



# Invasive Plant Management Section Research & Outreach Program Newsletter

Division of Habitat and Species Conservation

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## Newsletter Index

<b>IPR News</b>	<b>1</b>
<b><u>Aquatic Plant Research</u></b>	
<b>Algae</b>	<b>2</b>
<b>Salvinia</b>	<b>3</b>
<b>Cabomba</b>	<b>3</b>
<b>Hydrilla</b>	<b>4</b>
<b>Hygrophia</b>	<b>9</b>
<b>Nymphoides &amp; Rotala</b>	<b>9</b>
<b>Water hyacinth, lettuce</b>	<b>10</b>
<b>Wetland nightshade</b>	<b>10</b>
<b><u>Upland Plant Research</u></b>	
<b>Air potato</b>	<b>11</b>
<b>Brazilian pepper</b>	<b>11</b>
<b>Chinese tallow</b>	<b>12</b>
<b>Downey Rose Myrtle</b>	<b>13</b>
<b>Lygodium</b>	<b>13</b>
<b>Paragrass</b>	<b>16</b>
<b>Phragmites</b>	<b>16</b>
<b>Invasive Plant Ed.</b>	<b>17</b>

This research and outreach information, presented below, summarizes year end reports for studies that were funded by Florida’s Fish and Wildlife Conservation Commission (FWC) in fiscal year 2009-10 (July through June). Some of these studies are completed and are noted as such. Others are multi-year in nature and are continuing to receive FWC funding. Because these studies have not gone through the scientific peer-review process, and many are not complete, please consider this information to be preliminary at best and do not cite.

Please forward this research and outreach newsletter to ensure a wide distribution of this information. In addition, if there are avenues of research in the field of invasive plant management you believe are not being addressed or if you need a copy of a specific report, please email me your suggestions and/or requests (my email address and contact information are at the end of this newsletter) – *Don C. Schmitz, Editor*

## Invasive Plant Research News

**New biocontrol insect targets water hyacinth** - After undergoing a rigorous screening and regulatory process, a new insect was released by United States Department of Agriculture’s Agricultural Research Service (USDA-ARS) to control the South American water hyacinth (*Eichhornia crassipes*) in Florida. Dr. Phil Tipping, the project’s lead researcher, joined representatives from the Florida Fish and Wildlife Conservation Commission (FWC) and the U.S. Army Corps of Engineers at a May 18, 2010 event celebrating the insect’s release at the Edgefield Regional Stormwater Treatment Facility owned by the St. Johns River Water Management District near Palatka, Fla. FWC provided more than \$300,000 in financial support for this biological control research project.

*Megamelus scutellaris* is a small plant hopper native to South America whose nymphs and adults feed on the sap of water hyacinth. Their damage apparently creates a choke point between the leaf and petiole (see photos below) interfering with translocation between the leaf and root system.



**The Aquatic Plant Management Society celebrated its 50<sup>th</sup> Anniversary this past July. It is the world’s first scientific society to address invasive species management in natural areas.**



Dr. Phil Tipping, USDA-ARS, on the left showing Mr. Jim Jeffords, U.S. Army Corps of Engineers, *Megamelus scutellaris* damage on water hyacinths and a close up of the insect damage on the water hyacinth leaves (right photo).

## The "Richardson Lily"



**Palm Villa, 1947**



**Pam Villa, 2010**

Water hyacinth may have been in New Orleans before the World's Industrial and Cotton Centennial Exposition (1884-85) which has been historically linked with its introduction into North America.

A New Orleans amateur botanist and plant collector and his wife, Dr. Tobias and Mrs. Ida Richardson, traveled to the Amazon River Basin and collected non-native plants and brought them to their home in New Orleans before 1884, one of which may have been the water hyacinth.

Their residence in New Orleans was known as "Palm Villa" because of the non-native palms planted on their property. They also had the Amazon water lily and water hyacinth in their ornamental pond at the time of the Exposition. Back then, circa 1880s and 1890s, water hyacinth in the New Orleans area was once known as the "Richardson Lily."

Source: *Aquatic Plant Management Society 2010 Annual Meeting, presentation by Mr. Don C. Schmitz, FWC.*



**Dr. Robert Pemberton in his office at the USDA-ARS lab in Ft. Lauderdale, Florida.**

**Dr. Robert "Bob" Pemberton Retires** - After a long, busy, and productive career as a Research Entomologist with the USDA-ARS and authoring more than 120 scientific papers, Dr. Bob Pemberton formally retired earlier this year. His association with the USDA began in 1975 on the Biological Control of Weeds Lab in Rome, Italy, and then in East Africa in 1976. In 1981, Bob was hired by USDA-ARS Biological Control of Weeds Lab, Albany, CA, where he worked on leafy spurge, Russian thistle, and *Passiflora mollissima*. From 1989-1993, Dr. Pemberton was the Director of the Asian Parasite Laboratory in Seoul, South Korea and worked primarily on gypsy moth and the aquatic weed *Trapa natans*. In 1994, Bob joined the Ft. Lauderdale, Florida Laboratory. Dr. Pemberton's research has been funded throughout the years by Florida's state government invasive plant management research program (now managed by FWC) along with the South Florida Water Management District and others. Bob's recent research involved looking for biological control agents that would target invasive non-native plants found on Florida's public conservation lands. His research resulted in the release of several insects targeting Old World climbing fern and an insect that will likely be released sometime this year aimed at controlling air potato. In addition, Bob plans to stay busy in retirement by still conducting research and will maintain an office at the USDA-ARS Ft. Lauderdale Laboratory.

