

**Evolving and Integration of Management Plans for Major Taxonomic Groups
and Potential New Invasive Pests of Ornamental and Floriculture Production
Sept 17 2013 to Sept 16 2018
Final Report / Osborne & McKenzie**

This final report serves to document research conducted under a Non-Assistance Cooperative Agreement (NACA) between ARS (Cindy McKenzie, ADODR) and Lance Osborne with the University of Florida (58-6618-3-029). Additional details of research can be found in earlier FNRI reports for this agreement and the reports for the parent CRIS 6034-22320-003-00D, Exotic Whitefly Pests of Vegetables and Ornamental Plants. This report covers the fifth and final year of this agreement. Over the life of this NACA, nine postdoctoral research associates were supported (*Luisa Cruz, Aaron Dickey, Ismail Doker, Paula Hall, Garima Kakkar, Vivek Kumar, Avery Pasco, Vitalis Wekesa, Yingfang Xiao*), and cooperators from the Universities of California, Georgia, and Florida, Texas A&M, Rutgers, and Cornell University have contributed to this project. During the life of this NACA, 936 whitefly samples representing 14,112 individual whitefly have been molecularly biotyped for growers and researchers free of charge so that management programs could be tailored to an individual nursery or greenhouse grower's whitefly population (MEAM1 vs MED or B vs Q). Publications (including refereed research papers, extension and popular press) resulting from this NACA including management plans for thrips (<https://edis.ifas.ufl.edu/pdffiles/IN/IN114500.pdf>) and whiteflies (<http://edis.ifas.ufl.edu/pdffiles/IN/IN117100.pdf>) as well as a presentation summary (2008 to 2013) can be found at the end of this report.

Neonicotinoid Stewardship Program

With the overall goal to improve existing management strategies for *Bemisia tabaci* (MED or biotype Q) whitefly and stewardship of neonicotinoid class of insecticide (dinotefuran - grower standard), six greenhouse chemical efficacy trials were conducted on salvia. In these trials, the compatibility of non-neonic insecticides used in rotation programs to control *B. tabaci* with the predatory mite, *Amblyseius swirskii* used in biological control programs was evaluated. Experiments testing flupyradifurone and afidopyropen as a drench application were compatible with the predatory mite, and were found to significantly reduce whitefly populations during the majority of the study period. Foliar application of spinetoram + sulfoxaflor, pyrifluquinazon and flupyradifurone was effective against whitefly, however among these only flupyradifurone was found benign on the mite population. Greenhouse studies are currently underway to evaluate low rate rotations of products found compatible with biological control agents.

To complement the previous study, additional studies were conducted where the compatibility of insecticides used to control *Bemisia tabaci* with the parasitic wasp, *Eretmocerus eremicus* used in biological control programs were evaluated on mint in the greenhouse. *Eretmocerus eremicus* is among the parasitoids which utilize their prey for both food and a site of reproduction resulting in suppression of the pest population on the plant. In this study, whitefly parasitization by wasps was insignificant, and thus parasitized immatures and emerged wasps were not observed. Results

showed that the drench application of flupyradifurone, and the parasitic wasps applied alone or in combination can suppress whitefly population ≥ 5 weeks.

Chilli Thrips National Survey

The chilli thrips, *Scirtothrips dorsalis*, is a cryptic species complex (group of morphologically indistinguishable species) of at least nine distinct species, two (South Asia 1 and East Asia 1) of which exist in the US. To determine their distribution range and find the dominant member of this thrips complex in the US, a nationwide survey program is underway for the past two years. In FY18, thrips samples were processed from three counties of Florida (Hillsborough, Orange, and Indian River), two counties in Texas (Fort Bend, and Waller), two counties in California (Los Angeles, and Riverside), and one county in Massachusetts (Barnstable) and New York (Suffolk). Out of the 28 thrips samples processed from different locations in the US, 19 samples were confirmed as *S. dorsalis*. The *S. dorsalis* samples collected from Florida, Texas, and California were South Asia 1 species suggesting this species is more prevalent (dominant species) in the United States compared to another counterpart of *S. dorsalis* complex reported for the first time from the north eastern US during 2012. East Asia 1 was only found on hydrangea samples collected from two eastern states (New York and Massachusetts) indicating movement of this species in the neighboring states on hydrangea plants. Identity of *S. dorsalis* samples collected from blueberry in Hillsborough County, FL still needs to be verified. Apart from *S. dorsalis*, eight different thrips species were also identified from the collected samples that includes *Frankliniella occidentalis* Pergande, *F. schultzei* Trybom, *F. bispinosa* Morgan, *F. cephalica* Crawford, *Echinothrips americanus* Morgan, *Neohydatothrips burungae* (Hood) *Pseudothrips inaequalis* (Beach) and *Thrips hawaiiensis* Morgan. Additional thrips samples from ornamental nurseries in Alabama, North Carolina, Louisiana and Connecticut are expected during 2018.

