S1058 Annual Meeting – Southeastern Branch Meeting – Entomological Society of America, Biloxi MS

Sunday March 2016, 13:00-18:00.

The business meeting was proceeded by an official symposium at the conference, S1058 Biological Control of Arthropod and Weed Pests in the Southern United States. The organizers of the symposium was the chair of the group Emma Weeks from University of Florida and the secretary of the group Rodrigo Diaz from Louisiana State University. The talks were given by members of the group and included:

**Symposium**

 [Biological Control of Giant Salvinia (*Salvinia molesta*) in Temperate Regions: Old and New Approaches](https://esa.confex.com/esa/2016seb/webprogram/Paper106771.html). ***Rodrigo Diaz****, Louisiana State University; Lori Moshman, Louisiana State University ; Alana Russell, Louisiana State University ; Lauren Cozad, Red River Waterway Commission*

[*Calophya terebinthifolii* (Hemiptera: Calophyidae), a Potential Biocontrol Agent of Brazilian Peppertree:  Preliminary Results of a Field Impact Study in Gaspar, Santa Catarina, Brazil](https://esa.confex.com/esa/2016seb/webprogram/Paper106602.html)

***James P. Cuda****, University of Florida; Marcelo D. Vitorino, Fundação Universidade Regional de Blumenau; Marcus Boeno, Universidade Regional de Blumenau -FURB ; Firmino Moreira dos Santos, Universidade Regional de Blumenau -FURB; Patricia Prade, University of Florida*

[Biological Control of Air Potato in Florida: A Successful Multi-Agency Collaboration](https://esa.confex.com/esa/2016seb/webprogram/Paper106410.html)

***William A. Overholt****, University of Florida; Min Rajamajhi, United States Department of Agriculture; Eric Rohrig, Florida Department of Agriculture and Consumer Services; Ellen Lake, USDA - ARS; Melissa Smith, USDA-ARS; Stephen Hight, USDA - ARS; Kenneth Hibbard, Florida Department of Agriculture and Consumer Services; Veronica Manrique, University of Florida; Rodrigo Diaz, Louisiana State University*

[Georgia Agriculture Biocontrol Update: Observations and Ongoing Studies](https://esa.confex.com/esa/2016seb/webprogram/Paper106803.html)

***Jason M. Schmidt****, University of Georgia*

[From Predators to Parasitoids: Biological Control of Invasive Insect Pests of Tennessee Forests](https://esa.confex.com/esa/2016seb/webprogram/Paper106779.html)

***Gregory J. Wiggins****, University of Tennessee; Jerome F. Grant, University of Tennessee; Paris L. Lambdin, University of Tennessee; James Parkman, University of Tennessee*

[Cost Effectiveness of Biological Control: Invasive Mole Crickets in Florida Pastures](https://esa.confex.com/esa/2016seb/webprogram/Paper106599.html)

***Norman Leppla****, University of Florida; Daniel Solís, Florida A&M University; Michael Thomas, Florida A&M University; Grace Mhina, Florida A&M University*

**Business Meeting**

Present: Emma Weeks, University of Florida; Rodrigo Diaz, LSU; Jason Schmidt, University of Georgia; Jim Cuda, University of Florida; Rob Wiedenmann, University of Arkansas; Tim Kring, Virginia Tech; Greg Wiggins, Tennessee, Aurora Toennisson, North Carolina State University; Christine Nalepa, NCDA; Bill Overholt, University of Florida; Norm Leppla, University of Florida.

Apologies from Saeid Mostaghimi, Administrative Advisor, Virginia Tech.

1. Minutes of 2015 meeting- Emma Weeks offered to read the full minutes from the 2015 meeting. Norm Leppla made a motion that the reading of the minutes should be approved and submitted without reading Jim Cuda seconded the motion. The motion passed.
2. Notes from Academic Advisor: Emma recommended to check the presence of the members in the multi-state project. Emma and Rodrigo can help the member or institutions to be added on the project. Emma mentioned that Saied would like to see more collaboration among members and multistate projects will be easier to fund. There will be additional $700 million for NIFA grants and this will open opportunities for this group.
3. Availability of Group Award: Emma Weeks mentioned the existence of an award for collaboration within the group.
4. The purpose of the S1058 group: There was an extensive discussion how we can improve the cooperation among members. The take home message was that we need to put grant proposals as a group. Jim Cuda mentioned the availability NIFA grants and that project members should take the lead in grant writing. Jim suggested that the group could put together proposals for a weed and an insect. Tim Kring mentioned that years ago there was 30 to 40 people attending the S1058 meeting and proposals were prepared. Tim mentioned that those were two-day meetings with presentations and then the teams broke out and came out with proposals. There was a consensus to develop a meeting agenda that is centered on development of proposals. Furthermore, Bill Overholt suggested to include presentations on grant proposals including funding agencies and potential ideas. Having a meeting, which will include proposal writing, will be a great way to recruit new members and revitalize our group.
5. Annual meeting location: Emma Weeks mentioned that based on the survey among members the majority wanted to have the S1058 meeting at the SEB-ESA meeting. However, based on the need of time for proposal development the group probably will need to meet separately. Tim Kring mentioned that based on previous experience it would be ideal to have the meeting in one location (previously held in Orlando, FL). Rob Wiedenmann asked how we can transition from one meeting at the SEB-ESA to a working meeting in a separate location. For the next SEB-ESA meeting in 2017, we will find the time to work on grant proposals but for the 2018 meeting we can explore a separate location. One idea was to submit a symposium proposal to SEB-ESA in 2017 and make our presentations part of the main event. This will give us more time to meet separately for proposal development.
6. Project Rewrite: Emma Weeks will check with Saied about a potential project rewrite.
7. Sugar Cane Aphid: Tim Kring mentioned that many large grants have been submitted through the Task Force Groups. The program is very active and teams meet often.
8. Cogongrass: Jim Cuda and Bill Overholt mentioned the possibility to work on cogongrass as a regional problem. Bill Overholt mentioned that about the foreign exploration conducted in Asia and the availability of some host specific agents. However, Bill suggested the agents are probably years away from release because problems with colony establishment.
9. Emerald Ash Borer: Greg Higgins mentioned that the problem is spread across the several of our states and most of the biological control projects are funded by APHIS. Greg suggested the possibility to evaluate the role of native parasitoids in southern latitudes. Rodrigo mentioned that the establishment of exotic parasitoids will be evaluated in Louisiana in 2016 and 2017. Rob Wiedenmann and Tim Kring confirmed that exotic parasitoids have been released in Arkansas. Tim Kring suggested that as a group we should try to put together a regional grant on EAB biological control.
10. Brazilian peppertree: Bill Overholt mentioned that there are some agents in the pipeline.
11. Chinese tallow and Chinese privet: Rodrigo Diaz mentioned that these exotic weeds could be of interest to the group considering their southern distribution. There are some agents in the pipeline.
12. Conservation Biological Control: Aurora Toennisson asked whether the group works mostly with classical biological control programs. Emma Weeks mentioned the goals of the group which include conservation biological control. Jason Schmidt mentioned his work on conservation biological control and sustainable agriculture in Georgia. Jason expanded on some plant species that are used in conservation are potential invaders in southern regions. Jim Cuda and Bill Overholt mentioned the availability of lists about invasive plants from Florida and issues with biofuels (*Miscanthus* and *Jatropha*).
13. New agents approved for release: Emma Weeks asked about the status of new release applications submitted to APHIS. Jim Cuda mentioned that there has been no new agents released since 2011. Emma Weeks suggested that we need to follow up with the letter submitted from northeastern region about the issues with new agents. Bill Overholt will attend the new TAG meeting in April in Riverdale and will provide updates to our group on the status of new agents. Emma suggested that due to the problem of new agents being approved for release we should explore more the role of native natural enemies thorough conservation.
14. S1058 website: We need to update the highlighted pests. Rodrigo Diaz and Emma Weeks will work on this. Norma Leppla mentioned the website of State IPM coordinators is another source of information about pest problems. Emma mentioned the efforts to update the list of members in the website.
15. Officer nominations and elections: The secretary Rodrigo Diaz was automatically elected as chair. Volunteers were sought for the secretary position, no volunteers came forward. A motion was made by Bill Overholt to nominate Jason Schmidt for secretary. Seconded by Jim Cuda. Nomination passed. Rob Wiedenmann mentioned that there are no rules about one-year term in the officer’s position and that for the future we should consider having two-year terms. Rob mentioned this would facilitate the duties of the officers.
16. Meeting adjourned: No other business was discussed. Jim Cuda moved to adjourn the meeting at 18:00. Seconded by Bill Overholt. Motion passed.