## **Aquatic Plant Research**

### **Algae**

**Cyanobacteria and toxin transfer** - Research was initiated to determine whether the suspect avian vacuolar myelinopathy (AVM) toxin could be transferred from aquatic vegetation to bald eagles (*Haliaeetus leucocephalus*) or snail kites (*Rostrhamus sociabilis*) in Florida. Field monitoring was conducted to document the occurrence of the Stigonematalan cyanobacterium throughout sites where both apple snails (*Pomacea* spp.) and the endangered snail kites occur. Hydrilla with epiphytic cyanobacteria were collected during September 2009 from five lakes and a canal that have the invasive island apple snails (*P. insularum*) and snail kites co-occurring - Lake Orange, Lake Tohopekeliga, Lake Cypress, Rutland Canal, Lake Hatchineha, and Lake Kissimmee. **The Stigonematalan cyanobacterium was abundant on a site within Lake Tohopekeliga (Lake Toho).** Based on these screening results, there was a collection of an additional 14 samples for analysis from Lake Toho in November, 2009. The Stigonematales species was abundant (>50% leaf coverage) at two sites and present or common at 5 more. Additional potentially toxic cyanobacterial species were noted growing epiphytically on hydrilla leaves including *Pseudanabaena*, *Anabaena*, *Nostoc*, *Oscillatoria*, *Lyngbya*, *Microcystis*, and *Cylindrospermopsis*. Hydrilla and *Utricularia* leaves were screened for all algal species, but cyanobacteria were the dominant group,

with 87 species noted in the microscopy presence screening. The second phase of the project was to feed exotic island apple snails (*P. insularum*) hydrilla (*Hydrilla verticillata*) containing Stigonematales to determine impacts on the snails and potential for toxin transfer. **A VM suspect algae was documented throughout the digestive system of the apple snails and it was found present even after gut passage.** In order to determine the potential for disease, toxins are being tested in the tissues of the experimental snails. These tissues will also be used in future feeding trials to investigate the potential for cyanotoxin transfer to predators. Wilde, S.B., and R.S. Haynie. Epiphytic cyanobacteria and toxin transfer from algae growing on invasive aquatic vegetation to threatened and endangered species, Warnell School of Forestry and Natural Resources, University of Georgia, Athens, Georgia.

## Salvinia

**In vitro culture of *Salvinia minima*** - *Salvinia minima* is a floating fern native to Central and South America. It is considered an aquatic weed in Texas and Louisiana and is found in numerous water bodies throughout Florida. Although *Salvinia minima* is considered a nuisance species in most environments, micropropagation of this plant can be useful for research considerations. Little is known regarding *in vitro* propagation of this plant. A 3.0% sodium hypochlorite solution was found to effectively surface sterilize explants. Growth media consisting of half-strength Murashige and Skoog basal salt medium and 3% sucrose was used successfully as a stabilization medium in Stage 1 cultures. Cytokinin use was not found to be advantageous for Stage 2 shoot multiplication due to negative carry over effects on growth morphology. Explants were successfully transferred *ex vitro* following this study. Student paper - Berger, S., Agronomy Major, is in her first year of her M.S. degree with Dr. Greg MacDonald, University of Florida, Gainesville, FL, and is developing tissue culture techniques for culture of giant salvinia and other aquatic species.

## Cabomba

**Differential herbicide response among three phenotypes of *Cabomba caroliniana*** *Cabomba caroliniana* is a submersed aquatic plant native to the Southeastern United States that is commonly sold worldwide through the aquarium trade. While infrequently managed in its native range, cabomba has recently been reported as invasive and tolerant to management efforts in the northern areas of the United States and in other countries. Invasive populations of cabomba are characterized by a phenotype that is bright green. In contrast, cabomba native to the Southeastern United States is characterized by a red phenotype, while plants sold through the aquarium trade have intermediate characteristics of both the green and red phenotypes. The response of the three cabomba phenotypes to selected herbicides was evaluated by measuring photosynthetic response over the course of a static 144 hour exposure. Plants were exposed to the maximum recommended use rates of 2,4-D, carfentrazone, copper, diquat, endothall (amine and dipotassium salt formulation), flumioxazin, quinclorac, triclopyr and a combination of diquat and copper. A submersed plant species known to be sensitive to each of these herbicides was also included to compare photosynthetic response of the cabomba to a susceptible plant. The photosynthetic response of the red and green phenotypes differed following exposure to carfentrazone, diquat, 2,4-D, triclopyr, and flumioxazin. Diquat, diquat plus copper, endothall (amine salt), and flumioxazin were the only products that resulted in a greater than 50% reduction of photosynthesis in all three phenotypes of cabomba. A second experiment was conducted where all three phenotypes of cabomba were exposed to these four herbicides for 24 hours and photosynthesis was evaluated. **Following the 24 hour exposure, results further documented distinct response differences between the green and red phenotypes with the green phenotype demonstrating a reduced sensitivity to the herbicides evaluated.** Results demonstrate clear phenotypic differences in response to herbicide treatments and lack of susceptibility of cabomba to most herbicides. Student paper – Bultemeier, B.W., Agronomy Major, is working on his PhD. with Dr. Bill Haller, Center for Aquatic and Invasive Plants, University of Florida, Gainesville, FL.



