers. Long Island Agriculture Forum, Greenhouse Session/, January 14, 2010. 15 attendees.

Gilrein, Dan. 2010. News and Notes From the CCE Entomology Lab. Long Island Floriculture Conference, January 19, 2010. 75 attendees.

Kumar, Vivek, Dakshina R. Seal, David J. Schuster, Lance Osborne, Cindy L. McKenzie and Garima Kakkar. 2010. Optimizing abiotic conditions for higher efficacy of fungal pathogens against chilli thrips, *Scirtothrips dorsalis* Hood. Annual meeting of Caribbean Food Crops Society. July 11- 17, 2010, Dominican Republic.

Kumar, Vivek, Dakshina R. Seal, David J. Schuster, Lance Osborne, Cindy McKenzie and Garima Kakkar. 2010. "Influence of abiotic factors on activity of three fungal pathogens regulating chilli thrips, *Scirtothrips dorsalis* (Thysanoptera: Thripidae) on pepper". Annual FL Entomol Society Meeting, Jupiter, FL, July 26, 2010.

Kumar, Vivek, Dakshina R. Seal, David J. Schuster, Cindy L. McKenzie and Garima Kakkar. 2010. Standardizing cultural practices for enhanced activity of three entomopathogens in regulating chilli thrips, *Scirtothrips dorsalis* Hood on pepper. Florida Ag-Expo 2010, GCREC-UF. Wimauma, Florida.

Kumar, Vivek, Dakshina R. Seal, David J. Schuster, Lance Osborne, Cindy L. McKenzie and Garima Kakkar. 2010. *In vitro* effect of selected fungicides on three species of entomopathogenic fungi. Annual meeting of Entomological Society of America, December 12-15. San Diego, California, USA.

Ludwig, S. W. 2010. ID/Control, Landscape/Nursery Insect Pests and Reducing Economic Impact on You. North Texas Mid-Winter Green Industry Symposium. Dallas, TX. Jan 26, 2010.

Ludwig, S. W. 2010. Managing Troublesome Pests. Southeast Texas Nursery Growers Association Trade Show. Conroe, TX. Jan 30, 2010.

- Ludwig, Scott and Lance Osborne. 2010. *Invited* "Thrips management". Society of American Florists, 26th Annual Pest and Production Management Conference (P&PMC). Orlando, FL. Feb 26, 2010.
- Ludwig, S., P. Nester, A. Camerino, and C. Brouwer. 2010. Evaluation of *Scirtothrips dorsalis* Management Techniques. Southwestern Branch Meeting of the Entomological Society of America. Cancun, Mexico. Apr 13, 2010.
- Ludwig, S. W. 2010. Integrating Pest Management in the Rose Garden: Including Chilli Thrips. American Rose Society Rose Show and Convention. Shreveport, LA. May 1, 2010.
- Ludwig, S. W. 2010. Update on New Pests and Their Management. Texas Nursery and Landscape Association Pre-Expo. San Antonio, TX. Aug 19, 2010.
- Ludwig, S. W. 2010. University Extension Research and IPM. Biopesticide Industry Alliance. Sacramento, CA. Sep 30, 2010.
- McKenzie, Cindy and Cristi Palmer. 2010. *Invited* "Whitefly Management". Society of American Florists, 26th Annual Pest and Production Management Conference (P&PMC). Orlando, FL. Feb 27, 2010.
- McKenzie, Cindy, Cristi Palmer, Lance Osborne, Scott Ludwig, and Ron Oetting 2010. *Invited* "Chemical Class Rotations for Control of *Bemisia tabaci* on Poinsettia". Symposium on Innovative Arthropod Management Solutions, Florida Entomological Society, Jupiter, FL July 27, 2010.
- McKenzie, Cindy, Greg Hodges, Lance S. Osborne, Frank J Byrne, and Robert G. Shatters, Jr. 2010. *Invited* "Investigating the Q invasion of *Bemisia tabaci* in Florida: Current Status and Update" at the 2010 Florida Tomato Institute, hosted by the University of Florida, IFAS Extension, Naples, FL Sept 8, 2010.
- Oetting, Ron. 2010. *Bemisia*, B vs. Q. South East Entomologist Workshop at the Mid Florida Research and Education Center in Apopka, Florida on May 13-14, 2010.
- Osborne, L.S. 2010. "Newest Pest Control Compounds and Integration Methods". This included biological control and banker plants. In Service Training for Extension Agents. Broadcast Statewide from Gainesville, FL Feb 4, 2010.
- Osborne, L.S. 2010. Tour and Talks about Whitefly and Thrips Research including Banker Plants. University of Florida, Department of Entomology and Nematology, Biological Control Course. Apopka, FL Feb 13, 2010.
- Osborne, L.S. 2010. "Biological Control and Banker Plants". University of Florida, Department of Horticulture, Advanced Hydroponics Course. Citra, FL. Feb 18, 2010.