 **S-1058 ANNUAL REPORT FOR 2015 AND PLANS FOR 2016**

**NAME OF REPRESENTATIVE:** Tim Kring (2015) Rob Wiedenmann (2016)

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**ACCOMPLISHMENTS**

**Objective 1**. Characterize and evaluate the effect of established natural enemies.

Arkansas efforts under this objective involved development of techniques to evaluate the impact of established, introduced natural enemies of spotted knapweed, and parasitic flies released against imported fire ants.

Previous studies indicated that one knapweed biological control agent (*Urophora quadrifasciata*) had limited impact on the weed. Therefore, we determined that the redistribution of additional knapweed natural enemies was warranted. One of the additional knapweed agents released (*Larinus minutus*), is now known to be well-established in Arkansas and reducing weed populations.

For the fire ant project, although it appears both introduced fire ant parasitoids are established, they are not effective in controlling fire ants.

**Objective 2**. Exploration, importation, and assessment of natural enemies for invasive pests.

The knapweed root weevil *Cyphocleonus achates* was found after overwintering in Arkansas, demonstrating that it has established from releases that were completed in 2012. Together, this species and *L. minutus* are expected to help reduce the spread of this invasive species and suppress established knapweed populations, thus reducing herbicide use in both public and agricultural lands.

**Objective 3**. Implementation, evaluation, and enhancement (e.g., conservation) of biological control.

Research addressed whether availability of spotted knapweed flowers affects development and maturity of *Larinus minutus* ovaries and production of eggs. In answering that question, we determined that knapweed flowers are necessary for 2

egg production, but ovary maturation in the weevil occurs even without feeding on floral parts of spotted knapweed.

The presence of adults of both knapweed biological control agents *Larinus minutus* and *Cyphocleonus achates* at virtually all of the release locations signifies a high quality of the collected and released material. Longevity and retention of adults at release sites over multiple years gives us optimism about the ultimate reduction of spotted knapweed throughout northwestern Arkansas.

Research on fire ant and its phorid natural enemies (*Pseudacteon*) compared *Pseudacteon* sampling methods in associated with fire ants. Results indicated that sticky traps (both the Puckett and fly ribbon/sandwich trap) were effective in capturing multiple *Pseudacteon* species when baited with either live or dead ants. Traps baited with fire ant attractant bait were ineffective. These findings will allow more cost-effective sampling in the future to document the establishment and potential impact of the released agents.

**UTILITY OF FINDINGS:**

Three natural enemies attacking spotted knapweed are now known from the southern US. The tephritid, *Urophora quadrifasciata*, spread naturally from releases in the northern US, but its impact is limited. The flower head weevil, *Larinus minutus*, and the knapweed root weevil, *Cyphocleonus achates*, were intentionally established by this project in Arkansas via their redistribution from Colorado. Together, these species will help reduce the spread of knapweed and will suppress knapweed populations, thus reducing herbicide use on public and private land.

Additional *Pseudacteon curvatus* releases are not necessary at this time; instead, additional release efforts should concentrate on other *Pseudacteon* species. The scarcity and limited expansion of *Ps. tricuspis* requires further investigation.

The results of these research efforts were disseminated a broad array of outlets, such as refereed journals and presentations. Producers were notified of project results through Extension meetings, as well as providing results directly to private landowners.

**WORK PLANNED FOR NEXT YEAR (2012):**

We will continue annual evaluations of knapweed at long-term sites to provide data on impact of the introduced natural enemies.

Surveys will continue to identify the presence of *Ps. obtusus* and *Ps. cultellatus* at the recent release sites.

**PUBLICATIONS (2015)**

None 3

**S-1058 ANNUAL REPORT FOR 2015 AND PLANS FOR 2016**

**NAME OF REPRESENTATIVE:** Kristopher Giles

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**OTHER PARTICIPANTS: Tom Royer**

**ACCOMPLISHMENTS**

**Objective 1**. Characterize and evaluate the effect of established natural enemies.

Studies were completed and published to (1) determine whether the most abundant insect predators in winter canola demonstrate feeding preference among common winter canola aphids and (2) describe the suitability of these prey species for predator survival and development. Predators demonstrated no preference among prey and each aphid species was suitable for predator survival. However, predator development was delayed and surviving adults weighed less when they ate turnip or cabbage aphids; each sequester high levels of indole glucosinolates from their host plants. Results indicate that qualitative differences in nutritional suitability for common Brassica-specialist aphids are toxic to aphid predators. This finding is important because it appears to describe one mechanism for observed lower populations of insect predators in canola versus wheat. In coordination with a multi-year study to evaluate pests and beneficial insects in canola landscapes, additional data was summarized on parasitoid movement at wheat-canola field interfaces. Remarkably, based on sticky trap captures wheat-aphid parasitoids that are unable to utilize canola-aphids for development are found at extremely high numbers in winter canola fields. These parasitoids may be attracted to canola flowers, or more importantly find and kill (without possibility of survival) canola-aphids. Future studies are being planned to describe the role of wheat-aphid parasitoids that colonize canola plants/fields.

**Objective 2**. Exploration, characterization and assessment of natural enemies for invasive species.

NA

**Objective 3**. Implementation, evaluation, and enhancement (e.g., conservation) of biological control.

Dr. Tom Royer is the primary cooperator for this objective and his continuing work on biological control of saltcedar forms the foundation of this report. Current sampling efforts reveal that one species of weevil (*Diorhabda carinulata*) imported for control of saltcedar continues to move into Oklahoma primarily along rivers. Populations are sporadic but appear to be firmly established in Oklahoma. Their impact on saltcedar appears to be variable and future quantitative research is needed to document saltcedar survival. The primary objectives of current research are to document the presence of common predators of this beetle and describe their impact. To date, typical insect predator guilds are present on saltcedar and can be observed feeding on beetles, but 4

predator survival varies significantly among species. An ongoing study is investigating a technique to quantify predation: measuring beetle DNA in the gut of common insect predators. Ultimately, this data is needed to quantify the impact of saltcedar beetle predators, and whether predators interfere with biological suppression of this invasive plant.

**UTILITY OF FINDINGS:**

*Diorhabda carinulata* populations are moving throughout Oklahoma at a rapid pace, primarily along rivers. We will continue to evaluate whether native natural enemies pose a significant threat to *D. carinulata*. Natural enemies in intensively managed winter canola are contributing towards aphid suppression, but frequent insecticide use in canola and competition among natural enemies in wheat/canola landscapes may be reducing their impact in canola.

**WORK PLANNED FOR NEXT YEAR (2016)**

Continue towards completion and/or summarization of all ongoing or completed objectives listed above. Based on available abundance data in diverse landscapes, the most abundant wheat-aphid parasitoid may be interfering with canola-aphid parasitoids, preventing successful biological suppression in winter canola. Studies are being planned to describe interactions between wheat-aphid and canola-aphid parasitoids in agricultural landscapes.

**PUBLICATIONS (2015)**

Jessie, W. P., K. L. Giles, E. J. Rebekj, M. E. Payton, C. N. Jessie and B. P. Mccornack. 2015. Preference and Performance of *Hippodamia convergens* (Coleoptera: Coccinellidae) and *Chrysoperla carnea* (Neuroptera: Chrysopidae) on *Brevicoryne brassicae*, *Lipaphis erysimi*, and *Myzus persicae* (Hemiptera: Aphididae) From Winter-Adapted Canola. Environmental Entomology. 44: 880-889. 5

**S-1058 ANNUAL REPORT FOR 2015 AND PLANS FOR 2016**

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**ACCOMPLISHMENTS**

**Objective 1**. Characterize and evaluate the effect of established introduced natural enemies.

The multi-state project to characterize the natural enemy complex of the lecanium scales, *Parthenolecanium corni* and *Parthenolecanium quercifex*, in the urban landscape of GA (Kris Braman, UGA), SC (J.-H. Chong, Clemson), NC (Steve Frank, NCSU) and VA (Peter Schultz, VT) is completed in 2015. A total of 21 parasitoid species and 12 coleopteran and neuropteran predators were documented, of which *Coccophagus lycimnia* (Aphelinidae), *Blastothrix* spp. (Encyrtidae), *Encyrtus* spp. (Encyrtidae), *Metaphycus* spp. (Encyrtidae), *Eunotus* sp. (Pteromalidae), *Pachyneuron* sp. (Pteromalidae), *Chrysoperla rufilabris* (Chrysopidae), *Hyperaspis signata* sp. group (Coccinellidae) and *Anthribus nebulosus* (Anthribidae) were found to be the most numerous. Species diversities of the parasitoids and predators were largely similar across the four states. Among the major parasitoids, *C. lycimnia* was the only species emerged from scale insect nymphs, whereas other species emerged from adults. The natural enemies were active from early March to September. Parasitism rate ranged from 27 to 92%, whereas predation rate was difficult to assess. Five main parasitoid species (*Blastothrix* sp. 1, *Coccophagus lycimnia* (Walker), *Encyrtus* sp. 1, *Eunotus* sp. and *Pachyneuron* sp.) emerged from adults and parasitism by these species reduced the fecundity of the scales.