Chilli Thrips Host Plant Range

To determine the host range of the dominant member of chilli thrips, *Scirtothrips dorsalis* complex, South Asia 1, we conducted four greenhouse trials, where we evaluated 25 plant taxa (21 different species within 13 families and 11 plant orders) among ornamentals, landscape plant, herb and flowering shrubs as feeding and/or reproductive hosts of this pest. Among all the tested plant taxa, 16 were true hosts (reproductive + feeding) and one was just feeding hosts (thrips will feed on these but avoid laying eggs). We also found eight new true hosts of chilli thrips which were not earlier reported as the reproductive hosts of this pest in the literature.

Predatory Mites Barcoding

Traditional taxonomy for mite identification is becoming a lost art and expertise is extremely difficult to acquire. In collaboration with University of Florida, ARS researchers are developing molecular barcodes for commercially available predatory mites as well as those native to Florida. Traditional taxonomy is being used to identify mites morphologically and then this

information is being correlated with whole genome comparisons using nextgen sequencing of constructed cDNA libraries. This comparison is being done to identify the best diagnostic genome sequences for distinguishing species and evaluating within species sequence variation (i.e. cryptic species and intraspecies population variation). Libraries for 23 populations of predatory mites representing seven species: *Phytoseiulus persimilis* (5), *Neoseiulus californicus* (4), *N. cucumeris* (4), *N. fallacis* (2), *Amblyseius swirskii* (4), *A. andersoni* (3), *Amblydromalus limonicus* (1) have been constructed and Illumina sequencing is currently being finished and evaluated for this barcoding project. Benefits to stakeholders include new tools to identify/validate current and new predator populations and association of traceable genetic markers with effective predator populations being used in commercial settings. These results are being evaluated for their role in reducing predator failures, especially when growers are using multiple species and sources.

Rugose Spiraling Whitefly (RSW) Oviposition and Host Plant Preference

Rugose spiraling whitefly (RSW) is an exotic invasive species which had an outbreak in south Florida that became economically damaging to numerous plant species in many urban areas. Oviposition preference was determined for the following five known plant hosts: coconut, gumbo limbo, avocado, black olive v. shady lady and giant white bird of paradise (GWBP). Gumbo limbo was the most preferred and also had the highest number of eggs per spiral. GWBP was the least preferred host plant species but no statistically significant difference was found among the survival of RSW on different host plant species tested. Also, no significant correlation was found between the leaf area and number of eggs on each host species.

RSW Management and Compatibility with Predatory Beetle

Nephaspis oculata is a beetle predator, which has been reported feeding on several whitefly species including rugose spiraling whitefly (RSW) in south Florida. The management of RSW has been heavily reliant on the use of insecticides which may negatively impact biological control agents. We studied the effect of bifenthrin (spray) and imidacloprid (drench) application on survival, fecundity, and behavior of *Nephaspis oculata* in the laboratory. Generally, beetles avoided bifenthrin treatments and did not survive as long as they did on imidacloprid treatments. The results from this study shows that systemic imidacloprid is not repellent to *Nephaspis oculata* and does not significantly affect mortality of adult beetles in the tri-trophic system tested. Therefore, using systemic imidacloprid and *N. oculata* for controlling RSW might be compatible or at least not significantly incompatible. Future studies in the field may help us to have a better understanding about such interactions in the landscape.

Cumulative Publications and Presentations

Start Sept 17 2013 to Sept 16 2018

FNRI project funded nine postdocs (italics) over the life of the NACA and are indicated in italics in the references: *Luisa Cruz, Aaron Dickey, Ismail Doker, Paula Hall, Garima Kakkar, Vivek Kumar, Avery Pasco, Vitalis Wekesa, Yingfang Xiao*. Collectively this team has published 27 refereed publications, 40 other publications and made over 100 presentations.