- Osborne, L.S. 2010. Tour and Talks about Whitefly and Thrips Research including Banker Plants. The 26th Annual Pest & Production Management Conference (P&PMC). Apopka, FL. Feb 25, 2010.
- Osborne, L.S. 2010. Banker Plants (4 sessions). The 26th Annual Pest & Production Management Conference (P&PMC). Orlando, FL. Feb 26 2010.
- Osborne, L.S. 2010. Mite Biological Control and Banker Plants (16 sessions). The 26th Annual Pest & Production Management Conference (P&PMC). Orlando, FL. Feb 26 2010.
- Osborne, L.S. 2010. "Banker Plants". Annual Pest Management Update. Broad Cast Statewide via Polycom. Apopka, FL. Mar 9 2010.
- Osborne, L.S. 2010. "Dealing with thrips, whiteflies and mites". Fern CEU Day, Pierson, FL. Jun 8 2010.
- Osborne, L.S. 2010. "Biological Control Issues in the Florida Ornamental Industry". Annual meeting of the Florida Biological Control working group. Apopka, FL. Jun 21 2010.
- Osborne, L.S., Cindy McKenzie and Lin Schmale. 2010. *Invited* "Responding to Invasive Species that Threaten American Agriculture (Whitefly as a Model)". The Ohio Florists Short Course. Columbus, OH. July 10, 2010.
- Osborne, Lance S., Cindy McKenzie, Pasco Avery, and Yingfang Xiao. 2010. *Invited* "IPM in Florida Greenhouses". Flowers Canada Research Conference, Niagra Falls, Ontario, CA. August 26-27, 2010.
- Osborne, Lance S., Cindy McKenzie, Cristi Palmer, Scott Ludwig, Ron Oetting, *Pasco Avery*, and *Yingfang Xiao*. 2010. *Invited* "Dealing with Invasives". Flowers Canada Research Conference, Niagra Falls, Ontario, CA. August 26-27, 2010.
- Osborne, L.S. 2010. *Invited* "More than you wanted to know about Chilli Thrips". Central Florida Heritage Rose Society. Florida Southern College, Lakeland, FL. September 12, 2010.
- Osborne, Lance S., Scott Ludwig, Cindy McKenzie, and Cristi Palmer. 2010. *Invited* "What's Not So Hot about Chilli Thrips". Canadian Greenhouse Conference '10. Toronto, Ontario, CA. October 6, 2010
- Osborne, Lance S., Cindy McKenzie, Joe Chamberlin, Lin Schmale, Scott Ludwig, Amanda Hodges, and Robert G. Shatters. 2010. "Managing the Invasive Species Risk in the Ornamental Industry". Potential Invasive Species Workshop. Miami, Florida. October 11, 2010.

Publications

- Avery, Pasco B., Vitalis W. Wekesa, Wayne B. Hunter, David G. Hall, Cindy L. McKenzie, Lance S. Osborne, Charles A. Powell, and Michael E. Rogers. 2011. Effects of the fungus *Isaria fumosorosea* (Hypocreales: Cordycipitaceae) on reduced feeding and mortality of the Asian citrus psyllid, *Diaphorina citri* (Hemiptera: Psyllidae). *BioControl Science and Technology* 21(9):1065-1078. doi:10.1080/09583157.2011.596927.
- Avery, Pasco B., Catharine M. Mannion, Charles A. Powell, Cindy L. McKenzie, and Lance Osborne. 2011. Natural enemies managing the invasion of the Fig whitefly, *Singhiella simplex* (Hemiptera: Aleyrodidae), infesting a *Ficus benjamina* hedge. *FL Entomol* 94(3): 696-698. doi: 10.1653/024.094.0338
- Dogramaci, Mahmut, Jianjun Chen, Steven P. Arthurs, Cindy L. McKenzie, Irizarry Fabieli, Katherine Houben, Mary Brennan, and Lance Osborne. 2011. Mini-aspirator: A new device for collection and transfer of small arthropods to plants. *FL Entomol* 94(1): 22-27.
- Dogramaci, Mahmut, Steven P. Arthurs, Jianjun Chen, Cindy McKenzie, Fabieli Irrizarry, and Lance Osborne. 2011. Management of chilli thrips *Scirtothrips dorsalis* (Thysanoptera: Thripidae) on peppers by *Amblyseius swirskii* (Acari: Phytoseiidae) and *Orius insidiosus* (Hemiptera: Anthocoridae). *Biological Control* 59: 340-347. doi:10.1016/j.biocontrol.2011.09.008
- Kumar, Vivek, Dakshina R. Seal, David J. Schuster, Cindy McKenzie, Lance S. Osborne, James Maruniak, and Shouan Zhang. 2011. *Scirtothrips dorsalis* (Thysanoptera: Thripidae): Scanning electron micrographs of key taxonomic traits and a preliminary morphometric analysis of the general morphology of populations of different continents. *FL Entomol* 94(4):941-955. <http://www.bioone.org/doi/full/10.1653/024.094.0431>
- McKenzie, Cindy and Robert G. Shatters, Jr. 2011. North American mitochondrial whitefly (*Bemisia tabaci*) biotyping dataset (excluding Florida): 280 mtCO1 sequences. GenBank Acc.Nos. HQ198596-HQ198617, HQ198623-HQ198640, HQ198642-HQ198645, HQ198647-HQ198650, HQ198656-HQ198677, HQ198679-HQ198687, HQ198689, HQ198690, HQ198692- HQ198703, HQ198707- HQ198730, HQ198732- HQ198743, HQ198745- HQ198750, HQ198752, HQ198755, HQ198758, HQ198765, HQ198767, HQ198772- HQ198806, HQ877499-HQ877510, HQ877512-HQ877520, HQ877522- HQ877546, HQ877548-HQ877568, HQ877570, HQ877572, HQ877573, HQ877575, HQ877578, HQ877588-HQ877590, HQ877592-HQ877602, JF754907-JF754912, JF754914-JF754925, JN547217 National Center for Biotechnology Information (NCBI). <http://www.ncbi.nlm.nih.gov/> (Public Database).
- Huang, Ningxing, Annie Enkegaard, Lance S. Osborne, Pierre M. J. Ramakers, Gerben Messelink, Juliette Pijnakker, and Graeme Murphy. 2011. The banker plant method in biological control. *Critical Reviews in Plant Sciences* 30:259-278.