### **If you hunt or fish:**

Invasive upland plants reduce quality habitat for native game species. This stress on wildlife can impact hunting resources.

Invasive aquatic plants, like hydrilla and water hyacinth, form dense mats, and can restrict boat access and stunt fish populations by reducing oxygen and aquatic habitats.

## Hydrilla

**Granular herbicides release profiles** - Granular formulations of aquatic herbicides have been used for aquatic weed control for many years, but there has been little research on these products. In this study, the **herbicide release profiles of several granular products currently utilized in aquatic plant management were evaluated under static and flowing water**. Results indicate major differences in the herbicide release profile of fluridone as formulated on the Sonar series of granules. The most rapid release was from Sonar Q which required 27 days to release 50% of fluridone (ET<sub>50</sub>) compared to 72 days for Sonar SRP. However, when gentle aeration (water movement) was tested, it caused a significant change to the release rate. The ET<sub>50</sub> values on these aerated conditions ranged from 4-16 days. Triclopyr (Renovate OTF) and endothall (Aquathol Super K) granules released 50% herbicide at only 12 and 87 hours, respectively. These granules also had a faster release when exposed to aeration with ET<sub>50</sub> values of 1.2 and 1.1 hours for triclopyr and aquathol, respectively. **These studies demonstrate that herbicide release from granules in static conditions does not accurately predict the release that may occur in flowing or moving water.**

Further studies to quantify the affect of flow on release of herbicide granules is needed, as are studies on the uptake of herbicides by plant roots and the interaction of granules with the sediments. Student paper - Bultemeier, B.W., Agronomy Major, is working on his PhD. with Dr. Bill Haller, Center for Aquatic and Invasive Plants, University of Florida, Gainesville, FL.



*FWC photo*

### **Dr. Greg Wheeler targets Brazilian pepper and Chinese tallow for biocontrol research**

Dr. Greg Wheeler, U.S. Dept. of Agriculture, Agriculture Research Service, is working on finding host-specific insects that will reduce the growth rate and biomass of Brazilian pepper and Chinese tallow in Florida.

**Baseline susceptibility data for hydrilla to ALS inhibiting herbicides** - A series of laboratory, greenhouse, and outdoor mesocosm studies were conducted to determine the baseline susceptibility of different hydrilla populations in Florida to five acetolactate synthase (ALS) inhibitors and one new bleaching herbicide (HPPD inhibitor) being considered for aquatic registration. The ALS inhibitors bensulfuron-methyl, bispyribac-sodium, imazamox, and penoxsulam have been evaluated in greenhouse trials, whole-plant assays, enzyme-based assays, and in combination with the contact herbicide endothall. **Key findings from this research include the following: 1) different strains of dioecious hydrilla collected throughout Florida (including fluridone-resistant strains) show similar baseline susceptibility to the individual ALS herbicides; 2) despite acting at the same enzyme site, the four ALS herbicides differ in the concentration required to elicit a threshold or phytotoxic response by hydrilla; 3) an enzyme-based assay has been developed for 4 ALS inhibitors and this will aid in determining if hydrilla shows a change in response at the enzyme level (i.e. resistance) to one or more ALS inhibitors; 4) penoxsulam, bispyribac, and bensulfuron are generally herbicidal in the range of 10 to 40 ug/L, and while they result in similar symptoms, they require long-term and continuous exposure to provide hydrilla control; 5) imazamox behaves more as a growth regulator on hydrilla, but it can result in extended growth inhibition (70+ days) following exposure periods as short as a few days; 6) combining penoxsulam and bispyribac with 0.5 to 1 mg/L of the contact herbicide endothall can significantly reduce exposure requirements and result in enhanced control of hydrilla compared to treatments with the ALS herbicides used alone; 7) enhanced activity was not observed when endothall and imazamox were combined. The use of penoxsulam and low rate endothall combinations was suggested for operational use during the early phases of this research, and current work in this area will help to establish use patterns for additional ALS inhibitors and low rates of endothall. In 2009, all penoxsulam recommendations for state waters included the use of low rates of endothall and current studies suggest that operational use of bispyribac or bensulfuron should focus on combinations with endothall. While this treatment combination has shown significant promise in reducing penoxsulam exposure requirements, it is important to note that endothall alone at higher use rates (2.0 mg/L and higher) remains a separate use pattern and a significant component of the FWC hydrilla control**

### Highlighted Plant Species:



Univ. of Georgia photo

#### Wetland Nightshade

**Scientific name:**

*Solanum tampicense*

**Origin:** Mexico, West Indies

**Introduction:** 1970s,  
Aquatic community:  
Emergent

**Habitat:** Shorelines,  
wet soils

**Distribution:** Central  
Florida

**FWC Management effort:** Eradication

**2009 public waters / plant acres:** 1 / 16

program. A recent Experimental Use Permit (EUP) application for the ALS inhibitor trifloxysulfuron-methyl has also led us to evaluate the activity of this compound at the enzyme level. Laboratory data suggests a high level of sensitivity of hydrilla to this herbicide.