Refereed Publications (27)

1. Xiao, Y., Osborne, L., Chen, J., McKenzie, C.L. Functional responses and prey-stage preferences of a predatory gall midge and two predacious mites with twospotted spider mites, *Tetranychus urticae*, as host. *Journal of Insect Science*. 13:8. 2013. Available: <http://www.insectscience.org/13.8>
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10. Kumar, Vivek, Seal, D. R., Osborne, L. and McKenzie, C. L. Coupling scanning electron

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 32. Oetting, R., McKenzie C., and Townsend M. Efficacy of insecticide rotations and their impact on populations of the 'B' and 'Q' biotypes of *Bemisia tabaci*. In: Proceedings of the First International Whitefly Symposium, Kolybari, Crete, Greece T8.P-02: 229. 2013. (Proceedings)
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 34. Kumar, V., Kakkar, G., McKenzie, C.L., Seal, D.R., and Osborne, L. 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). 2013.
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 63. Kumar, V., Palmer, C., McKenzie, C.L. and Osborne, L.S. Whitefly management program for ornamental plants, online extension publication. EDIS- online extension publication. Entomology and Nematology Department, Florida Department of Plant Industry, Institute of Food and Agricultural Sciences, University of Florida. EDIS# 989. Available <http://edis.ifas.ufl.edu/pdf/files/IN/IN117100.pdf> (Public database).
 64. Ahmed, Mahammad Z., Hernandez, Yisell V., Skelly, Paul, Rohrig, Eric, McKenzie, Cindy, Osborne, Lance S., Mannion, Catharine. Eucalyptus gall wasp, *Leptocybe invasa* Fisher & La Salle (Insecta: Hymenoptera: Eulophidae), an emerging pest of eucalyptus in Florida. Florida Department of Agriculture and Consumer Services, Division of Plant Industry, FDACS-01783, Issue No. 436, December 2017, 8 pp.
 65. Kumar, V., Kakkar, Garima, Palmer, C., Myers, Wayne, McKenzie, C.L. and Osborne, L.S. Thrips management program for ornamental plants. International Society of Horticultural Science, VII International Symposium on Rose Research and Cultivation. VII: 125. (Book of Abstracts)
 66. Kumar, V., McKenzie, Cindy L., Osborne, Lance S. Effect of foliar application of afidopyropen on *Bemisia tabaci* (MED whitefly) and *Amblyseius swirskii*, 2018. Arthropod Management Tests. 43(1): G tsy071, 2 pp. 2018. (Report)
 67. Kumar, V., McKenzie, Cindy L., Osborne, Lance S. Control of *Bemisia tabaci* (MED) on salvia, 2018. Arthropod Management Tests (submitted 5/11/2018).

Oral and Poster Presentations

2013

- Aristizabal L. F., P. B. Avery, V. Kumar, J. H. Caldwell, C. L. McKenzie and L. S. Osborne. 2013. Pre-shipment 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. 96th Annual Meeting Florida

- Entomological Society. July 14-17, 2013. Naples, Florida, USA.
- Boughton A., Siavash Taravati, Catharine Mannion and Lance Osborne. 2013. Rugose spiraling whitefly and prospects for biological control by parasitoids. Annual Meeting of Florida Entomological Society. July 14-17, 2013. Naples, Florida, USA.
- 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.
- 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 [abstract]. Entomological Society of America. Paper No 0973
- Kumar V., Osborne L. S., McKenzie, C. L., Arthurs, S., Xiao, Y. F., Miller C., and Chen J. 2013. Predator In First: Introducing a novel biocontrol strategy for managing thrips and other key pests in pepper crops. Palm Beach County Growers Meeting. November 25. Boynton Beach, Florida, USA.
- 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. March 8. Barry University, Miami, Florida, USA.
- Kumar V., P. B. Avery, R. D. Cave, A. Francis, T. R. Smith, C. L. McKenzie and L. S. Osborne. 2013. Efficacy of an entomopathogenic fungus, *Isaria fumosorosea*, and an insect growth regulator against the rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae). Annual Meeting of the Entomological Society of America. November 11-14. Austin, Texas, USA.
- 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.
- 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 Entomological Society of America Annual Meeting, 10-13 Nov, 2013, Austin, TX. Paper No. D0554.

Osborne, L. S., and the Palm Beach Whitefly Task Force. 2013. Responding to an invasive species at the community level. Annual Meeting of Florida Entomological Society. July 14-17, 2016, Naples, Florida, USA.

Osborne L. S., Cindy L. McKenzie, Steven Arthurs, Yingfang Xiao, Vivek Kumar, Christian Miller and Jianjun Chen. 2013 A novel biocontrol strategy for managing thrips and other key pests in pepper crops. Annual Meeting of Florida Entomological Society. July 14-17. Naples, Florida, USA.