**Objective 2.** Exploration, importation, and assessment of natural enemies for invasive pests.

A study was initiated in 2015 to investigate the influence of plant architecture, specifically the number of leaves and branches, on the foraging behavior of the predatory beetle, *Cryptolaemus montrouzieiri*, when offered varying densities of the invasive citrus mealybug, *Planococcus citri*. The citrus mealybug is a major pest of horticultural crops in both outdoor production and protected cultures. This study is currently on-going.

**Objective 3**. Implementation, evaluation, and enhancement of biological control.

Compatibility of a novel miticide, cyflumetofen (Sultan), with the predatory mites *Amblyseius swirskii* and *Phytoseiuslus persimilis* has been evaluated in greenhouses in CA (Jim Bethke, UC Extension), FL (Lance Osborne, UF) and SC (J.-H. Chong, Clemson) since 2013. The study found that cyflumetofen did not cause elevated acute and residual mortality in both predatory 6

mite species. The new miticide also did not cause a reduction in the reproduction of *A. swirskii*. The project demonstrated that cyflumetofen can be used with biological control in greenhouse ornamental plant production system.

**UTILITY OF FINDINGS**

The results of this project were disseminated mainly through extension workshops and presentations, as well as extension articles in trade journals and newsletters. This project showed that the peak activity periods of the parasitoids and predators of *Parthenolecanium* spp. coincide with the timing of scale insect crawler emergence. Current recommendation for the management of *Parthenolecanium* spp. includes application of contact insecticides against the crawlers in late May to mid-June. Considering the potentially detrimental impact of foliar applications of contact insecticides on the natural enemies, we suggest that the current recommendation to be modified to reduce the non-target impact of applications. Growers and landscape care professionals targeting lecanium scales should not apply contact insecticides. Instead, an indirect application (i.e. soil drench, soil injection, trunk spray and granule) of systemic neonicotinoids (acetamiprid, clothianidin, dinotefuran, imidacloprid and thiamethoxam) should be applied in May to achieve reduction of the population of nymphs and to avoid direct impact on the natural enemies. This recommendation is applicable to all states studied (GA, NC, SC and VA) because the natural enemy assemblage and activity periods are similar or closely aligned.

**WORK PLANNED FOR NEXT YEAR (2016)**

Study on the compatibility of cyflumetofen with *A. swirskii* and *P. persimilis* will be repeated in the spring of 2016. The study on the foraging behavior of *C. montrouzieiri* on plants of different structural characteristics will continue in 2016.

**PUBLICATIONS (2015)**

Peer-reviewed articles:

Chong, J.-H., L. F. Aristizabal, and S. P. Arthurs. 2015. Biology and management of *Maconellicoccus hirsutus* (Green) (Hemiptera: Pseudococcidae) on ornamental plants. Journal of Integrated Pest Management 6: 5; 13 pp. DOI: 10.1093/jipm/pmv004

Trade journal articles:

Chong, J.-H. 2015. Tea scale (*Fiorinia theae*). The South Carolina Nurseryman. September/October 2015, pp. 6-7.

Chong, J.-H. 2015. Cottony cushion scale (*Icerya purchasi*). The South Carolina Nurseryman. July/August 2015, pp. 26-27.

Chong, J.-H. 2015. False oleander scale, *Pseudaulacaspis cockerelli* (a.k.a. magnolia white scale). The South Carolina Nurseryman. May/June 2015, pp. X-Y.

Chong, J.-H. 2015. Wax myrtle scale, *Melanaspis deklei*. The South Carolina Nurseryman. 7

January/February 2015, pp. 32-33.

Chong, J.-H. 2014. New insecticides for the turf market. South Carolina Sod Producers Association Newsletter. December 2014.

Robayo Camacho, E., and J.-H. Chong. 2014. Florida wax scale, *Ceroplastes floridensis*. The South Carolina Nurseryman. November/December 2014, 18-19.

Chong, J.-H. 2014. Brother, can you spare a fall armyworm? South Carolina Sod Producers Association Newsletter. October 2014.

Chong, J.-H. 2014. Scale insects: The banes of ornamentals. The South Carolina Nurseryman. September/October 2014, pp. 26-28. 8

**S-1058 ANNUAL REPORT FOR 2015 AND PLANS FOR 2016**

**NAME OF REPRESENTATIVE:** James P. Cuda

**AES (STATE):** Florida

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Jesusa C. Legaspi

**ACCOMPLISHMENTS**

*OBJECTIVE 1. Characterize and evaluate the effect of established natural enemies.*

Air potato: A statewide survey was conducted in September 2015 to determine the spatial distribution of *Lilioceris cheni* (Coleoptera: Chrysomelidae), being released in Florida for biological control of *Dioscorea bulbifera* (air potato). Beetles or beetle damage was found at 97 of 113 randomly selected sites, but no damage was found at several sites in the panhandle or in Miami-Dade County. The production of bulbils, the vegetative reproductive structure of air potato, decreased with increasing beetle damage.

*OBJECTIVE 2. Exploration, importation, and assessment of natural enemies for invasive pests.*

Brazilian peppertree: In September 2015, we established a field site at the Universidade Regional de Blumenau (FURB) experimental unit located in Gaspar, Santa Catarina, Brazil to evaluate the impact of the Brazilian peppertree natural enemy *Calophya terebinthifolii*, a leaflet galling psyllid, in its native range. The specific research goal is to quantify the psyllid’s impact on Brazilian peppertree. Biomass of Brazilian peppertree will be compared to plants not exposed to the psyllid using the chemical exclusion method. Potted plants from seeds collected from a single mother plant susceptible to the psyllid were propagated in a Laboratory de Monitoramento e Proteção Florestal (LAMPF) greenhouse located in Blumenau, Santa Catarina, Brazil, for 4-6 9

months prior to the experiment. Plants were transferred to the Gaspar field site and divided into a control group (psyllids excluded) and three experimental groups: (natural), low psyllid density (4 adults /plant) and high density (16 adults/plant). In total, 16 seedlings were planted in each of 4 rows (64 plants total). All the seedlings were watered twice daily per day if no rain events occurred that day. The experimental design is randomized complete block (8 blocks per replicate with 4 treatments /block) and 2 replications. Treatment positions in each block were randomly assigned in each of the two replicates. The height (cm) and basal stem diameter (mm) of each of the established plants were measured with ruler and caliper, respectively. An additional 8 potted seedlings also were measured (height, stem diameter) and transported back to LAMPF to be dried in an oven for 4 days at 70 oC. Biomass data from these plants will be used as baseline to calculate the Relative Growth Rate of the test plants at Gaspar when the experiment is terminated.

Continued maintaining a colony of *A. pipitzi* collected in Paraguay in 2006 using established procedures. During this reporting period, a total 1,247, 1,169 and 875 new adults were produced in the F18, F19, and F20 generations, respectively. The sex ratio (M:F) was 1.04: 1.

Multiple generation tests on Brazilian peppertree and six non-target species that supported

development of the weevil *A. pipitzi* in no-choice tests are nearing completiton To date, sustained reproduction of the weevil *A. pipitzi* has occurred only on Brazilian peppertree, *Schinus polygamus*, and *Pistacia chinensis*. Both *S. polygamus* and *P. chinensis* are considered invasive species.

The temperature tolerance experiment, which determined if the weevil *A. pipitzi* posed a risk to the native *Rhus aromatica*, was completed during this reported period. *Rhus aromatica* only occurs in the western Panhandle of Florida- Escambia and Jackson counties. Weevil-exposed Brazilian peppertree stems subjected to freezing temperatures for 53 hours produced no adults whereas control logs produced on average 14.7 ± 9.1 males and 15.3 ± 12.7 females. These results showed developing weevils would not survive in North Florida where *R. aromatica* occurs naturally, and confirmed biogeographical incompatibility between the weevil and this non-target plant.