Osborne, Lance, Joe Chamberlin, Cindy McKenzie and Scott Ludwig. 2011. Moving plants means moving pests. Society of American Florists, Proceedings of the 27th Annual Pest and Production Management Conference. XXVII: 6-13. (Proceedings).

Wekesa, Vitalis W., Pasco B. Avery, Cindy L. McKenzie, Charles A. Powell, and Lance S. Osborne. 2011. Control of *Liriomyza trifolii* (Diptera: Agromyzidae) in cut flowers using *Isaria fumosorosea* (Hypocreales: Cordycipitaceae) alone and in combination with insecticides. J Entomol Science 46(1): 80-84.

Wang, H-H, Z. Lei, X. Li, and R.D. Oetting. 2011. Rapid cold hardening and expression of heat shock protein genes in the B-biotype *Bemisia tabaci*. Environ. Entomol 40(1):132-139.

Xiao, Yingfang, Jianjun Chen, Daniel Cantliffe, Cindy McKenzie, Katherine Houben, and Lance Osborne. 2011. Establishment of papaya banker plant system for parasitoid, *Encarsia sophia* (Hymenoptera: Aphelinidae) against *Bemisia tabaci* (Hemiptera: Aleyrodidae) in greenhouse tomato production. Biological Control 58: 239-247.
Doi:10.1016/j.biocontrol.2011.06.004.

Xiao, Yingfang, Lance S. Osborne, Jianjun Chen, Cindy McKenzie, Katherine Houben, and Fabieli Irizarry. 2011. Evaluation of corn plant as potential banker plant for supporting predatory gall midge, *Feltiella acarisuga* (Diptera: Cecidomyiidae) against *Tetranychus urticae* (Acari: Tetranychidae) in greenhouse vegetable production. Crop Protection 30: 1635-1642.
doi:10.1016/j.cropro.2011.09.004

Presentations

Kumar V., D. R. Seal, D. J. Schuster, L. Osborne, C. L. McKenzie and G. Kakkar. 2011. A New report on abundance of chilli thrips, *Scirtothrips dorsalis* (Thysanoptera: Thripidae) on fruit hosts in south Florida. Annual Meeting of Southeastern Branch of the Entomological Society of America, March 19-22, 2011. San Juan, Puerto Rico.

Kumar V., D. R. Seal, C. L. McKenzie, D. J. Schuster, L. Osborne, C. Powell and G. Kakkar. 2011. Preventive and curative control of chilli thrips *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae) using various regimes of biological and chemical insecticides. 94th Annual meeting of Florida Entomological Society, July 24-27, 2011. Sanibel, Florida. USA.

Kumar V., D. R. Seal, D. J. Schuster, L. Osborne, and C. L. McKenzie. 2011. Coupling scanning electron microscopy with DNA bar coding for morphological and molecular identification of thrips. Annual meeting of Entomological Society of America, November 13-16. Reno, Nevada, USA.

McKenzie, Cindy. 2011. “*Bemisia tabaci* Biotypes: History, Importance, and Current Status in Florida”, Whitefly Workshop for Landscape Professionals, Town of Palm Beach Council Chambers, Palm Beach, FL July 18, 2011.

- McKenzie, Cindy. 2011 *Invited*. “Whiteflies in Tomatoes: A Florida Perspective”, Symposium-Industry: Advances in Vegetable Entomology Research in Florida: A Tribute to the Research Programs of Dr. Dave Schuster, Florida Entomological Society, Sanibel, FL July 25, 2011.
- McKenzie, Cindy. 2011 *Invited*. “Research Needs for Invasive Species in Florida, (*Bemisia tabaci*, Q Biotype)”, Symposium: Invasive Species: Are We Communicating?” Florida Entomological Society, Sanibel, FL July 25, 2011.
- McKenzie, Cindy Vivek Kumar, Dak Seal, & Lance Osborne. 2011. *Invited* “A Novel Technique for Direct Correlation of Traditional Morphological Taxonomy with Molecular DNA Barcoding for Identification of Chilli Thrips Using Scanning Electron Microscopy”, Symposium: Chilli Thrips: Current Status and Future Challenges, Florida Entomological Society, Sanibel, FL July 25, 2011.
- Osborne, L.S. 2011. Banker Plants – systems that work for specific pests. Update on Banker Plants for Nursery Production – a PolyCom “Broadcast” program on the use of banker plants and biological controls in nurseries to Extension Offices around the State. January 12, 2011.
- Osborne, L.S. and K.S. Houben. 2011. How to grow your own predators/banker plants. Update on Banker Plants for Nursery Production – a PolyCom “Broadcast” program on the use of banker plants and biological controls in nurseries to Extension Offices around the State. January 12, 2011.
- Osborne, L.S. 2011. Banker Plants Explained. Society of American Florists, Proceedings of the 26th Annual Pest and Production Management Conference (P&PMC) XXVI: 50-53. February 24, 2011.
- Osborne, L.S. 2011. Banker Plants, mite and whitefly control. CEU Day, Volusia Cut Foliage Grower Association. Pierson, Florida. April 6, 2011.
- Osborne, L.S. Beneficial Arthropod Rearing: Banker plants and open rearing systems. A PolyCom “Broadcast” program to 10 County Extension offices. June 7, 2011.
- Osborne, L.S. Onsite training of extension agents and master gardener trainers on producing natural enemies using banker plants and open rearing systems. Palm Beach County Extension Office. June 20, 2011.
- Osborne, L.S. 2011. Predatory Mite Quality Control and the Use of Banker Plants to Assess Quality. Biological Control Working Group. Apopka, Florida. June 21, 2011.
- Osborne, L.S. 2011. Mite Management. Apopka, Florida. June 23, 2011.
- Osborne, L.S. 2011. Mite Management. Homestead, Florida. July 19, 2011. St. Petersburg, FL.