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, Y., Lance Osborne, Cindy McKenzie, Vivek Kumar, Junjian Chen, and Siavash Taravati. 2013. Giant whitefly (*Aleurodicus dugesii*) as a surrogate for evaluating the parasitoid wasp (*Encarsiella noysei*) for potential biological control of Rugose Spiraling Whitefly (*Aleurodicus rugioperculatus*). Annual Meeting of Florida Entomological Society. July 14-17, 2013. Naples, Florida, USA.

2014

Aristizabal L. F., P. B. Avery, V. Kumar, J. H. Caldwell, C. L. McKenzie and L. S. Osborne. 2014. Evaluation of potential biopesticides for mitigating the spread of whitefly *Bemisia tabaci* (Hemiptera: Aleyrodidae) using pre-shipment treatments on ornamental plants. 78th Annual Meeting Florida Academy of Sciences. March 7-18. Fort Pierce, Florida, USA.

Aristizabal, L. F., Pasco B. Avery, Vivek Kumar, Jean H. Caldwell, Cindy L. McKenzie, and Lance S. Osborne. 2014. Bio-rational insecticides used for mitigating the spread of whitefly *Bemisia tabaci* (Hemiptera: Aleyrodidae) on ornamental shipments from Florida. Annual Meeting of Florida Entomological Society. August 3-6, 2014, Jupiter, Florida, USA.

Dickey, A.M., Kumar, V., Jara-Cavieres, A., Morgan, J.K., Shatters, R.G., Jr., McKenzie, C.L., Osborne, L.S. 2014. A novel mitochondrial genome architecture in Thysanoptera. Entomological Society of America Annual Meeting, 16-19 November 2014, Portland, OR.

Kumar, V., McKenzie, C.L., Osborne, L.S. 2014. Rugose Spiraling Whitefly: A new invasive pest in Florida. Annual Meeting of Florida Pest Management Association Inc. Pest and Lawn Care Expo Research Symposium, January 23, 2014. Kissimmee, Florida

Kumar, V., Xiao, Y., McKenzie, C.L., Osborne, L. 2014. Predator-in-first: A novel biocontrol strategy for managing thrips and other key pests in pepper crops. Entomological Society of America Annual Meeting, 16-19 November 2014, Portland, OR.

McKenzie, C.L., Dickey, A., Stocks, I., Osborne, L.S. 2014. Barcoding Exotic Whitefly in Florida. Entomological Society of America Annual Meeting, 16-19 November 2014, Portland, OR.

McKenzie, Cindy, Kumar, Vivek, Osborne, Lance. 2014. "Pepper Banker Plant Systems and Predatory Mites" Pickle Packers International, Inc., 2014 Annual Meeting and Product Showcase, Orlando, FL October 23, 2014.

Osborne Lance. 2014. Co-Organizer-Symposium: Clayton McCoy Legacy, Impact on Citrus IPM and Invertebrate Pathology. Remembering Clayton W. McCoy Jr. 1938-2013: A video biography. Annual Meeting of Florida Entomological Society. August 3-6, 2014, Jupiter, FL USA.

Osborne, L. S. and Cindy L. McKenzie. 2014. Banker plant systems: Tools and tactics in managing key pest problems in ornamental production. Annual Meeting of Florida Entomological Society. August 3-6, 2014, Jupiter, FL USA.

2015

Dickey A. M., Kumar V., Hoddle M. S., Funderburk J. E., Morgan J. K., Jara-Cavieres A., Shatters, Jr., R. G., Osborne, L. S., McKenzie, C. L. The *Scirtothrips dorsalis* Species Complex: Endemism and Invasion in a Global Pest. Entomological Society of America Annual Meeting, Minneapolis, Minnesota November 15-18, 2015.

Kumar, V., Xiao, Y., McKenzie, C.L., Osborne, L. 2015. Application of *Predator-in-First* approach in managing thrips and other key pests in pepper crops. Entomological Society of America - Southeastern Branch annual meeting, 15-18 March, 2015, Biloxi, MS.

Kumar, Vivek, McKenzie, Cindy L., Pasco, Avery B., Cave, Ronald D., Francis, Antonio, Smith, Trevor, Osborne, Lance, S. The entomopathogenic fungus *Isaria fumosorosea* and its compatibility with buprofezin: effects on the rugose spiraling whitefly *Aleurodicus rugioperculatus*. Entomological Society of America - Southeastern Branch annual meeting, 15-18 March, 2015, Biloxi, MS.

Kumar V., C. L. McKenzie and L. S. Osborne. 2015. Ornamental pepper banker plants: Can we bank on them? Annual Meeting of the Entomological Society of America. November 15-18. Minneapolis, MN, USA.