Lastly, interest in registering the bleaching herbicide topramazone for aquatic use led to research to determine the potential for cross-resistance between fluridone resistant hydrilla and this herbicide, and laboratory and whole plant studies to determine threshold concentrations required to provide control of hydrilla. **Results indicate that fluridone resistant hydrilla is not cross-resistant to topramazone and they suggest that hydrilla will require sustained exposure to topramazone** at concentrations greater than 20 µg/L in order to control hydrilla. Throughout this project, research protocols were adapted to provide the most relevant information to aquatic plant managers. This research helped lead the switch from use of penoxsulam alone to use of penoxsulam in combination with endothall. This major shift in philosophy for a compound registered in 2007 has proven beneficial to managers and has significantly increased the use and effectiveness of penoxsulam. Netherland, M.D.<sup>1</sup>, Puri, A.<sup>2</sup>, and W.T. Haller<sup>2</sup>. Development of Baseline Susceptibility Data for Hydrilla to ALS Inhibiting Herbicides. <sup>1</sup>USAERDC, Center for Aquatic and Invasive Plants University of Florida, Gainesville, FL, <sup>2</sup>Center for Aquatic and Invasive Plants, University of Florida, Gainesville, FL.

#### Mesocosm and field evaluations of non-target impacts of new aquatic herbicides -

The acetolactate synthase (ALS) inhibitors penoxsulam and imazamox were registered for aquatic use by the U.S. EPA in 2007 and 2008 respectively, and there are currently four other herbicides in various stages of the registration process. While this abundance of new registrations is seen as a positive development for hydrilla and aquatic plant control, there is a strong need to determine optimal use patterns for these new products, and this includes the determination of impacts on non-target submersed and emergent native plants. Selectivity of an herbicide used for hydrilla control can be impacted by many factors including:

- 1) the plant species and growth stage;
- 2) the scale and timing of the application;
- 3) the use rate and subsequent exposure period;
- 4) pre and post-treatment water quality and clarity; and
- 5) water depth and sediment type.

Mesocosm trials were initiated with the EUP products penoxsulam, imazamox, and bispyribac-sodium to directly evaluate response of emergent and submersed plants. These mesocosm trials have proven strongly predictive for many species, but in some cases the significant injury observed in mesocosms has not translated to field observations. It is encouraging that when mesocosm observations with ALS herbicides do not match with field outcomes, predictions have been conservative (i.e. injury was minimal in the field). Initial use patterns for the ALS herbicides were designed to mimic fluridone (low use rate and long-term exposures); however, research findings and field observations resulted in significant changes in the use patterns of both penoxsulam and imazamox by 2009. This change in use pattern was driven primarily due to efficacy concerns. **Penoxsulam recommendations have moved towards incorporation of low use rates of the contact herbicide endothall and away from extended bump applications** that can result in exposures exceeding several months. Field observations suggest that while extended penoxsulam residuals did improve hydrilla control, they also had negative impacts on some of the more sensitive native species such as giant spikerush, soft-stem bulrush, pickerelweed, and vallisneria.

**Imazamox use patterns changed in response to field observations, indicating this product was more likely to perform as a growth regulator of hydrilla regardless of the exposure period.** In fact, recent data suggests that just several days of exposure to imazamox may provide growth regulating results for hydrilla that are similar to



FWC photo

### FWC's Present Research Effort:

FWC has funded 4 universities and 2 government agencies for 29 research and outreach projects in FY 10-11 to find more cost-effective means of controlling invasive plant species and educating the citizens in Florida about the dangers of uncontrolled growth of invasive plants.

extended exposures achieved through successive bump applications. This broad change in operational use patterns starting in late 2008 and through 2009 was an adaptive response to early treatment outcomes; however, it also means that observations on selectivity for these new use patterns are fairly limited and the observations for the older use patterns may be somewhat obsolete.

In the case of both penoxsulam (in combination with endothall) and imazamox, it is expected that exposure periods will be significantly reduced, compared to earlier treatment strategies. The ability to reduce exposure times will have a positive impact on selectivity for some of the more sensitive species identified. In our surveys we used the term "sensitive" to describe moderate to severe injury symptoms following a submersed application of a herbicide. In some cases sensitive plants did indeed decline over time while in other cases initial sensitivity and severe injury symptoms were followed by native plant recovery. While the sensitive native plants often recovered from these exposures, so did the hydrilla. And given the wide range of results we have noted in terms of longevity of hydrilla control, putting the term non-target selectivity in a proper context has proven to be a significant challenge. There are numerous specific examples where one of the ALS herbicides has greater impact on a particular native plant when compared to the other ALS herbicides. Several lines of research indicate that **each ALS herbicide is likely to have a different use and selectivity pattern.** We have ultimately observed recovery of most of the sensitive non-target species following ALS treatments and therefore avoiding consecutive applications with ALS products will likely promote the recovery of native vegetation that is initially susceptible to these herbicides. Netherland, M.D.<sup>1</sup> and W.T. Haller<sup>2</sup> Evaluation of Non-target Impacts of New Aquatic Herbicides. <sup>1</sup>USAERDC, Center for Aquatic and Invasive Plants, <sup>2</sup>University of Florida, Gainesville, FL, Center for Aquatic and Invasive Plants, University of Florida, Gainesville, FL.