Initial no-choice oviposition tests with the leaf galling psyllid *C. terebinthifolii* were conducted with 37 different plant species, from 7 different families at the UF/IFAS BCRCL from February-July 2015 under greenhouse conditions. The species where selected based on the centrifugal phylogenetic method. *Calophya terebinthifolii* showed a high degree of specificity to the family Anacardiaceae; oviposition occurred only on 5 of the 37 species tested. The highest number of eggs/plant was observed on Brazilian peppertree (mean =160) compared to

*Schinus molle* (59), *Pistacia* UCB (10), *Schinus polygamus* (9) and *Pistacia vera* (5) with no oviposition on the other species. Complete nymphal development and adult emergence occurred only on Brazilian peppertree, the target weed. Eggs deposited by the psyllid on the

other non-target species either died, or the nymphs died before completing their development. Another experiment was conducted with adult *C. terebinthifolii* and 12 plant species and cotton with water (control) to compare survival of adults on the target plant and non-target species; test plants where selected based on the oviposition test results. The experiment also was conducted at the UF/IFAS BCRCL from May- July 2015 under greenhouse conditions. *Calophya* 10

*terebinthifolii* survived up to 37 days in Brazilian peppetree (*S. terebinthifolia*), 11 days on the congeneric *Schinus molle* L., and only 7 days on the other plant species or the control (cotton with water).

Host range testing of *Calophya latiforceps* (Hemiptera: Calophyidae), a leaf galling psyllid of Brazilian peppertree, was completed in 2015. A petition requesting field release of the psyllid *C. latiforceps* was prepared and submitted to the USDA APHIS Technical Advisory Group for Biological Control Agents of Weeds (TAG) in April 2015. The petition is currently under review.

Cogongrass: Exploration for natural enemies of cogongrass, *Imperata cylindrica* (Poaceae) was conducted in March 2015 in the Philippines, and Indonesia in May 2015. A pyralid stemborer was found in the Philippines and 23 larvae were imported into the University of Florida’s quarantine laboratory in Fort Pierce, FL in late March 2015. Unfortunately only 5 adults were reared from the larvae and a colony was not established. In Indonesia, 247 stems galled by *Orseolia javanica* (Diptera: Cecidomyiidae) were collected and hand-carried to the Fort Pierce quarantine. Parasitoids (3 different species) emerged from the vast majority of galls and only 3 midges were obtained. A colony was not established.

Bromeliad Weevils: Monitoring of release sites for the parasitoid *Lixadmontia franki* (Diptera: Tachinidae) during this reporting period provided no evidence of the parasitic fly’s establishment.

Cycad Aulacaspis Scale: A petition for release from quarantine of *Phaenochilus kashaya* (Coleoptera: Coccinellidae) was denied by APHIS. However, consideration for release on Guam will be considered.

*OBJECTIVE 3. Implementation, evaluation, and enhancement (e.g., conservation) of biological control.*

Air potato: In collaboration with USDA/ARS and the Florida Department of Agriculture and Consumer Services, UF/IFAS released 116,095 air potato leaf beetles (*Lilioceris cheni*) at 1100 locations in Florida in 2015.

Hydrilla: Laboratory experiments with the stem miner *Cricotopus lebetis* (Diptera: Chironomidae) have continued to improve methods of mass rearing and release. Two experiments were conducted in 2015 to determine the survival of larvae once hatched prior to placing on hydrilla. For the first experiment, three egg masses were isolated individually in Petri dishes and the larvae were left to hatch. Once hatched 60 larvae were placed into individual wells of three 96-well plates (one for each egg mass or replicate) and survival was monitored daily. The experiment was replicated three times, across several weeks. Larvae began to hatch by day 2, by day 3 only 50/60 were alive, by day 40 only 39/60 were alive and by day 5 only 8/60 were alive. A second experiment looked at the development of those surviving larvae on hydrilla. Again three egg masses were isolated individually in Petri dishes and the larvae were left to hatch. Once hatched larvae were remove daily and placed in test tubes filled with well water with one hydrilla tip. Each day 10 larvae were removed until there were no live larvae remaining in the dish. Tubes were monitored daily after day 10 for development to pupation and adult 11

eclosion. The experiment was replicated three times, across several weeks. Average midge emergence declined with increasing time since the eggs were laid, again larvae began to hatch by day 2 and if placed immediately on hydrilla ~50% of adults emerged, if left until day 3 less than 20% of adults emerged and by day 4 less than 5%. If larvae were left to day 5 there was no adult emergence. Therefore, midge larvae must be used relatively quickly once hatched and cannot be stored as this will have impacts on their survival and subsequent development. A manuscript of the findings is being prepared.

An impact study was completed in the greenhouse setting to investigate the impact of the midge when applied alone to hydrilla. Four cages were set up, two controls and two with midges added. Midges were added as recently laid egg masses of approximately 100 fertile eggs. Each cage had approximately 100 larvae to 500 hydrilla stem tips in aerated well water in a tray. After 10 days the cages were monitored daily for adult emergence. Adults were counted and removed from the cage. After 30 days the tips were dissected to look for larvae and tip damage. *Cricotopus lebetis* was already present in the field collected hydrilla so the experiment tested the impact of augmenting the natural population. The natural population resulted in 36% damage, which doubled to 74% when one midge per five tips was added to the hydrilla. The addition of 100 fertile eggs, therefore, resulted in the damage of 190 tips, or 38%. Each larva has the potential to damage approximately two dips during development.

An experiment was completed to see if water type or hydrilla biotype could provide a barrier to midge survival. Hydrilla and water samples were collected from a potential release site in Martin Co. Florida. A test tube experiment was set up including the treatments UF hydrilla and UF well water (control), UF hydrilla and study site water, study site hydrilla and UF well water and study site hydrilla and water. Each treatment combination was repeated with larvae from three different egg masses, 10 larvae per egg mass. Adult emergence was highest for the treatment of study site water and UF hydrilla (77%) and lowest for UF well water and UF hydrilla (40%), not surprisingly tip damage followed the same trend but with 93% and 63% for the same two treatments, respectively. Therefore, it appears as though a release site with different hydrilla and water would not hinder biological control agent success. In fact, the additional nutrient in the water may provide an additional advantage to the developing midge.

Throughout 2015, midges were supplied at regular intervals to a release site in Hillsborough Co. Florida. In late 2015, a sample of hydrilla was collected in water from one of the ponds and shipped to the lab. Midge presence and damage were confirmed in the hydrilla samples at a rate of 50% infestation.

In 2015, 12 limnocorrals were built and established in ponds at the UF/IFAS Center for Aquatic and Invasive Plants. A limnocorral is a plastic tube attached to a floating ring and weighted down to create a mesocosm within the water column. In each of three ponds there were four limnocorrals. Treatments were applied to these limnocorrals in three experiments throughout the year. One replicate of each treatment was placed in each of the three ponds. Experiment 1: Control, midge, fungus, midge+fungus; Experiment 2: Control, midge, herbicide, midge+herbicide; Experiment 3: Control, midge+fungus, midge+herbicide, and midge+fungus+herbicide. Between each experiment the limnocorrals will be removed, cleaned 12

and placed in a new pond. Results so far have shown that the midge+fungus combination is the most damaging to the hydrilla with an average reduction in biomass of ~70%.

Another study was undertaken to determine if the feeding action of *C. lebetis* on hydrilla (*H. verticillata*) can reduce the competitiveness of this invasive weed in favor of the native species, *Vallisneria americana*. The study has four treatments 1. Control (*H. verticillata* present in a tank, but *C. lebetis* and *V. americana* absent); 2. Competition (*H. verticillata* and *V. americana* present in a tank, but *C. lebetis* absent); 3. Herbivory (*H. verticillata* and *C. lebetis* present in a tank, but *V. americana* absent); 4. Competition-herbivory (*H. verticillata*, *V. americana* and *C. lebetis*, all present in a tank*)*. Each treatment was replicated four times. Plants required for the above four treatments were planted in twenty 900-liter outdoor concrete tanks during the summer of 2014. The plants were cut back in July 2015. A month later, 1200 *C. lebetis* eggs were added into each tank. Shading and temperature parameters in each tank are monitored constantly using a Hobo® data logger. Insect populations were monitored monthly, and plants were harvested after 16 weeks. Root, stem, tuber and turion biomass were measured and compared among treatments.

Asian Citrus Psyllid: Fifth instar nymphs of *Diaphorina citri* appear to be the preferred host instar and yield the largest *Tamarixia radiata* progeny with the greatest percentage of females; the use of fifth instar *D. citri* nymphs is recommended for mass rearing of *T. radiata*.

Mole Cricket: During the approximately 34 years of the Mole Cricket Biological Control Project (MCBCP) (1979 to 2012), about $8.7 million was spent on faculty salaries and operating costs and the overall annual savings in control costs was estimated to be $13,609,698; a first year benefit: cost ratio of 1.6:1. Applying a 3% social discount rate (perpetual benefit), the MCBCP will save cattle producers $453 million for a long-term benefit-cost ratio of 52:1.