Mannion C., L. S. Osborne, A. Boughton, M. Z. Ahmed, T. Smith, A. Francis, V. Kumar and C. L. McKenzie. 2015. Parasitoids of rugose spiraling and ficus whitefly. Annual Meeting of Florida Entomological Society. August 2-5, 2015, Fort Myers, FL, USA.

McKenzie, C.L. and Osborne, L.S. 2015. Biotype Q in North America and Whitefly Control Updates" at the Society of American Florists 31st Annual Pest and Production Management Conference, Orlando, FL Feb 21, 2015.

McKenzie, C.L. "President's Overview of the Florida Entomological Society" at the 12th Annual

- Arbovirus Surveillance & Mosquito Control Workshop, St. Augustine, FL Mar 24, 2015.
- McKenzie, C.L., Kumar, V., Xiao, Y., Osborne, L. "Predator in First: A prophylactic biological control strategy for management of multiple pests of pepper", Thrips symposium, Florida Entomological Society Annual Meeting, Sanibel, FL Aug 4, 2015.
- Osborne, L.S. and McKenzie, C.L. 2015. Using Banker Plants to Control Insects. Society of American Florists 31st Annual Pest and Production Management Conference, Orlando, FL Feb 21, 2015.
- Osborne, L.S. & C.L. McKenzie. 2015. Whitefly Control Update. SAF 2015 Pest & Production Management Conference. Orlando, FL. February 19-21, 2015.
- Osborne, L.S. & C.L. McKenzie. 2015. Four hour workshop on Pest Identification. SAF 2015 Pest & Production Management Conference. Orlando, FL. February 19-21, 2015.
- Osborne L. S., V. Kumar, and C. L. McKenzie. 2015. What happens in greenhouses doesn't stay in greenhouses. Annual Meeting of Florida Entomological Society. August 2-5, 2015. Fort Myers, FL, USA.
- Osborne, L.S. 2015. Scouting for Pests Workshop (4 hours). Florida Nursery, Growers and Landscape Association Annual Landscape Show. September 24, 2015. Orlando, FL.
- Osborne, L.S. 2015. Minimizing Honey Bee Exposure to Pesticides. *In-Service Training* 30947: Minimizing Honey Bee Exposure to Pesticides. Organized by J. Ellis. February 2, 2015. MREC-Apopka, FL.
- Osborne, L.S. 2015. Banker Plants. *In-Service Training* 30969: Implementing Biological control of Ornamental Pests. Organized by Vanessa Campoverde, S. Arthurs, & C. Mannion. Mid-Florida Research & Education Center, Apopka, FL. April 22, 2015.
- Osborne, L.S. 2015. Biological control of whiteflies (Osborne). *In-Service Training: Collection and Identification of Whiteflies for County Agents*. Annual Meeting of Florida Entomological Society. August 2-5, 2015. Fort Myers, FL, USA.
- Osborne, L.S. 2015. Scouting for Insects and Mites. Scout Training Program. Mid-Florida Research & Education Center. Apopka, FL. November 4, 2015.
- Osborne, L.S. 2015. Beginning Biological Control in Protected Agriculture. Mid-Florida Specialty Crops Conference. Mid-Florida Research & Education Center. Apopka, FL. November 6, 2015.
- Osborne, L.S. 2015. Advanced Biological Control in Protected Agriculture. Mid-Florida Specialty Crops Conference. Mid-Florida Research & Education Center. Apopka, FL. November 6, 2015.

Osborne, L.S. 2015. Tours of greenhouses. Mid-Florida Specialty Crops Conference. Mid-Florida Research & Education Center. Apopka, FL. November 6, 2015.

Osborne, L.S. 2015. *Pest Management Update*. Georgia-Florida Green Industry Update. Quincy, FL. November 10, 2015.

2016

Ahmed M., A. Francis, G. Evans, E. Rohrig, L.S. Osborne, and C.M. Mannion. 2016. Genetic and behavioral differentiation between two closely related whitefly parasitoids. International Congress of Entomology. September 25-30. Orlando, FL, USA.

Bethke J.A., L.S. Osborne, A. Hara, and C.L. Palmer. 2016. Management of arthropods during shipping: A collaboration among entomologists associated with ornamental plant production. International Congress of Entomology. September 25-30. Orlando, Florida, USA.

Francis, Antonio, Ahmed, Muhammad, *Kumar, Vivek*, Osborne, Lance S., McKenzie, Cindy. 2016. Biological control based strategies to manage privet whitefly (*Aleurotrachelus trachoides*) in Florida. XXV International Congress of Entomology, Orlando, FL Sept 25-30, 2016.