### **Physiology and biochemistry studies to optimize new herbicides use rates, combinations and application timing**

- Physiological and biochemical studies in the laboratory were conducted to study absorption, translocation, and metabolism of new aquatic herbicides (imazamox, bispyribac and topramezone) in hydrilla. Hydrilla tips were exposed to <sup>14</sup>C labeled herbicides to evaluate the optimum herbicide application rate for maximum loading in hydrilla, and to evaluate the herbicide concentration and exposure time relationships in hydrilla. Results indicate that the **absorption of imazamox in hydrilla is passive and occurs at slow rate.** The imazamox absorption increased significantly from 6 hours to 10 days after treatment. There was not much herbicidal absorption in hydrilla up to 4 days after application. The highest absorption of imazamox occurred at 7 days or 10 days after herbicide treatment. These **results suggested that imazamox needs 7-10 days of contact exposure time with hydrilla** for maximum absorption in the plants. Metabolism studies confirmed that there were no metabolites of imazamox in hydrilla plants at 7 days after treatment. More than 90% of <sup>14</sup>C recovery of parental compound (imazamox) occurred after the study period of 7 days. Bispyribac-sodium absorption increased as the rate increased from 25 to 100 ppb, and there is no increase in absorption at higher rates (>100 ppb) of bispyribac-sodium. Puri, A.<sup>1</sup>, Haller, W.T.<sup>1</sup>, and G.E. MacDonald.<sup>2</sup> A New Aquatic Herbicide Physiology and Biochemistry Studies to Optimize Use Rates, Combinations and Application Timing. <sup>1</sup>Center for Aquatic and Invasive Plants, University of Florida, Gainesville, FL, <sup>2</sup> Agronomy Dept., University of Florida, Gainesville, FL. (COMPLETED)

**Selectivity of EUP and other potential new hydrilla herbicides** - When evaluating compounds for possible use in aquatic weed control, and in order to proceed towards registration for aquatic use, the selectivity or effects of the herbicide on non-target native plants needs to be determined. Also, registrants are concerned about phytotoxicity and applicators desire minimal irrigation restrictions for ornamentals and turf. Mesocosm and greenhouse studies show that quinclorac, topramezone, and bispyribac have some activity on native aquatic plant species (within 3-4 times expected label rates). Similarly, caladium was, in general, the most sensitive of the ornamental plants irrigated with herbicide treated water, but vinca was by far the most sensitive to topramezone (110 ppb). EC-50 values or the concentration of the herbicide

that reduces growth or biomass by 50% when compared to the weight of the control plants is presented below.

The EC-50 values (ppb) for aquatic plants grown for 8-12 weeks in herbicide treated water or the EC-10 values for ornamental species irrigated with herbicide treated water.

		EC-Value	quinclorac	topramezone	bispyribac
Aquatic Plants	Nuphar lutea	EC-50	2,567	156	NA
	Nymphaea odorata	EC-50	183	93	NA
	Sagittaria latifolia	EC-50	>100,000	618	65
	Eleocharis cellulosa	EC-50	NA	65	NA
Annuals	Begonia	EC-10	1,930	2,320	NA
	Vinca	EC-10	1,710	110	NA
	Melampodium	EC-10	410	1,590	NA
	Impatiens	EC-10	2,520	4,680	NA
Perennial	Caladium	EC-10	367	186	182
	Syngonium	EC-10	871	6,271	2,050
	Anthurium	EC-10	18,916	4,248	3,571
	Spathophyllum	EC-10	6,306	2,545	5,575

Haller, W.T., and L. Gettys. Selectivity of EUP and Other Potential New Hydrilla Herbicides. Center for Aquatic and Invasive Plants, University of Florida, Gainesville, FL. (COMPLETED)

**Identifying new herbicides for possible use for control of fluridone resistant hydrilla**

**hydrilla** - The unexpected development of hydrilla populations resistant to the aquatic herbicide fluridone (registered in 1985) occurred in the Kissimmee Chain of Lakes in the early 2000's. The lack of an inexpensive alternative means of hydrilla control stimulated the search for additional slow acting systemic herbicides that are selective and effective at managing fluridone-resistant hydrilla. **The screening of herbicides for possible use in aquatic weed control has resulted in the discovery and continued evaluation of six new potential aquatic herbicides.** One of these (Clearcast) now has a full U.S. EPA Section 3 aquatic label and four continue to have EUPs. The time consuming and expensive task of evaluating and labeling of aquatic herbicides require close industry, research, and regulatory agency cooperation.