Whiteflies: (DNA barcode development for three recent exotic whitefly (Hemiptera: Aleyrodidae) invaders in Florida)- Several new whitefly (Hemiptera: Aleyrodidae) species have become established in Florida in the past decade. Three of these: fig whitefly (FW), rugose spiraling whitefly (RSW) and Bondar's nesting whitefly (BNW) have caused noticible damage to residential plants in the landscape including ficus hedges, palms and bird of paradise. Whiteflies are difficult to identify and fourth instar nymphs are needed for morphological identification making whiteflies good candidates for identification via DNA barcoding. A DNA barcoding cocktail to amplify the 5? end of the coxI mitochondrial gene from these species was developed. Subsequently, primers were developed for each species, validated with multiple populations collected throughout Florida, and a phylogenetic tree was constructed for placement of the three species in the whitefly tree of life. Besides FW, RSW, and BNW; two additional species of whiteflies were detected in collections, *Paraleyrodes pseudonaranjae* Martin (Hemiptera:Aleyrodidae), and a species provisionally designated Aleurodicinae sp1. RSW and BNW clustered with congeners within the phylogeny and FW was resolved as a possible sister taxa to the genus *Bemisia*. The barcoding cocktail should allow sequencing of 5? coxI from multiple genera and both sub-families of whiteflies and the primers developed for each species will facilitate rapid identification of these three invasive WFs.

(Rugose Spiraling Whitefly Field Trials - New Invasive Exotic Pest in Florida Landscape)-

The pathogenicity of a naturally occurring entomopathogenic fungus, *Isaria fumosorosea* (PFR 97®) alone and in combination with an insect growth regulator (Talus®) was evaluated against a 13

new invasive pest rugose spiraling whitefly (RSW) under field condition in the fall 2014 and spring 2015. Talus treatments, Talus alone or in combination with PFR was found to be more effective on RSW life stages than PFR alone. Overall seasonal mortality in three treatments ranged between 34-83% for PFR, 41-99% for Talus and 55-100% in PFR + Talus treatment. PFR was found inconsistent in regulating RSW life stages and it was effective until 3-6 weeks after application of treatment (WAT). Talus alone or in combination with PFR significantly suppressed RSW life stages soon after application of treatments and were effective until 8-10 WAT. Results suggest that Talus alone and in combination with PFR could be efficacious against RSW and would help mitigate the spread of this pest in Florida.

(Entomopathogenic Fungus Compatibility Trials)- The compatibility of five different petroleum spray oils with *Isaria fumosorosea* - (PFR-97) PFR were assessed using two different lab assays. Compatibility assessment was done based on the spore viability via colony forming units (CFUs) and radial growth (mm) when the products were mixed together, compared to PFR alone with water only. Four out of five products were found compatible with PFR. However, the same products mixed with PFR did not show any significant differences with PFR alone when assessed using the radial growth over the 12 day observation period for both trials.

Whiteflies, Broad Mite, Thrips, and Aphids: (Susceptibility of ornamental pepper banker plant trials (multiple studies)- The suitability of four ornamental pepper banker plant candidates, Black Pearl (BP), Explosive Ember (EE), Masquerade (MA), Red Missile (RM), and a commercial pepper cultivar Blitz (BL) were assessed with three objectives: 1) determine susceptibility against three major arthropod pests of agricultural importance, *Bemisia tabaci*, *Polyphagotarsonemus latus* and *Frankliniella occidentalis*, 2) evaluate pest abundance in the presence of predatory mite *Amblyseius swirskii*, and 3) determine the interplay between pest damage to hosts’ physical characteristics and *A. swirskii* abundance. In choice and no-choice assays, BL and BP were highly susceptible to *P. latus* attack with a moderately high damage rating index of > 3.5/5, and *B. tabaci* and *F. occidentalis* were abundant on BL and EE. The presence of *A. swirskii* greatly reduced the abundance of pests on pepper cultivars. RM and MA exhibited significantly higher *A. swirskii* densities compared to other cultivars. When the effect of *P. latus* on the banker plants’ physical characteristics was assessed, significant reduction in leaf area and tuft domatia/leaf was observed in all the cultivars. Although all ornamental pepper cultivars exhibited varying degrees of susceptibility against different pests, if used strategically, cultivars MA and RM can efficiently harbor *A. swirskii* populations and reduce multiple pests in the greenhouse or interiorscape conditions. This study provided new information and supportive evidence to the available literature on the suitability of ornamental pepper cultivars as potential banker plant candidates for sustainable management of various arthropod pests of agricultural importance.

(Application of Predator-in-First (PIF) approach in commercial production of pepper)- PIF is a novel approach towards establishing predators before the appearance of pests in an agro-ecosystem. PIF utilizes the characteristics of type III generalist phytoseiid mites such as *Amblyseius swirskii*, which can survive on pollen and nectar provisioned by its host plant, and establish in the absence of their prey. Researchers at the University of Florida in collaboration with USDA-ARS, U.S. Horticultural Research Laboratory in Fort Pierce, Florida tested PIF approach of pest management in greenhouse and field pepper production systems. PIF approach 14

was found to be successful in managing multiple pests of pepper (whitefly, thrips, broad mite) in both greenhouse and field conditions. In a greenhouse, a single application of predatory mites was sufficient for mite establishment on host seedlings and providing effective suppression of the pest population. However, an augmentative release of mites was required under field conditions. Results obtained during different pepper growing seasons (spring and fall) suggests that PIF can be an effective pest management tool for pepper growers in the fall season when the climate is suitable for mite reproduction and population growth, but it may not be as efficient in the spring season when frequent cold fronts and intermittent low temperatures can occur during the field production of pepper.

(Entomopathogenic Fungus Compatibility Trials)- The compatibility of five different petroleum spray oils with *Isaria fumosorosea* - (PFR-97) PFR were assessed using two different lab assays. Compatibility assessment was done based on the spore viability via colony forming units (CFUs) and radial growth (mm) when the products were mixed together, compared to PFR alone with water only. Four out of five products were found compatible with PFR. However, the same products mixed with PFR did not show any significant differences with PFR alone when assessed using the radial growth over the 12 day observation period for both trials.

Whiteflies and aphids are important insect pests in vegetable crops. Laboratory olfactometer or odor detecting tests showed that mustard*, Brassica juncea* (var. Caliente 19 and Giant red mustard) and arugula, *Eruca sativa* (var. Nemat) plants are promising repellent plants against the sweetpotato whitefly, *Bemisia tabaci*. Preliminary analysis of a field study on annual ornamental plants, sweet alyssum, *Lobularia maritima*, intercropped with kale revealed the most abundant predatory hoverflies to be *Toxomerus marginatus,* followed by *Allograpta oblique*, and 5 other species*.* Our results indicate that use of companion and natural enemy refuge plants are promising cultural management techniques in an integrated pest management program to control vegetable insect pests such as whiteflies and aphids.

Mexican Bromeliad Weevil: Growth and oviposition rates and survival of the bromeliad-eating weevil *Metamasius callizona* were measured at a range of temperatures to determine optimal temperature range, lower and upper developmental thresholds, and degree-days needed for maturation. Optimal temperature range for growth was 25-30 °C and for oviposition 22-33 °C. Lower developmental threshold was 13 °C and upper threshold was about 35 °C. Development from egg to pupa required 518 degree-days and from pupa to adult 140 degree-days. Adult weevils suffered higher mortality at 35 °C than at 25 or 16 °C. Typical winter conditions likely only affect weevil populations in central Florida and not in southern Florida, but only minimally. As well, high summer temperatures could potentially cause weevil mortality due to heat stupor but, as with winter temperatures, the effects would be minimal. Extremely cold winters may cause heavy weevil mortality, particularly in central Florida. Likewise, extremely high summer temperatures could cause increased weevil mortality. Sea breezes on the East Coast of Florida may create cooler habitat during the summer and therefore less mortality due to summer temperatures.

Fertility was measured for 48 female weevils. The average pre-oviposition period was 21 days, and the average adult lifetime was 173 days. The total number of eggs collected was 4,263 eggs; 74% of the eggs (3,147) were inserted in the host plant leaf, and 26% were laid outside the leaf. 15

Larvae emerged from 2,496 (79%) of the eggs that were oviposited inside the leaf. Larvae emerged from less than 4% of the eggs that were laid outside the leaf. Females tended to lay fewer eggs inside the leaf and more outside the leaf as they aged (past about 120 days old). Growth, development, and oviposition rate of the Mexican bromeliad weevil have been tested on the Florida and Central American (Belize) forms of *T. utriculata*. These studies allow us to understand the demographics of MBW in Florida and hypothesize why it is a pest in Florida but not in Central America.