Kumar, Vivek, Kakkar, Garima, McKenzie, Cindy L., Seal, Dakshina R., Osborne, Lance, S. 2016. Biology, behavior and management of chilli thrips, and other invasive thrips (Thysanoptera: Thripidae) in south Florida. Hitchhikers in Florida: History and Control Symposium, XXV International Congress of Entomology, Orlando, FL Sept 25-30, 2016.

Kumar, Vivek, McKenzie, Cindy. L., Osborne, Lance S. 2016. Susceptibility of ornamental pepper banker plant candidates to common greenhouse pests. Southeastern Branch Meeting of Entomological Society of America, 13-16 March, 2016, Raleigh, NC.

Ludwig, S.W., C.L. Palmer, J.A. Bethke, J. Chamberlin, D. Gilrein, C.L. McKenzie, R. Oetting, and L. S. Osborne. 2016. Q biotype control in ornamentals — the invasion from Europe to the US. International Congress of Entomology. September 25-30. Orlando, FL, USA.

Mannion, C., Osborne, L.S., M.Z. Ahmed and A. Francis. 2016. Whitefly Project Review – Extension Agent Volunteers. *In-Service Training: Whiteflies Affecting Ornamental Plants*. August 10, 2016. MREC-Apopka, FL.

McKenzie C.L. 2016. “Exotic Whitefly in Florida and the use of Banker Plant Systems for their Control” at the Garden Club of Fort Pierce, Heathcote Botanical Gardens, Fort Pierce, FL March 9, 2016.

McKenzie, C.L. and L.S. Osborne. 2016. Update- *Bemisia*. Dealing with the Q-Biotype-What to Do. *In-Service Training: Whiteflies Affecting Ornamental Plants*. August 10, 2016. MREC-Apopka.

- McKenzie, C. and L.S. Osborne. North American Q-Biotype Invasion Project. Q-Whitefly Webinar hosted by Anita Neal (Southern District Extension Director). August 12, 2016. Indian River-REC, Fort Pierce, FL.
- McKenzie, Cindy, *Dickey Aaron*, M, Stocks, Ian, *Kumar, Vivek*, Osborne, Lance S. “Florida Exotic Whitefly Invaders from the Last Decade”, Hitchhikers in Florida: History and Control Symposium, XXV International Congress of Entomology, Orlando, FL Sept 27, 2016.
- Osborne, L.S. 2016. Biological Control in the Landscape. April 5, 2016. Leu Gardens. Orlando, FL.
- Osborne, L.S. 2016. What it is to be an Entomologist. Tour and lecture for local Cub Scout pack. April 16, 2016. MREC-Apopka, FL.
- Osborne, L.S. and C. McKenzie. 2016. An Update on the Detection of *Bemisia tabaci* Biotype-Q in Florida Landscapes. 2016 Annual Meeting of the Florida State Horticultural Society. June 13, 2016. Stuart, FL.
- Osborne, L.S. 2016. Principles of biological control, conservation of natural enemies, compatibility with pesticides, and resistance issues. June 30, 2016. Miami Dade Extension Office, Miami, FL.
- Osborne, L.S. 2016. Imminent Treat or Tempest in a Tea Pot? Assessing implications of the Q biotype in Florida Landscapes. July 29, 2016. Miami Dade Extension Office, Miami, FL.
- Osborne, L.S., V. Kumar and C. Mannion. 2016. Whitefly management – Landscape (not *Bemisia*). In-Service Training: Whiteflies Affecting Ornamental Plants. August 10, 2016. MREC-Apopka, FL.
- Osborne, L.S., C. McKenzie and V. Kumar, Whitefly management- Production. 2016. In-Service Training: Whiteflies Affecting Ornamental Plants. August 10, 2016. MREC-Apopka, FL.
- Osborne, L.S., V. Kumar, M.Z. Ahmed and A. Francis. 2016. Biological control of whiteflies. Viewing samples of natural enemies. In-Service Training: Whiteflies Affecting Ornamental Plants. August 10, 2016. MREC-Apopka, FL.
- Osborne, L.S. and C. McKenzie. 2016. Managing the US Invasion of Cryptic Whitefly Species: Q vs. B Whiteflies. Q-Whitefly Webinar hosted by Anita Neal (Southern District Extension Director). August 12, 2016. Indian River-REC, Fort Pierce, FL.
- Osborne, L.S. 2016. The Q-Whitefly Invasion. IFAS meeting to discuss the issues and plans for managing this new pest. August 31, 2016. MREC-Apopka, FL.
- Osborne, L.S. 2016. Managing Whiteflies. FNGLA-The Landscape Show. Pest/Disease Management Workshop. September 16, 2016. Orlando, FL.