The current status of EUP products which is a direct result of this project is as follows:

Name (EUP-Date)	Company	Mode of Action	Status
flumioxazin (2006)	Valent	PPO-Contact	EUP submitted for full EPA label
bispyribac (2006)	Valent	ALS-Systemic	EUP submitted for full EPA label
quinclorac (2007)	BASF	Auxin-Systemic	EUP - Current
topramezone (2008)	BASF	Bleacher	EUP - Current
trifloxysulfuron (2009)	Syngenta	ALS	EUP - Current

**General principles of herbicide resistance management:**

Apply integrated weed management practices. Use multiple herbicide modes-of-action with overlapping weed spectrums in rotation, sequences, or mixtures.

Use the full recommended herbicide rate and proper application timing for the hardest to control weed species present.

Survey treatment sites after herbicide application to ensure control has been achieved. Avoid allowing weeds to reproduce by seed or to proliferate vegetatively.

Monitor treatment site and clean equipment between sites.

Source: modified from [HRAC](#)

Potential herbicides for hydrilla control:

Herbicide family	Mechanism of action	Number of herbicides tested
<b>ACCCase Group</b> (Clethodim, Diclofop)	Inhibition of acetyl CoA carboxylase enzyme	18
<b>ALS inhibitors</b> (Imazamox, penoxsulam, bispyribac)	Inhibition of acetolactate synthase enzyme	33
<b>Cell division inhibitors</b> (Trifluralin)	Inhibition of microtubule assembly	6
<b>Synthetic Auxins</b> (Quinclorac)	Growth inhibition	17
<b>Photosynthetic Inhibitors A</b> (Atrazine and other triazines)	Inhibition of photosynthesis at photosystem II site A	8
<b>Photosynthetic Inhibitors B</b> (Bromacil, ioxynil)	Inhibition of photosynthesis at photosystem II site B	13
<b>Aminoacid Inhibitor</b> (Glyphosate)	Inhibition of EPSP Synthase enzyme	1
<b>Aminoacid Inhibitor</b> (Gluphosinate)	Inhibitor of Glutamine synthase enzyme	1
<b>Bleaching herbicides</b> (Fluridone)	Inhibition of phytoene desaturase	6
<b>Bleaching herbicides</b> (Topramezone)	Inhibition of hydroxyhenyl pyruvate dioxygenase (HPPD)	5
<b>PPO inhibitor</b> (Flumioxazin, carfentrazone)	Inhibition of protoporphyrinogen oxidase enzyme	15
<b>Others</b> (Diquat, endothall)	Inhibition of very long chain fatty acids	8
	Cell wall synthesis inhibition	7
	Photosystem-I electron diverters	5



FWC photo

**The benefits of Aquatic Plant Management:**

\$1.5 billion in annual revenues to Florida from freshwater fishing and wildlife observation.

Source: U.S. Fish and Wildlife Agency

The information in the above tables represents years of effort. In 2000, there was only one systemic, slow acting enzyme inhibitor registered for hydrilla control (fluridone). Since 2000, four ALS inhibitors have either labels or EUPs, one synthetic auxin (EUP), one bleacher (EUP), and two PPO inhibitors (one label, one EUP). Instead of one mode of action, these candidates will allow the applicator/manager four potential modes of action in which to develop a hydrilla management program depending on their efficacy on hydrilla. Haller, W.T. and A. Puri. Evaluation of New Herbicides for Hydrilla Control (Identifying new herbicides for possible use for control of Fluridone resistant hydrilla). Center for Aquatic and Invasive Plants, University of Florida, Gainesville, FL. (COMPLETED)

**Flumioxazin and bispyribac-sodium combinations for controlling hydrilla -**

Combinations of registered and experimental use permit (EUP) aquatic herbicides were evaluated in low dose treatments to determine whether combinations of bispyribac-sodium (10 µg active ingredient (a.i.) L<sup>-1</sup>), diquat (100 µg a.i. L<sup>-1</sup>), endothall (500 and 750 µg acid equivalent (a.e.) L<sup>-1</sup>), flumioxazin (50 µg a.i. L<sup>-1</sup>), imazamox (50 µg L<sup>-1</sup>), or penoxsulam (5 µg L<sup>-1</sup>) would improve control of hydrilla compared to these

**“In aquatic systems, water hyacinth, water lettuce and giant salvinia may all be present in the same region. Biological control of just one member of this invasive floating-plant guild may lead to eruption of another invader that was formerly out-competed for control of space or resources by the dominant invader.”**

Source: R.G. Van Driesche et al. Classical biological control for the protection of natural ecosystems. *Biological Control* 54 (2010) S2-S33

herbicides applied alone at low rates. Bispyribac-sodium, diquat, and endothall (500  $\mu\text{g L}^{-1}$ ) alone reduced hydrilla shoot weight 48 to 95% compared to the nontreated control, whereas endothall (750  $\mu\text{g L}^{-1}$ ), flumioxazin, imazamox, and penoxsulam applied alone failed to reduce shoot dry weight. Combinations of bispyribac-sodium, diquat, or endothall plus many of the other herbicides reduced hydrilla shoot and root dry weight. Although many combinations of bispyribac-sodium, diquat, and endothall plus other herbicides were efficacious against hydrilla, no additional control was provided compared to these products alone. Flumioxazin, imazamox, and penoxsulam when used in combination with each other failed to significantly reduce plant biomass. These results indicate low concentration combinations of several registered and EUP herbicides may be effective in controlling hydrilla and warrant further evaluation in laboratory and mesocosm trials. Mudge, C.R., and L.S. Nelson. Flumioxazin and Bispyribac-sodium Combinations for Controlling Hydrilla. U.S. Army Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS.