- Osborne, L.S., C.L. McKenzie, Y. Xiao, P. B. Avery, and J. Chen. 2011. Ornamental Pepper: A Potential Banker Plant for Establishment of *Amblyseius swirskii* (Acari: Phytoseiidae) to Manage Chilli Thrips. Florida Entomological Society Annual Mtg, Jupiter, FL, July 25.
- Osborne, L.S. 2011. Mite Management. Balm, Florida. Aug. 18, 2011.
- Osborne, L.S. 2011. Insect Management in Commercial Florida Greenhouses. U.S. Nursery Certification Program. Apopka, Florida. August 12, 2011.
- Osborne, L.S. 2011. What's New in IPM. Keynote Address. Florida Master Gardener Continued Training Conference. Orlando, Florida. October 24, 2011.
- Osborne, L.S. 2011. Using banker plants in Florida greenhouses. Entomological Society of America Annual Meeting. Reno, NV. November 13-16, 2011.
- Osborne, L.S., C.L. Palmer, S.W. Ludwig. 2011. Development of the thrips management program for ornamental horticulture. Entomological Society of America Annual Meeting. Reno, NV. November 13-16, 2011.
- Popenoe, Juanita. 2011. What we have learned in nursery trials. Update on Banker Plants for Nursery Production – a PolyCom “Broadcast” program on the use of banker plants and biological controls in nurseries to Extension Offices around the State. January 12, 2011.
- Popenoe, J., W. Schall, L. Osborne. (poster). 2011. Countertop Production of Predatory Mites for Public Distribution. Florida Central District Extension Faculty Symposium. Kissimmee, FL. April 28, 2011.
- Popenoe, J., (presenter), W. Schall, L. Osborne. 2011. Countertop Production of Predatory Mites for Public Distribution. Florida State Horticulture Society annual meeting. June 5-7, 2011. St. Petersburg, FL.
- Popenoe, J. & L.S. Osborne. 2011. Banker plants for nursery production. Rose IPM and Production. A PolyCom “Broadcast” Statewide. July 22, 2011.
- Schall, W., J. Popenoe, L. Osborne, S. Brown, B. Burn, L. Singleton, J. Davis, D. Culbert, T. DelValle; E. Harlow, D. Levulis, C. Saft, 2011. Beneficial Arthropod Rearing by Master Gardener Programs for Public Distribution. Extension Professional Associations of Florida 2011 Professional Improvement Meeting Lake Buena Vista, Florida. Aug. 31, 2011.
- Xiao, Y., L.S. Osborne (Presenter), J. Chen, C. McKenzie, P.B. Avery, K.S. Houben, and F. Irizarry. 2011. Ornamental pepper: a potential banker plants for augmentation of predatory mites, *Amblyseius swirskii* (Acari: Phytoseiidae). Entomological Society of America Annual Meeting. Reno, NV. November 13-16.
- Xiao, Y., L.S. Osborne (Presenter), J. Chen, C. McKenzie, K.S. Houben, and F. Irizarry. 2011. A potential banker plant for management of *Tetranychus urticae* (Acari: Tetranychidae) by

augmenting *Feltiella acarisuga* (Diptera: Cecidomyiidae) in greenhouse vegetables. Entomological Society of America Annual Meeting. Reno, NV. November 13-16.

2012

Publications

Dickey, Aaron, Lance S. Osborne, and Cindy L. McKenzie. 2012. Papaya is not a host for Tomato Yellow Leaf Curl Virus. *Florida Entomol* 95:211-213.
<http://dx.doi.org/10.1653/024.095.0136>

Dickey, Aaron, Robert G. Shatters, Jr., and Cindy L. McKenzie. 2012. A comparison of two methods of eluting insect DNA from Flinders Technology Associate Cards. *Florida Entomol* 95 (3): 790-793.

Doğramacı, Mahmut, Steven P. Arthurs, Jianjun Chen & Lance Osborne. 2013. Silicon Applications have Minimal Effects on *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae) Populations on Pepper Plant, *Capsicum annum* L. *Florida Entomologist* 96(1) 48-54.

Kumar, Vivek, Dakshina R. Seal, Garima Kakkar, Cindy L. McKenzie, and Lance S. Osborne. 2012. New tropical fruit hosts of *Scirtothrips dorsalis* (Thysanoptera: Thripidae) and its relative abundance on them in South Florida. *Florida Entomol.* 95:205-207.
<http://dx.doi.org/10.1653/024.095.0134>

Kumar, V., D. R. Seal, G. Kakkar, C. L. McKenzie, and L. S. Osborne. 2012. Chilli thrips, *Scirtothrips dorsalis*: A potential threat to cotton production in the USA. *Proceedings Beltwide Cotton Conferences, 65th Cotton Insects Research Control Conf.* 2:817-819.