Osborne, Lance S., *Kumar, Vivek, Kakkar, Garima, McKenzie, Cindy L.* 2016. Banker Plants: Using a Systems Approach for dealing with Exotic Invasives in Florida, Hitchhikers in Florida: History and Control Symposium, XXV International Congress of Entomology, Orlando, FL Sept 27, 2016.

Osborne, L.S. 2016. Pest Management in Hops. MREC Florida Hops Field Day. September 27, 2016. MREC-Apopka, FL

Osborne, L.S. 2016. Scouting for Insects. Central Florida Scout Training Course, October 5, 2016. MREC-Apopka, FL.

2017

Francis A., Z. Ahmed, V. *Kumar, L. Osborne* and C. Mannion. 2017. Developing a biological control based strategy for solanum/pepper whitefly, an emerging pest in Florida. Annual Meeting of the Florida Entomological Society. July 16-20. San Juan, Puerto Rico, USA.

Kumar, Vivek, Kakkar, Garima, Palmer, Cristi, Myers, Wayne, McKenzie, Cindy L., Osborne, Lance S. 2017. Thrips management program for ornamental plants. VII International Symposium on Rose Research and Cultivation, July 2-7, 2017, Angers, France.

Kumar, Vivek, Kakkar, Garima, Palmer, Cristi, McKenzie, Cindy L., Osborne, Lance S. 2017. Thrips management program for horticultural ornamental crops. Southeastern Branch Entomological Society of America, Memphis, TN, March 12-15, 2017.

Kumar V., C. L. McKenzie and L. S. Osborne. 2017. Prey stage preference and functional response of *Delphastus catalinae* and *D. pallidus* (Coleoptera: Coccinellidae) on *Bemisia tabaci* (Hemiptera: Aleyrodidae). Annual Meeting of the Entomological Society of America. November 5-8. Denver, Colorado, USA.

McKenzie, Cindy, Osborne, Lance. 2017. “*Bemisia tabaci* MED (Q biotype) is on the move in Florida to residential landscapes and threatens open field agriculture”, Turf and Ornamental Symposium, Southeastern Branch Entomological Society of America, Memphis, TN, March 15, 2017.

McKenzie, Cindy, Osborne, Lance, *Kumar, Vivek, Oetting, Ron, Palmer, Cristi.* 2017. “The Importance of Understanding *Bemisia tabaci* Cryptic Species Identification (i.e. biotypes) and How This Can Impact Insecticide Resistance Management Programs”, P-IE Section Symposium: New Tools and Tactics to Manage Insecticide Resistance. Entomological Society of America, Denver, CO, Nov 5-8, 2017.

Osborne, L.S., C. McKenzie and V. Kumar. 2017. Q type Whitefly update and management. CEU UPDATE-MREC, Apopka, FL. February 8, 2017.

Osborne, L.S., C. McKenzie and V. Kumar. 2017. Managing whitefly in nurseries and the

- landscape. Manatee County Extension, FL. February 16, 2017.
- Osborne, L.S. 2017. Training on Insect Identification for Ocoee High School students participating in the CDE contest. MREC-Apopka, FL April 12, 2017.
- Osborne, L.S., C. McKenzie and V. Kumar. 2017. Managing insects and mites on Citrus grown in greenhouses using Banker Plants. Citrus Update. MREC, Apopka, FL. May 25, 2107.
- Osborne, L.S., C. McKenzie and V. Kumar. 2017. Whitefly Management. Florida First Detector Training. Brevard County FL, May 26, 2017.
- Osborne, L.S., C. McKenzie and V. Kumar. 2017. Q type Whitefly update and management. CEU UPDATE-Lake County Extension. June 1, 2017.
- Osborne L., V. Kumar, G. Kakkar, and C. L. McKenzie. 2017. Thrips management program in ornamental horticulture. 7th Annual Cattleya Symposium. August 3-5, 2017. Fort Pierce, FL, USA.
- Osborne, L.S. and C. McKenzie. 2017. Tour of the South Florida Q-whitefly infested areas. WTF-Q task force, Apopka, FL. August 30, 2017.
- Osborne, L.S. and C. McKenzie. 2017. Tour of Mid-Florida Research and Education Center to demonstrate biological control projects in protected culture. Biocontrol East Conference-FL. October 11, 2017.
- Osborne, L.S., C. McKenzie and V. Kumar. 2017. Problems with utilizing commercially available biological control agents in protected culture. Biocontrol East Conference-Orlando, FL. October 12, 2017.
- Osborne, L.S. and Katherine Houben. Scouting for Insect and Beneficials (two separate talks). Scout Training Program. MREC-Apopka, FL, October 19, 2017.