## Hygrophila

**Biological control of hygrophila: Prioritizing areas for native range surveys using MaxEnt Model** - Hygrophila, *Hygrophila polysperma* (Roxb.) T. Anders (Acanthaceae) is an invasive aquatic weed in the Southern United States and Mexico. Native to Southeast Asia, hygrophila has escaped cultivation and is causing problems in lotic habitats. A visible increase in the number of water bodies invaded by hygrophila since 1990 suggests that current methods employed to control this weed are inadequate. Classical biological control may be a viable option.

The Maximum Entropy Species Distribution Model (MaxEnt) was used in this study to prioritize climatically suitable native habitats in India and Bangladesh for conducting exploratory surveys to collect biological control agents of this weed. A niche based modeling approach, MaxEnt, attempts to predict a species' ecological niche using point (latitude, longitude) locations and environmental layers. In total, 164 point occurrences from the United States and Mexico and 20 climatic variables, including 19 bioclimatic variables and altitude, were used in our study to predict the native distribution of hygrophila. A data partitioning technique was used following accepted methods and a threshold dependent binomial test was performed to statistically verify model accuracy. Native distributions of hygrophila also were verified from an ecological perspective by examining visual concurrence of predicted habitats with water areas of India and Bangladesh. The binomial test results showed that MaxEnt predictions were accurate and significantly better than random. In native habitats, high suitability of presence of hygrophila was predicted in northeastern regions of India and in northern parts of Bangladesh, showing high concurrence with important rivers. Based on this prediction, areas were prioritized for conducting future surveys. Our study also **confirmed the effectiveness of MaxEnt as a tool in classical biological control for identifying climatically suitable native habits for foreign exploration studies.** Mukherjee, A.<sup>1</sup>, Christman, M.C.<sup>2</sup>, Beaman, R.S.<sup>3</sup>, Overholt, W.A.<sup>4</sup>, and J.P. Cuda<sup>1</sup>. Biological control of hygrophila: Prioritizing areas for native range surveys using MaxEnt Model. <sup>1</sup>Entomology and Nematology Department, University of Florida, Gainesville, FL, <sup>2</sup>Department of Statistics, University of Florida, Gainesville, FL, <sup>3</sup>Florida Museum of Natural History, University of Florida, Gainesville, FL, <sup>4</sup>Biological Control Research and Containment Laboratory, University of Florida, Fort Pierce, FL. (COMPLETED)

## Nymphoides and Rotala

**Best management practices (BMP's) for Rotala and Nymphoides control** - Studies were conducted in mesocosms as well as in South Florida canals to develop best herbicidal management programs for *Nymphoides indica* and *Rotala rotundifolia*. Treatments included imazamox (50, 100, 200, 400 ppb), endothall (0.25, 0.5, 1.5 and 2.5 ppm), triclopyr (0.5, 1, 2, 2.5 ppm), flumioxazin (50, 100, 200, 400 ppb) and UF-20 (25, 50, 100, 200 ppb). **For *N. cristata*, endothall was the most effective herbicide and gave 98-100% control at 1.5 and 2.5 ppm.** UF-20 at 100 and 200 ppb gave 82

and 93% control, respectively. Flumioxazin was also effective at higher doses of 200 and 400 ppb and gave 82 and 87% control of *Nymphoides*, respectively. Tryclopyr and imazamox were the least effective treatments and even maximum labeled rate of tryclopyr (2.5 ppm) gave only 55% control. Results of field trial were similar. Submersed treatments of endothall at 2-3 ppm gave about 80-90% control 8 weeks after treatment. Other herbicide treatments were not effective in controlling this weed species. **For *R. rotundifolia*, triclopyr was the most effective herbicide in the mesocosm experiments.** Triclopyr was the most effective herbicide in the mesocosm experiments Triclopyr @ 1 or 2 ppm provided 100% control of *R. rotundifolia*. 2,4 D @ 1 ppm gave 93% and at 2 ppm provided 99% control and diquat @ 400 ppb provided 80% control. 2, 4 D was also effective at higher doses of 200 and 400 ppb and gave 82 and 87% control of *Nymphoides*, respectively. Other herbicide treatments were not effective in controlling this weed species. Puri, A. and W.T. Haller. Best Management Practices (BMP's) for *Rotala* and *Nymphoides* Control. Center for Aquatic and Invasive Plants, University of Florida, Gainesville, FL. (COMPLETED)



FWC photo

### **Chinese tallow spread**

Recent research indicates that Chinese tallow has yet to occupy the full extent of its potential range in North America. Projections using climate modeling and manipulative field studies predict potential spread 500 km north of its current range into the Mid-Western USA and west into the southern Great Plains.

Source: Dr. Greg Wheeler, USDA-ARS, Ft. Lauderdale.