McKenzie, Cindy L., James A. Bethke, Frank J. Byrne, Joseph R. Chamberlin, Timothy J. Dennehy, Aaron M. Dickey, Dan Gilrein, Paula M. Hall, Scott Ludwig, Ronald D. Oetting, Lance S. Osborne, Lin Schmale, Robert G. Shatters, Jr. 2012. Distribution of *Bemisia tabaci* (Hemiptera: Aleyrodidae) Biotypes in North America following the Q Invasion. *J Econ Entomol* 105(3): 753-766. DOI: <http://dx.doi.org/10.1603/EC11337>

Osborne, Lance, Joe Chamberlin and Cindy McKenzie. 2012. Moving plants means moving pests (updated version). *Society of American Florists, Proceedings of the 27th Annual Pest and Production Management Conference.* XXVIII: 26-33. (Proceedings).

Osborne, Lance, Yingfang Xiao, J. Chen, and Cindy McKenzie. 2012. Using Banker Plants to control insects. *Society of American Florists, Proceedings of the 28th Annual Pest and Production Management Conference.* XXVIII: 85-90. (Proceedings).

Xiao, Yingfang, Pasco Avery, Jianjun Chen, Cindy McKenzie and Lance Osborne. 2012. Ornamental pepper as banker plants for establishment of *Amblyseius swirskii* (Acari: Phytoseiidae) for biological control of multiple pests in greenhouse vegetable production. *Biological Control* 63: 279-286. <http://dx.doi.org/10.1016/j.biocontrol.2012.09.007>

Presentations

- Avery, P. B., Guerrero, S., Hodges, A. C., Powell, C. A. and L. S. Osborne. 2012. Efficacy and infectivity of *Isaria fumosorosea* for controlling Madeira mealybug, *Phenacoccus madeirensis* on plants for shipping. 60th Annual Meeting of the Entomological Society of America, Knoxville TN November 11-14, 2012.
- Avery P., Skvarch, E., Goodiel, Y., McKenzie, C. L. and L. Osborne. Efforts to develop an IPM program for rugose spiraling whitefly in the Jensen Beach area. Rugose Spiraling Whitefly meeting, Island Club of Hutchinson Island. Jensen Beach, FL, July 18, 2012.
- Buss, E., S. Arthurs, and L.S. Osborne. 2012. Aphids, hoppers, psyllids, and bugs – Identification of key pests and damage; hands-on activity. In-Service Training on “Horrible Hemiptera Identifying and Managing Important Hemiptera Pests of Turf and Ornamentals”. May 2, 2012. Apopka, Florida.
- Dickey, A. M., Osborne, L. S., Shatters Jr., R. G., McKenzie, C. L. 2012. Isothermal amplification of insect DNA. International IPM Symposium, Memphis TN March 27-29, 2012.
- Dickey, A. M., Osborne, L. S., Shatters Jr., R. G., McKenzie, C. L. 2012. LAMP: a technique for biotype discrimination in *Bemisia tabaci*. Annual Meeting Florida Entomological Society, Jupiter FL 22-25 July, 2012.
- Dickey, A. M., Osborne, L. S., Hall, P. M., Shatters Jr., R. G., McKenzie, C. L. 2012. Evolution and homoplasy at the bem6 microsatellite locus in three *Bemisia tabaci* cryptic species. Annual Meeting Entomological Society of America, Knoxville TN November 11-14, 2012.
- Dickey, A. M., Osborne, L. S., Kumar, V., Shatters Jr., R. G., McKenzie, C. L. Haplotype analysis of global chili thrips (*Scirtothrips dorsalis*) populations using the metazoan barcode. 2012. Annual Meeting Entomological Society of America, Knoxville TN 11-14 November, 2012.
- Goodiel, Y., Avery, P., Hodges, A., Kumar, V., Mannion, C., McKenzie, C., Osborne, L., E. Skvarch. A collaborative effort to address whitefly issues in Florida. EPAF’s Educational Table Top Exhibits, Okeechobee, FL, August 27-29, 2012.
- Guerrero, Sarahlynn, A. Hodges, L. Osborne, and P. Avery. 2012. Efficacy of *Isaria fumosorosea* (= *Paecilomyces fumosorosea*) and horticultural oil on cuttings infested with the Madeira mealybug, *Phenacoccus madeirensis* Green. 96th Annual Meeting of the Florida Entomological Society 2012, Jupiter, FL, July 22-24, 2012.
- Kumar V., Kakkar, G., Seal D. R., McKenzie C. L., and Osborne L. 2012. Chilli thrips, *Scirtothrips dorsalis*: A potential threat to cotton production in the USA. Beltwide cotton conference, January 4-7. Orlando, Florida, USA.
- Kumar, V., Avery P., Skavarch, E., Goodiel, Y., McKenzie, C. L. and L. Osborne. Efforts to develop an IPM program for rugose spiraling whitefly in the Jensen Beach area. Rugose Spiraling Whitefly Meeting, Island Club of Hutchinson Island. Jensen Beach, FL, July 18, 2012.