Yellowmargined leaf beetle: Two trials were conducted to test the effect of three entomopathogenic fungi, *Isaria fumosorosea*, *Metarhizium anisopliae*, and *Beauveria bassiana*, on the fecundity and fertility of females of the yellowmargined leaf beetle, *Microtheca ochroloma*, when applied topically. Formulations commercially available that contain spores of these entomopathogens were diluted to obtain a concentration of 1 X 106 spores. Adult female beetles (10 days old) were dipped in the solutions. An untreated male and a treated female were kept in a container and provided with food. The number of eggs produced and percentage of eggs hatching were during each female’s lifetime. Six insects per treatment were used in each of two trials. The total number of eggs oviposited per treatment differed considerably between trials. In the first trial, the average number of eggs laid was highest in the *I. fumosorosea* treatment followed by the control, *M. anisopliae*, and *B. bassiana*. In the second trial, the total number of eggs laid was statistically similar among treatments. In the first trial, the percentage of emergence varied from 32% to 83%, while in the second trial it varied from 62% to 79%. Additional trials need to be conducted to understand the effect of these entomopathogens on *M. ochroloma* fecundity and fertility.

Ambrosia Beetles: Two different sets of bioassays (dipping beetles and dipping paper disks) were conducted to determine the time that each of three commercial formulations of entomopathogenic fungi, *Beauveria bassiana* (BotaniGard® ES), *Isaria fumosorosea* (PFR 97® 20% WDG), and *Metarhizium brunneum* (Met F52 ES), take to cause mortality of the ambrosia beetles *Xylosandrus crassiusculus* (*Xc*) and *Xyleborus volvulus* (*Xv*). The spore densities of the fungal solutions in the different bioassays were all similar (2.4 x 106 spores/mL). The treatment with lowest mean survival of beetles dipped in fungal solution was *Beauveria < Metarhizium < Isaria* for *Xc* and *Beauveria* = *Metarhizium* < *Isaria* for *Xv* (Figure 34). The treatment with lowest mean survival of beetles consuming treated filter paper was *Beauveria* = *Metarhizium* = *Isaria* for *Xc* and *Xv*.

The conidia of *Beauveria* and *Metarhizium* persisted up to 21 days after treatment (DAT) on avocado bolts under field conditions; however, more *Isaria* colony-forming units (CFUs) appeared 21 DAT than at 1 DAT. At 21 DAT, CFUs of *Isaria* were also found in plates with bark samples from the *Beauveria* and control treatments. This suggests that the *Isaria* blastospores germinated on the bark of the avocado bolt and then formed aerial conidia which dispersed to the other treatments. Field trials are being continued.

Sri Lankan Weevil: A laboratory bioassay evaluated six commercial products (treatments) for toxicity to adults of the polyphagous herbivore *Myllocerus undecimpustulatus undatus*. The products were: suspensions of three entomopathogenic fungi, *Isaria fumosorosea*, *Beauveria bassiana*, and *Metarhizium anisopliae*; solutions of three OMRI-approved insecticides, spinosad, 16

pyrethrum, and azadirachtin; carbaryl; and water only. The materials were applied directly to *Chysobalanus icaco* (cocoplum) leaves. Weevils were assessed at 14 days post-treatment to determine mortality and product efficacy. Five trials were performed. The spinosad and *B. bassiana* provoked 80% and 70% mortality, respectively. Mortality rates in the azadirachtin and carbaryl treatments were 35% and 28%, respectively. Weevils in the pyrethrum, *M. anisopliae*, and *I. fumosorosea* treatments suffered 18-21% mortality. The mortality rate in the water only control was 8%.

Green Croton Scale: Our objective was to evaluate the control efficacy and compatibility of *Thalassa montezumae* and *Isaria fumosorosea* using laboratory and greenhouse bioassays applied to green croton scale-infested croton plants. There were no significant differences between survival times for 21 days between the beetle life stages dipped in a *I. fumosorosea* suspension compared to those in water. Overall, the mean survival time in days for larvae dipped in *I. fumosorosea* was 19.7 ± 0.8 and in water was 18.5 ± 1.1, whereas for adults it was 18.8 ± 0.8 compared to 18.0 ± 0.8, respectively. A significantly higher number of colony-forming units (CFUs) resulted from *I. fumosorosea*-contaminated adult beetles compared to contaminated larvae. No CFUs were detected in the control plates. All plates with *I. fumosorosea*-contaminated *T. montezuma* adults roaming on the plate agar surface displayed a trail of *I. fumosorosea* CFUs. None of the plates with larvae contaminated with *I. fumosorosea* blastospores displayed any CFUs, only saprophytic fungi or bacteria.

Mortality rates of green croton scale in the three treatments with biological control agents were significantly higher (*P* < 0.05) than the mortality rate in the control treatment. The mean mortality rates of the scale when the beetle predator was released, either alone or in combination with the fungus, were not significantly different. However, the combination treatment had a higher mortality rate compared with the treatment of *I. fumosorosea* only. In addition, mortality rates of the scale for the treatments of either *I. fumosorosea* or *T. montezumae* alone were similar.

The mean number ± SE of *T. montezumae* larvae dead after 10 days in the treatments of *T. montezumae* alone and Ifr + *T. montezumae* for all three trials was 0.3 ± 0.2. Only in the firstst trial did predator mortality occur but it was similar between treatments with (1.0 ± 0.5) and without (0.8 ± 0.4) the fungus. There was no predator mortality in the second and third trials.

**UTILITY OF FINDINGS**

Air potato: A statewide survey revealed a wide spatial distribution of the air potato biological control agent, *Lilioceris cheni*, in most of peninsular Florida, but little or no damage in the panhandle or in far south Florida. These results will be used to better target future releases to areas where beetles are not yet established or density is low.

Brazilian peppertree: Petitions to release two natural enemies (*Pseudophilothrips ichini* and *Calophya latiforceps*) have been submitted to the Technical Advisory Group for Weed Biological Control and we are awaiting outcomes of the review process. The host ranges and biologies of two other candidate agents are under investigation. Results of the host range tests 17

and impact study suggest the stem boring weevil *A. pipitzi* is a viable candidate for biological control of Brazilian peppertree. Colonies of thrips *P. ichini* and the psyllids are being maintained for species description (*Calophya* sp.), host range and temperature tolerance studies (*C. terebinthifolii*, *Calophya* sp.) and/or anticipation of field release (*C. latiforceps*).

Cogongrass: The exploration for natural enemies of cogongrass over the past several years has identified several natural enemies which are thought to be specialists. Future efforts need to be directed at developing effective rearing methods so that laboratory based host range testing can be initiated.

Hydrilla: a) Storage of eggs and larvae destined for field release should be avoided. (c) Water type and hydrilla type had no negative impact on the survival of colony midges and so the colony appears to be able to adapt well to new conditions (d) The midge established in Hillsborough Co. Florida (e) Incorporating proven biological controls like the fungal pathogen Mt and the hydrilla stem miner *C. lebetis* into an integrated weed management strategy could reduce overreliance on herbicides and provide a more sustainable solution to the hydrilla problem.

Asian Citrus Psyllid: The efficiencyis improved for mass rearing *Tamarixia radiata* by the Florida Department of Agriculture and Consumer Services, Division of Plant Industry and other states and countries for biological control of the Asian citrus psyllid, *Diaphorina citri*.

Mole Cricket: Due to prudent investments made in the MCBCP, parasitized and infected mole crickets continually reestablish the three biological control agents in infested pastures as pest populations build and there is no recurring cost to the cattle producers.

Whiteflies, Broad Mite, Thrips and Aphids: These studies enable us to better identify what invasive species are infesting protected agriculture/horticulture prodcution and develop IPM programs specifically for them. We also are able to utilize natural enemies that are not commercially available. These research areas also will complement cultural techniques such as use of “push-pull” strategies to control whiteflies and other insect pests in vegetables in an integrated pest management program.

Mexican Bromeliad Weevil: Establishment of the Honduran parasitic fly *L. franki* will save populations of native Florida bromeliad species which are currently threatened and endangered due to the presence of the Mexican bromeliad weevil in the state. Information from biological studies of the weevil will help us better understand the ecology of the pest, as well as improve our method for mass-rearing *L. franki*. The studies on development and host-plant interactions of the weevil allow us to understand the demographics of MBW in Florida and hypothesize why it is a pest in Florida but not in Central America.

Yellowmargined leaf beetle: The research on entomopathogenic fungi provides knowledge on the best biopesticide that organic growers of cole crops can apply to diminish populations of the pest beetle and increase yield and profitability of their produce.

Ambrosia Beetles: The research on entomopathogenic fungal strains will determine those that are infective against the red bay ambrosia beetle under field conditions, cause epizootics, and reduce 18

brood production in infested natural areas and commercial avocado groves. Biological studies will provide greater insight into biological control agent/pest interactions.