2018

- Kumar, V., McKenzie, C.L., Osborne, L. 2018. Neonics stewardship program for the management of the invasive *Bemisia tabaci* (MED) whitefly. Florida Entomological Society, St. Augustine, FL, July 22-25, 2018.
- McKenzie, Cindy L., Osborne, Lance S. 2018. "Whitefly Identification and Control" in the Interiorscape Technician Workshop for Florida Nursery, Growers and Landscape Association at the Tropical Plant Industry Expo, Fort Lauderdale, FL, Jan 16, 2018
- McKenzie, Cindy L. 2018. "Exotic Whiteflies in South Florida Gardens" at the Jenson Beach Garden Club, Bocchino Center in Langford Park, Jenson Beach, FL, Jan 17, 2018
- McKenzie, Cindy, Kumar, Vivek, Osborne, Lance. 2018. Predator in First: Commercial Bell

- Pepper Field Production. Southeastern Branch Entomological Society of America, Orlando, FL, March 4, 2018.
- McKenzie, C.L. and L.S. Osborne. 2018. IPM for the non-entomologist-using pesticide to manage the Q-Biotype whitefly. Second of three classes. Palm Beach Garden Club, Palm Beach, FL. March 19, 2018.
- McKenzie, Cindy, Sparks, Alton, Roberts Phillip, Osborne, Lance. 2018. Survey of *Bemisia tabaci* (Hemiptera: Aleyrodidae) in Agricultural Ecosystems in Georgia. Florida Entomological Society, St. Augustine, FL, July 22-25, 2018.
- Osborne L.S. V. Kumar, and C. L. McKenzie. 2018. Pest Management Update – whiteflies, thrips and mites. CEU Day program in ornamental horticulture. Apopka, FL, USA. January 8, 2018.
- Osborne L.S., and C. L. McKenzie. 2018. IPM for the non-entomologist (concentration on managing thrips and whiteflies). First of three classes. Palm Beach Garden Club, Palm Beach, FL. February 5, 2018.
- Osborne L.S. V. Kumar, and C. L. McKenzie. 2018. Update on managing invasive whiteflies, CEU program for Manatee Extension Ornamental Horticulture Program. Palmetto, FL, USA. February 16, 2018.
- Osborne L.S., and C. L. McKenzie. 2018. Lecture and Tour of Mid-Florida Research and Education Center. A talk on our FNRI program to 35 Orange County Public School District Agriscience Teachers. Apopka, FL. March 15, 2018.
- Osborne L.S., and C. L. McKenzie. 2018. IPM for the non-entomologist (concentration on managing thrips and whiteflies). Second of three classes. Palm Beach Garden Club, Palm Beach, FL. March 19, 2018.
- Osborne L.S., and C. L. McKenzie. 2018. IPM for the non-entomologist (concentration on managing thrips and whiteflies). Third of three classes. Palm Beach Garden Club, Palm Beach, FL. April 16, 2018.
- Osborne L.S. V. Kumar, and C. L. McKenzie. 2018. Update on managing invasive pests and mites, CEU program for Orange County Extension Ornamental Horticulture Program. Orlando, FL, USA. May 8, 2018.
- Osborne L.S. and C. L. McKenzie. 2018. Update on managing invasive pests and mites in ornamental cutting production. Program for Syngenta Cutting production team. Alva, FL, USA. June 14, 2018.
- Osborne L.S. V. Kumar, and C. L. McKenzie. 2018. Latest on Q-Biotype Whitefly. Cultivate '18. Columbus, OH, USA. July 14, 2018.

- Osborne L.S. *V. Kumar*, and C. L. McKenzie. 2018. Managing Invasive Whiteflies using the Latest Whitefly Action Plan. Cultivate '18. Columbus, Ohio, USA. July 15, 2018.
- Osborne L.S. and C. L. McKenzie. 2018. Pest Management Update – Mites. CEU Day program in ornamental horticulture. Homestead, Florida, USA. July 24, 2018.
- Osborne L., *V. Kumar*, *G. Kakkar*, and C. L. McKenzie. 2018. Thrips management program in ornamental horticulture. 8th Annual Cattleya Symposium. August 3-5, 2018. Fort Pierce, Florida, USA.
- Osborne L.S. and C. L. McKenzie. 2018. Orange County 4H Volunteer Training-New Invasive Pests Identification and Management. August 14, 2018. Apopka, Florida, USA.