- Kumar V., Kakkar, G., Seal D. R., McKenzie C. L., and Osborne L. 2012. Assessing abundance and damage potential of an invasive thrips species *Scirtothrips dorsalis* (Thysanoptera: Thripidae) in south Florida. Annual Meeting of South-eastern Branch of the Entomological Society of America, March 4-7, 2012, Little Rock, Arkansas, USA.
- McKenzie, C. L., Bethke, J. A., Byrne, F. J., Chamberlin, J. R., Dennehy, T. J., Dickey, A., Gilrein, D., Hall, P. M., Ludwig, S., Oetting, R. D. et al: 2012. Distribution of *Bemisia tabaci* (Hemiptera: Aleyrodidae) biotypes in North America following the Q invasion. Southeastern Branch/Southwestern Branch of the Entomological Society of America, Little Rock, AK, March 4-7, 2012.
- McKenzie, C. L., Bethke, J. A., Byrne, F. J., Chamberlin, J. R., Dennehy, T. J., Dickey, A., Gilrein, D., Hall, P. M., Ludwig, S., Oetting, R. D. et al: 2012. Distribution of *Bemisia tabaci* (Hemiptera: Aleyrodidae) biotypes in North America following the Q invasion. Annual Meeting Florida Entomological Society, Jupiter FL July 22-25, 2012.
- Kumar, V., Avery P., Skavarch, E., Goodiel, Y., McKenzie, C. L. and L. Osborne. Efforts to develop an IPM program for rugose spiraling whitefly in the Jensen Beach area. Rugose Spiraling Whitefly Meeting, Island Club of Hutchinson Island. Jensen Beach, FL, July 18, 2012.
- Osborne, L.S. 2012. Whitefly meetings with local extension agents, press, public officials and pest control companies: continuous effort with at least 2 per month throughout most of the year.**
- Osborne, L.S. 2012. Foliage Plant Entomology Program at MREC, University of Florida. Society of American Florists 2012 Pest and Production Management Conference. Tour- talks given multiple times. Apopka Florida. February 16.
- Osborne, L.S., Yingfang Xiao, J. Chen, and Cindy McKenzie. 2012. Using Banker Plants to Control Insects. Society of American Florists 2012 Pest and Production Management Conference. Orlando, Florida. February 16-18.
- Osborne, L.S. 2012. New Faculty Tour of MREC Multiple talks and tours. April 11, 2012.
- Osborne, L.S. 2012. MREC Open House. Multiple talks and tours. April 19, 2012.
- Osborne, L.S. 2012. National Webinar on Developments in Biological Insecticides. April 19, 2012.
- Osborne, L.S. and C. Mannion. 2012. Whiteflies – Identification of key pests and damage; hands-on activity. In-Service Training on “Horrible Hemiptera Identifying and Managing Important Hemiptera Pests of Turf and Ornamentals”. May 2, 2012. Apopka, Florida.
- Osborne, L.S. E. Buss, and C. Mannion. 2012. Scales/Mealybugs – Identification of key pests and damage; hands-on activity. In-Service Training on “Horrible Hemiptera Identifying and Managing Important Hemiptera Pests of Turf and Ornamentals”. May 2, 2012. Apopka, Florida.

- Osborne, L.S. and C. Mannion. 2012. Whiteflies – Managing Hemiptera in production (nursery, greenhouse). In-Service Training on “Horrible Hemiptera Identifying and Managing Important Hemiptera Pests of Turf and Ornamentals”. May 2, 2012. Apopka, Florida.
- Osborne, L.S. Biological and Chemical Insect Control in Greenhouses. Florida Small Farms and Alternative Enterprises Conference. Kissimmee, Florida. July 28, 2012.
- Osborne, L.S. & Hugh Smith. 2012. GOOD BUG, BAD BUG ID. Florida Small Farms and Alternative Enterprises Conference. Kissimmee, Florida. July 29, 2012.
- Osborne, L.S. 2012. Mite Management. Homestead, Florida. July 31, 2012.
- Osborne, L.S. 2012. Whitefly and Mite Resistance Management. Balm, Florida. August 1, 2012.
- Osborne, L.S. 2012. Whitefly and Mite Resistance Management. Apopka, Florida. August 2, 2012.
- Osborne, L.S. 2012. Central Florida Green Team Meeting. Invasive Species Update. MREC. October 5, 2012.
- Osborne, L.S. 2012. Invasive Whitefly Update for the Brevard County Extension and Clientele. Brevard County Library. October 10, 2012.
- Osborne, L.S. 2012. New Invasives. Fern Growers CEU Day. Volusia County. October 24, 2012.
- Osborne, L.S. 2012. Whitefly Summit for Vegetable Transplant Producers. Sun City, Florida. November 6, 2012.
- Osborne, L.S. 2012. Are resistant pests more of a threat than new invasive species in ornamentals? Entomological Society of America Annual Meeting. Knoxville, Tennessee. November 11-14.
- Osborne, L.S., and C. L. McKenzie. 2012. Whitefly Update. Palm Beach County. December 19, 2010.

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Publications

- Aristizabal, L.F., Avery, P.B., Kumar, V., Caldwell, J.H., McKenzie, C.L., Osborne, L.S. 2013. Pre shipping dip treatments using soap, natural oils, and *Isaria fumosorosea*: potential biopesticides for mitigating the spread of whitefly *Bemisia tabaci* (Hemiptera: Aleyrodidae) invasive insects on ornamental plants [abstract]. Florida Entomological Society. Paper No. 54.
- Avery, P.B., McKenzie, C.L., Powel, C.A., Osborne, L.S. 2013. Efficacy of *Isaria fumosorosea* Wize (Hypocreales: Cordycipitaceae) on the leaf phylloplane over time for controlling

Madeira mealybug nymphs preshipping. *Florida Scientist* 76:9-10. (Proceedings).