Sri Lankan Weevil: The research on entomopathogenic fungi provides knowledge on the best biopesticide(s) that peach growers, nurseries, and homeowners can apply to diminish populations of the pest weevil and increase yield and profitability of their produce and protect their gardens.

Green Croton Scale: The entomopathogenic fungus *Isaria fumosorosea* and the lady beetle *Thalassa montezumae* are both efficacious biocontrol agents for management of the green croton scale on croton plants. However, when *I. fumosorosea* is sprayed first and then combined with beetle predators, there seems to be an additive mortality effect against the scale insects. Also, after beetle adults and larvae were dipped directly in the fungus (simulating direct spray contact) or larvae exposed to fungal residue on the plant surface post-release under greenhouse conditions, the fungus had little or no negative effect on predator mortality. Therefore, spraying *I. fumosorosea* prior to releasing *T. montezumae* is an effective and compatible biological control strategy for management of the green croton scale on croton plants. It provides an alternative to using synthetic chemical pesticides which may be harmful to both the biocontrol agents as well as the environment.

**WORK PLANNED FOR NEXT YEAR (2016)**

Air potato: Releases of *Lilioceris cheni* will continue and target areas in the panhandle and far south Florida where beetles were absent or at very low density during a survey in the fall of 2015.

Brazilian peppertree: Travel to Brazil during August- September to continue monitoring the impact of the psyllid *C. terebinthifolii* on Brazilian peppertree as part of a native range pre-release efficacy assessment, and study the biology of the weevil *Apocnemidophorus blandus*, a congener of *A. pipitzi.* Continue maintaining a colony of the stem boring weevil *A. pipitzi* and prepare / resubmit a petition to TAG requesting field release. Revise and resubmit manuscript on the biology of *A. pipitzi* and its impact on Brazilian peppertree. Complete host range testing of *C. terebinthifolii* and prepare formal description of a newly discovered *Calophya* sp. Prepare and submit manuscript on host range of the leaf roller *Episimus unguiculus*.

Cogongrass: A second visit to Indonesia is scheduled for February 2016 to collect *Orseolia javanica* and hand-carry back to a quarantine laboratory in Florida. Collaborators in Japan will continue to try and collect and ship *Acrapex azumai* to Florida.

Hydrilla: A manuscript of the findings of the midge survival study will be prepared and submitted to Florida Entomologist. Midge releases will continue in Hillsborough Co., Florida and the ponds will be resampled to determine if the midge was able to overwinter. Limnocorral experiments will continue with an emphasis on confirming the effect demonstrated with the midge+fungus combination. Complete the competitive interaction study between the midge, hydrilla and the native eelgrass (*V. Americana*), and a study to determine the maximum depth the midge is capable of attacking hydrilla. 19

Asian Citrus Psyllid: Data analysis and publication of research on production and evaluation of *Tamarixia radiata* is planned for 2016*.*

Mole Cricket: No research on exotic invasive mole crickets is planned for 2016.

Whiteflies, Broad Mite, Thrips, and Aphids: Continue with the same lines of investigation, develop new management plans based on evaluations of pesticide rotations and the impact of pesticides on natural enemies. We also will evaluate the use of commercial products such as “preda-lure” and annual ornamental plants such as sweet alyssum in attracting beneficial insects to control whiteflies and aphids in vegetable crops.

Yellowmargined Leaf Beetle: We will evaluate non-crucifer extracts to repel or mask host plant odors to reduce damage caused by the beetle, and the effect of those extracts on the occurrence of predators in the field. Additional trials will be conducted to better evaluate the effect of entomopathogenic fungi on *M. ochroloma* fecundity and fertility.

Ambrosia Beetles: Our goals are to 1) determine antagonisms and potential complimentary and/or synergistic relationships between entomopathogenic fungi and the fungicides used by avocado growers, 2) use this knowledge to improve efficacy of entomopathogenic fungi used by avocado growers, 3), and 4) engage more growers into using entomopathogenic fungi in an integrated management approach. Surveys, workshops, and participatory research will be used to promote the integrated use of entomopathogenic fungi by avocado growers.

Sri Lankan weevil: A project proposal will be submitted to the Specialty Crop Block Grant Program to conduct research on novel strategies using entomopathogenic fungi and nematodes to control the Sri Lankan weevil in peach groves. The objectives of the project will be 1) evaluate native and commercially available species of entomopathogenic bacteria, fungi, and nematodes to determine the most pathogenic against the Sri Lankan weevil larvae and pupae under laboratory conditions, 2) evaluate suites of entomopathogens in greenhouse trials, and 3) initiate long-term trials in the field that employ conservation biological control tactics for certain entomopathogenic nematodes in combination with regular augmentation of other entomopathogenic nematodes, fungi, or bacteria (individually or combined) when necessary. If approved for funding, the project would begin in late 2016.

Cycad Aulacaspis Scale: A petition for field release of *Phaenochilus kashaya* on Guam will be submitted for consideration by APHIS.

**PUBLICATIONS (2015)**

**Refereed Journals:**

Amalin, D. M., L. Averion, D. Bihis, J. C. Legaspi, and E. F. David. 2015. Effectiveness of kaolin clay particle film in managing *Helopeltis collaris* (Hemiptera: Miridae), a major pest of cacao in the Philippines. Florida Entomologist. 98(1): 354-355.

Avery, P. B., M. S. J. Simmonds, and J. Faull. 2015. Comparative growth and efficacy 20

of Trinidadian strains of *Isaria fumosorosea* blastospores for controlling *Trialeurodes vaporariorum* on bean plants. Journal of Biopesticides 8: 1-12.

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**S-1058 ANNUAL REPORT FOR 2015 AND PLANS FOR 2016**

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**ACCOMPLISHMENTS**

**Objective 3**. *Implementation, evaluation, and enhancement of biological control.*

**Giant Salvinia**

**Cross Lake.** The salvinia weevil, *Cyrtobagous salviniae* Calder and Sands, was imported into the US for control of the invasive aquatic fern, giant salvinia (*Salvinia molesta* Mitchell). On 8 April 2015, an estimated 21,970 weevils were released at a single site on Cross Lake. The release area and surrounding giant salvinia had been boomed off to prevent movement of the salvinia from the release area. Salvinia was sampled for weevils at the release site on 27 May, 25 June, 9 and 30 July, and 2 and 30 September. Salvinia samples were hand-grabbed and placed in 3.78 L Ziploc® bags with 3-4 samples taken from the release site on each sample date. Samples collected were returned to the lab and placed in a Berlese funnel to determine the number of weevils per kg of giant salvinia During 2015, the weevil population increased from 7.2 weevils/kg salvinia (27 May) to a peak of 28.4 (2 September) before declining to 4.2 (30 September) (Fig. 1). 27

Figure 1. Salvinia weevil light trap captures and weevils/kg

giant salvinia on Cross Lake during 2015.

A bucket-style, black light trap was operated from 24 June through 23 September and checked weekly. Black-light trap captures increased from 8 weevils (week ending 1 July) to a peak of 29 weevils (week ending 30 July). Despite high weevil density at the site after 30 July, the number of weevils captured in the light trap did not exceed 6 weevils per weekly period for the remainder of the sampling period. By late September, sampling was difficult because much of the mat in the initial release area had submerged and the area had been taken over by other aquatic plants and terrestrial plants that had rooted in the salvinia mat (Photo 1). This likely occurred as a result of the large and dense salvinia mat that had built up against the boom. Although the weevils had spread from the initial release area, their numbers were low outside this area.

Photo 1. By mid-October the release area looked like a

meadow with terrestrial sedges, grasses, and

wild flowers. 28

**Lake Bistineau.** In mid-December 2015, 4 floating PVC enclosures were installed on Lake Bistineau. The enclosures contained salvinia and weevils. Two of them were covered with plant protection cloth of two different thicknesses. The other two were left uncovered. One open enclosure and the two cloth covered enclosures contained weevils from our greenhouse colony originally established from weevils from south Louisiana. The other open enclosure contained weevils from our “cold-tolerant’” colony collected from Cross Lake in January of 2013. All four enclosures have Hobo temperature loggers in them to monitor air and water temperature. In late March or early April 2016, samples will be collected from the four enclosures to determine weevil survival.

**Cold tolerance of the salvinia weevil from foreign locations.** Since 2010 LSU has led the research and implementation of a biological control program using the giant salvinia weevil (*C. salviniae*). Successful control of giant salvinia using the salvinia weevil has been achieved in southern Louisiana. However, winter mortality is a major limitation for the survival of this weevil in central and northern regions of the state. To address this problem, we are evaluating the cold tolerance of populations from Australia, Argentina, and Uruguay.