Avery, P. B., Kumar, V., Xiao, Y., Powell, C. A., McKenzie, C. L. and L. S. Osborne. Preference of *Amblyseius swirskii* on ornamental pepper banker plant candidates for potential control of insect pests in floriculture. *Arthropod-Plant Interactions* (In internal review). or - Plant characteristics influencing host selection by *Amblyseius swirskii* on ornamental pepper banker plant candidates for potential biocontrol of insect pests in floriculture.

Chamberlin, Joe, Cindy McKenzie, Lance Osborne, Lin Schmale. 2013. A call to action – Or others will force their will upon us! Society of American Florists, Proceedings of the 29th Annual Pest and Production Management Conference. XXIX: 71-81. (Proceedings).

Dickey, Aaron, Lance S. Osborne, Robert G. Shatters. Jr., Paula Hall, and Cindy L. McKenzie. 2013. Population genetics of invasive *Bemisia tabaci* cryptic species in the United States based on microsatellite markers. *J Econ Entomol.* 106(3):1355-1364.

Dickey, Aaron, Paula M. Hall, Robert G. Shatters. Jr., and Cindy L. McKenzie. 2013. Evolution and homoplasy at the Bem6 microsatellite locus in three *Bemisia tabaci* cryptic species. *BMC Research Notes* 6:249. DOI: [10.1186/1756-0500-6-249](https://doi.org/10.1186/1756-0500-6-249)

Dickey, Aaron M., Lance S. Osborne, Robert G. Shatters, Jr. and Cindy L. McKenzie. 2013. Identification of the MEAM1 cryptic species of *Bemisia tabaci* (Hemiptera: Aleyrodidae) by loop-mediated isothermal amplification. *Florida Entomol* 96(3): 756-764.

Dickey, A.M., Trease, A., Jara, A., Kumar, V., Christenson, M.K., Portluri, P., Morgan, J.K., Shatters, R.G., Jr., Davis, P.H., McKenzie, C.L., Osborne, L.S. 2013. Next-generation DNA sequencing of the globally invasive plant pest, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae) [abstract]. Florida Entomological Society. Paper No. 41.

Kumar, V., G. Kakkar, C. L. McKenzie, D. R. Seal and L. Osborne. 2013. An overview of chilli thrips, *Scirtothrips dorsalis* (Thysanoptera: Thripidae) Biology, Distribution and Management. Pp. 53-77. In: S. Solenski and M. Larramendy (eds.), *Weed and Pest Control – Conventional and New Challenges*. Intech. Rijeka, Croatia. 205 pp. (Book Chapter).

Kumar, V., Kakkar, G., Seal, D.R., McKenzie, C.L., Osborne, L.S. 2013. Vertical and horizontal distribution and seasonal dynamics of an invasive thrips species, *Scirtothrips dorsalis* (Thysanoptera: Thripidae) in south Florida. *Florida Scientist* 76:7-8. (Proceedings).

Kumar, V., Wekesa, V., Avery, P.B. Powell, C.A., McKenzie, C.L., Osborne, L.S. 2013. Effect of different ornamental pepper pollens on the development and reproduction of *Amblyseius swirski* (Acari: Phytoseiidae) [abstract]. Southeastern Branch of Entomological Society of America. Paper No. DSP50.

Kumar, Vivek, Garima Kakkar, Dakshina R. Seal, Cindy L. McKenzie, James Colee, and Lance Osborne. 2013. Temporal and spatial distribution of an invasive thrips species *Scirtothrips dorsalis* (Thysanoptera: Thripidae). *Crop Protection*. Accepted with revision.

- Kumar, Vivek, Avery, P. B., Cave, R. D., Francis, A. Smith, T., McKenzie, C.L., and Osborne, L., 2013. Efficacy of an entomopathogenic fungus, *Isaria fumosorosea*, and an insect growth regulator against the rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae). [abstract]. Entomological Society of America. Paper No. D0393.
- McKenzie, C.L., Dickey, A., Osborne, L.S., Kumar, V. Shatters, R.G, Jr. 2013. Haplotype analysis of global chilli thrips (*Scirtothrips dorsalis*) populations using the metazoan barcode [abstract]. Florida Entomological Society. Paper No. 40.
- McKenzie, C.L., Kumar, V., Palmer, C.L., Oetting, R.D., Osborne, L.S. 2013. Chemical class rotations for control of *Bemisia tabaci* (Hemiptera: Aleyrodidae) on poinsettia and their effect on cryptic species population composition [abstract]. Entomological Society of America. Paper No. D0554.
- McKenzie, Cindy L., Vivek Kumar, Cristi L. Palmer, Ronald D. Oetting, and Lance S. Osborne. 2013. Chemical class rotations for control of *Bemisia tabaci* (Hemiptera: Aleyrodidae) on poinsettia and their effect on cryptic species population composition. Pesticide Management Science (accepted 8/22/2013).
- Oetting, R., McKenzie C., and Townsend M. 2013. Efficacy of insecticide rotations and their impact on populations of the 'B' and 'Q' biotypes of *Bemisia tabaci*. First International Whitefly Symposium, Kolybari, Crete, Greece T8.P-02: 229 (Proceedings).
- Wilkerson, M., Hix, R.L., Dickey, A.M., McKenzie, C.L. 2013. Characterizing population and genetic structure of *Aleurodicus rugioperculatus* Martin (Hemiptera:Aleyrodidae) in Florida [abstract]. Southeastern Branch of Entomological Society of America. Paper No. 032.
- Xiao, Yingfang, Lance Osborne, Jianjun Chen, Cindy McKenzie. 2013. Functional responses and prey-stage preferences of a predatory gall midge and two predacious mites with twospotted spider mites, *Tetranychus urticae*, as host. J Insect Science 13: 3.
<http://www.insectscience.org/13.3>.
- Xiao, Y., Osborne, L., McKenzie, C.L., Chen, J. 2013. Influence of diet conditions on predation response of a predatory mite to a polyphagous insect pest. *Florida Scientist* 76:16-17. (Proceedings).
- Xiao, Y., Osborne, L.S., McKenzie, C.L., Kumar, V., Chen, J., Taravati, S. 2013. Giant whitefly (*Aleurodicus dugesii*) as a surrogate for evaluating the parasitoid wasp (*Encarsiella noysei*) for biological control of Rugose spiraling whitefly (*Aleurodicus rugioperculatus*) [abstract]. Florida Entomological Society. Paper No. 16.

Presentations

- Aristizabal, L.F., Avery, P.B., Kumar, V., Caldwell, J.H., McKenzie, C.L., Osborne, L.S. 2013. Pre shipping dip treatments using soap, natural oils, and *Isaria fumosorosea*: potential

biopesticides for mitigating the spread of whitefly *Bemisia tabaci* (Hemiptera: Aleyrodidae) invasive insects on ornamental plants [abstract]. Florida Entomological Society Annual Meeting, Naples, FL, July 15, 2013.

Avery, P.B., McKenzie, C.L., Powel, C.A., Osborne, L.S. 2013. Efficacy of *Isaria fumosorosea* Wize (Hypocreales: Cordycipitaceae) on the leaf phylloplane over time for controlling Madeira mealybug nymphs preshipping. 77th Annual Meeting of the Florida Academy of Sciences, Barry University, Miami Shores, FL, March 8, 2013.

Dickey, A.M., Trease, A., Jara, A., Kumar, V., Christenson, M.K., Portluri, P., Morgan, J.K., Shatters, R.G., Jr., Davis, P.H., McKenzie, C.L., Osborne, L.S. 2013. Next-generation DNA sequencing of the globally invasive plant pest, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae). Florida Entomological Society Annual Meeting, Naples, FL, July 16, 2013.

Dickey, A., Osborne, L.S., Shatters, R.G., Jr., Hall, P.M., McKenzie, C.L. 2013. Population genetics of invasive *Bemisia tabaci* cryptic species in the US based on microsatellite markers. Annual Meeting of the Entomological Society of America, Austin, TX, November 12, 2013.

Kumar, V., Wekesa, V., Avery, P.B. Powell, C.A., McKenzie, C.L., Osborne, L.S. 2013. Effect of different ornamental pepper pollens on the development and reproduction of *Amblyseius swirski* (Acari: Phytoseiidae). Southeastern Branch of Entomological Society of America Annual Meeting, Baton Rouge LA, March 5, 2013.

Kumar, V., Kakkar, G., Seal, D.R., McKenzie, C.L., Osborne, L.S. 2013. Vertical and horizontal distribution and seasonal dynamics of an invasive thrips species, *Scirtothrips dorsalis* (Thysanoptera: Thripidae) in south Florida. 77th Annual Meeting of the Florida Academy of Sciences, Barry University Miami Shores, FL, March 8, 2013.

McKenzie, C.L., Dickey, A., Osborne, L.S., Kumar, V. Shatters, R.G, Jr. 2013. Haplotype analysis of global chilli thrips (*Scirtothrips dorsalis*) populations using the metazoan barcode. Florida Entomological Society Annual Meeting, Naples, FL, July 16, 2013.

McKenzie, C.L., Kumar, V., Palmer, C.L., Oetting, R.D., Osborne, L.S. 2013. Chemical class rotations for control of *Bemisia tabaci* (Hemiptera: Aleyrodidae) on poinsettia and their effect on cryptic species population composition. Annual Meeting of the Entomological Society of America, Austin, TX, November 13, 2013.

Oetting, R., McKenzie C., and Townsend M. 2013. Efficacy of insecticide rotations and their impact on populations of the 'B' and 'Q' biotypes of *Bemisia tabaci*. First International whitefly symposium, Kolybari, Crete, Greece, May 23, 2013.

Wilkerson, M., Hix, R.L., Dickey, A.M., McKenzie, C.L. 2013. Characterizing population and genetic structure of *Aleurodicus rugioperculatus* Martin (Hemiptera:Aleyrodidae) in Florida. Southeastern Branch of Entomological Society of America Annual Meeting, Baton Rouge LA, March 4, 2013.

Xiao, Y., Osborne, L., McKenzie, C.L., Chen, J. 2013. Influence of diet conditions on predation response of a predatory mite to a polyphagous insect pest. 77th Annual Meeting of the Florida Academy of Sciences, Barry University Miami Shores, FL, March 8, 2013.

Xiao, Y., Osborne, L.S., McKenzie, C.L., Kumar, V., Chen, J., Taravati, S. 2013. Giant whitefly (*Aleurodicus dugesii*) as a surrogate for evaluating the parasitoid wasp (*Encarsiella noysei*) for biological control of Rugose spiraling whitefly (*Aleurodicus rugioperculatus*). Florida Entomological Society Annual Meeting, Naples, FL, July 15, 2013.