**Foreign exploration of weevils.** Using a climate model, we found that winter temperatures in northeastern Argentina, central Uruguay and the higher elevations of southern Brazil are similar to those experienced in central and north Louisiana (**Fig. 2**). Since February of 2015, we are collaborating with scientists in southern Brazil (FURB), a research institute in Argentina (FUEDEI), and the Department of Agriculture in Uruguay (INIA). These institutions facilitated the procurement of collecting permits and will assist during field work which include the access to known populations of giant salvinia. We also have an import permit to bring salvinia weevil populations from the United States Department of Agriculture. A trip to Uruguay was conducted from Nov. 15 to the 20th. We meet with scientists at INIA, gave a talk and explored the region of Treita y Tres. This region has extensive canals and waterbodies. We found several sites with *Salvinia* spp., probably *Salvinia minima* and *Salvinia biloba*. Despite collecting more than 30 samples from six locations, we could not find *C. salviniae*. Reasons could be that we sampled early in the summer.

**Figure 2**. Similarity of minimum temperature during the coldest month between locations with Salvinia in Louisiana and South America. 29

Mariel Guala from FUEDEI in Argentina visited LSU in October 2015 and exchanged outcomes of the field exploration and rearing conditions at Buenos Aires. In October 2015, scientists from FUEDEI confirmed the presence of *C. salviniae* in the province of Entre Rios (**Fig. 3**)*.*

**Figure 3.** Visit of Mariel Guala from FUEDEI and map of northeastern Argentina showing locations of *C. salviniae* populations.

**Evaluation of winter cover fabrics for cold protection.** This research focuses on a practical approach to protecting cold-susceptible weevils over the winter. It has been previously observed that the Brazilian (via Australia) weevils that were introduced in the southern U.S. to control giant salvinia have been very effective biocontrol agents and have successfully overwintered in the southernmost areas of their release range. However, they have been unsuccessful in surviving the winters in areas north of the 32° latitude line. Currently, in order to achieve biological control of giant salvinia in northern regions of Louisiana, Texas, and nearby states, weevils must be transported from southern overwintering sites every year and re-released in the spring. Our goal is to find a practical method of protecting weevils in designated overwintering refugia to facilitate local recolonization of the salvinia mats in northern sites. We evaluated agricultural row cover as a means of insulating weevil-infested salvinia mats to provide a more favorable microclimate for overwintering. The goal of the first experiment was to evaluate three thicknesses of row cover on plant quality in a controlled (greenhouse) setting to determine the optimal level of insulation and light intensity that will best favor plant growth.

Uncovered treatments exposed to freezing temperatures had statistically higher mortality than all other treatments (**Fig. 4**). Lowest water surface temperature recorded was -1°C. A control treatment was kept uncovered at a constant temperature of 13°C to observe levels of mortality that would occur with no freeze exposure. Survival in all treatments was very high. Uncovered containers experienced the highest mortality after freeze exposure. Mortality in all three fabric treatments was statistically equivalent to mortality in the 13°C control. 30

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**Figure 4.** Average mortality by treatment after 10h exposure to freezing temperatures.

**Describe the reproductive changes of *C. salviniae* over time.** We are monitoring the reproductive status of *C. salviniae* in central and south Louisiana. Results from field sampling in Marrero and Lena, LA show a decrease in percent gravid females over time (**Fig. 5**). Southern weevils from Marrero had a notably higher frequency of gravid females in comparison to central/northern weevils from Lena on both sampling occasions. We hypothesize that the broad difference in gravid females is due to poorer plant quality and colder temperatures at the central/north site. Further analysis of temperature data from HOBO data loggers and photographs of plant quality will help explain the trends.

**Figure 5.** Percent gravid female *C. salviniae* collected from Marrero and Lena, LA in December 2015 and January 2016.

**Mass production and releases of weevils.** The goal of the LSU AgCenter is to mass produce weevils for our stake holders. Weevil rearing ponds were located at the LSU research station located in New Iberia, Idlewild and St. Gabriel (**Fig. 6**). We have established a quality control protocol for the rearing operation. To determine the quality of the females, we are recording the reproductive status of the females including presence or absence of immature eggs. 31

**Figure 6.** Mass rearing of the Salvinia weevil at the St. Gabriel Research Station.

**Emerald Ash Borer**

The emerald ash borer (*Agrilus planipennis* Fairmaire, Coleoptera: Buprestidae) is the most devastating pest of ash trees (*Fraxinus* spp.) in the United States. The recent detection of emerald ash borer (EAB) in Louisiana suggests that this pest has adaptations to colonize regions with warmer and longer growing seasons. Whether the climate of the Deep South will result in faster development rates (two generations) of EAB or negative impacts on introduced parasitoids remains unknown.

**Parasitoid releases.** During the spring of 2015, the emerald ash borer was reported in two sites in Webster parish in northern Louisiana. These sites are located in the northern (N 33.0167°, W -93.3152°) and central (N 32.6625°, W -93.3693°) regions of the Webster parish. Larvae as well as adults were collected from ash trees at these sites and later identified by taxonomists (USDA-APHIS). We obtained the USDA-APHIS-PPQ-526 permit to conduct the interstate movement of the parasitoids (R. Diaz permit # P526-15-02246) and added the information of the release sites to the database maintained by the USDA-APHIS Brighton EAB Biocontrol Rearing Facility in Michigan. We currently have the approval to receive and release *Oobius agrili* Zhang and Huang (Encyrtidae), *Spathius agrili* Yang (Braconidae) and *Tetrastichus planipennisi* Yang (Eulophidae) at both sites.

We released parasitoids at two private properties located in Webster parish. The owners have agreed to allow EAB trapping, and release and monitoring of parasitoids. The sites could be described as bottomland hardwood forest (**Fig. 7**). Both sites have active populations of EAB as indicated by the presence of larvae, pupae and adults in infested trees. Additionally, infested trees show classic EAB symptoms of presence of epicormic shoots, woodpecker activity, tree dieback, and adult exit holes. 32

c

b

a

**Figure 7.** Bottomland hardwood forest with ash trees infested with EAB (a), EAB damage (b) and EAB adult before emergence (c). Pictures taken on May 1st, 2015 in Webster Parish, Louisiana by R. Diaz.

**Crape myrtle bark scale**

The crape myrtle bark scale, *Eriococcus lagerstroemiae* Kuwana, is a new introduced insect pest of crape myrtle, *Lagerstroemia* spp. L. (Myrtales: Lythraceae). Native to Asia, the crape scale bark scale was first reported in 2004 on crape myrtles in a landscape plant nursery in Richardson, TX (Dallas CO.). In the next ten years, the scale has spread to 31 cities in eight states at a fast rate. Although direct feeding of the scale has not been shown to have detrimental effects to plant health, dense infestations are associated with sooty mold which significantly reduces the aesthetic value of crape myrtle.

**Discovery of parasitoids and natural enemies in Louisiana and China.**

During sampling at different locations in Louisiana, we found several natural enemies including two predators and one parasitoid (**Fig. 8 A, C, E**). A cooperation between LSU AgCenter and the Beijing Forestry University was established for exploring natural enemies of CMBS in China. We found four parasitoids and one predator attacking CMBS in China (**Fig. 8 F-I**). Further investigation of the biology and ecology of these natural enemies can be used to design the biological control program for CMBS. Field observations in Houma and Shreveport revealed that the cactus lady beetle, *Chilocorus cacti*, is a common predator of the *E. lagerstroemiae*. Larvae and adults of this lady beetle prey on scale eggs and nymphs. In the laboratory, 4th instars can feed about 400 scale eggs in 24 hours. 33

**Figure 8.** Natural enemies of CMBS found in Louisiana and China. A and C are predatory ladybeetles found in Louisiana, and B and D were the larvae of A and C feeding the eggs of CMBS, respectively. E is the parasitoid found in Louisiana. F - I are natural enemies found in Beijing, China. J is the damage caused by natural enemy complex in China.

**Mentoring and Teaching**

To conduct research on Biological Control, we put together a great team of young scientists in 2015 (Table 1).

|  |  |
| --- | --- |
| Table 1. Graduate students and postdoctoral associate conducting research on Biological Control in the Department of Entomology at LSU. **Student name/ degree**  | **Project**  |
| Zinan Wang, Masters  | Biology and Ecology of the crape myrtle bark scale  |
| Alana Russell, Masters  | Cold tolerance of the salvinia weevil  |
| Lori Moshman, Masters  | Evaluation of overwintering refugia for the salvinia weevil  |
| Balwinder Kaur, Masters  | Monitoring the establishment of emerald ash borer parasitoids  |
| Yi Wang, Postdoctoral Associate  | Ecology of the salvinia weevil in Louisiana  |