## **Water hyacinth and water lettuce**

**Foreign surveys and development of biological control agents for water hyacinth and water lettuce** - Water hyacinth (*Eichhornia crassipes*) and water lettuce (*Pistia stratiotes*) are two South American freshwater plants considered as among the world's worst aquatic weeds. To find biological control candidates for water lettuce, twenty-eight sites in northern Argentina were surveyed for host specific herbivores. Collection and rearing efforts concentrated on four weevil species: *Argentinorhynchus breyeri*, *A. squamosus*, *A. bruchi*, and *Pistiicola cretatus*. A *P. cretatus* colony was established in the laboratory and permits for shipping to quarantine facilities in the US are being sought. Rearing methods for *Argentinorhynchus* are still under development. For water hyacinth, a plant hopper, *Megamelus scutellaris*, was granted a federal permit in February for general release in Florida. A permit was also obtained for Texas. A total of 75,000 insects have been consigned to rearing tanks outside of quarantine and/or released in the field (see page 1 for additional details about this biological control agent release targeting water hyacinth).

A third year of pre-release field ecology studies for water hyacinth was conducted at one site in South Florida. The existing biological control agents released through the years significantly reduced water hyacinth biomass in the field by 62.3% and seed production by 85.7%. Unfortunately, water hyacinth plant coverage was still at 100% regardless of these biological control impacts. A first year of pre-release field ecology studies was conducted for water lettuce at three locations in South Florida. **The percent coverage and biomass produced varied according to the levels of herbivory by a suite of insects, especially *Neohydronomus affinis*, a biological control agent released in 1987.** Ted D. Center, Juan Briano Tipping, P.W.<sup>1</sup>, Center, T.D.<sup>1</sup>, and J. Briano<sup>2</sup>. Foreign Surveys and Development of Biological Control Agents for Water hyacinth and Water lettuce. <sup>1</sup>USDA-ARS Invasive Plant Research Laboratory, 3225 College Ave., Ft. Lauderdale, FL, <sup>2</sup>USDA/ARS South American Biological Control Lab, Buenos Aires, Argentina.

## **Wetland nightshade**

**Biocontrol of wetland nightshade** - Host-range specificity tests (multiple-choice and no-choice tests) with a still unidentified leaf feeder weevil were conducted at the Gainesville quarantine facility exposing adult weevils to 53 plant species in nine families including the target weed, wetland nightshade. Additional host-specificity tests will conclude in the spring 2011, and a request for field release in Florida will be submitted to the UF-IFAS Biological Control Review Committee and TAG (Technical Advisory Group for Biological Control of Weeds) if the host-range tests corroborate the specificity of the leaf feeder weevil and also pending specific identification to species. **Field release approval of the flower-bud weevil *Anthonomus elutus***

**petition submitted on December 9, 2008 is pending**, and it is expected to initiate the field release in the spring 2011. Medal, J. Biological control of wetland-nightshade, *Solanum tampicense*. University of Florida, Department of Entomology & Nematology, Gainesville, FL.

## Upland Plant Research

### Air potato

**Pre-release colonization of *Lilioceris sp.* for control of *Dioscorea bulbifera* (air potato)** – Studies have been completed on the host range of the leaf beetle *Lilioceris sp.*, an undescribed species from Nepal, which shows potential to control air potato in Florida. It is a potent defoliator, but more importantly, the insect destroys aerial bulbils. Extensive studies in quarantine demonstrated host specificity which restricts it to air potato and it should not pose a risk to native and/or economic plant species. A petition was submitted to APHIS in support of the proposed release. The petition was reviewed by the Technical Advisory Group, which concurred with the recommendation, but issuance of a permit to release the leaf beetle was precluded by the lack of a valid scientific name. **Once a species description of this new biocontrol species is published, a release permit is expected within the next year.** Center, T.D., Rayamajhi, M.B., and R.W. Pemberton. Pre-release colonization of *Lilioceris sp.* for control of *Dioscorea bulbifera* (air potato)., USDA-ARS, Ft. Lauderdale, FL.

### Brazilian pepper

**Genotype matching to select the most effective biological control agents of Brazilian peppertree** - Research was conducted to examine the compatibility of two populations of *Pseudophilothrips ichini* with Florida types of Brazilian peppertree. Results indicated that a population from Ouro Preto performed well on all Florida types, whereas a population from Salvador had low survival on Florida hybrid A plants and on *Schinus molle*. Studies revealed that the Salvador thrips were slightly more cold tolerant than the Ouro Preto thrips. A trip to northern Brazil in March 2010 resulted in the establishment of additional colonies of *P. ichini* at the Fort Pierce quarantine laboratory, and the establishment of *Paectes sp.*, a defoliating caterpillar. Genetic studies revealed that *P. gandolfi*, a newly described thrips (in earlier reports referred to as the ‘Curitiba’ thrips) is found only in extreme southern Brazil and appears to have a very close association with Brazilian peppertree haplotypes C and D, which do not occur in Florida. *Pseudophilothrips ichini* is found throughout Brazil, and on a greater variety of Brazilian peppertree haplotypes than *P. gandolfi*. **Several potentially undescribed thrips from BP may warrant further study as potential biological control agents.** Collections of thrips or other potential biological control agents from Santa Catarina and Salvador are predicted to be the most specific agents on Florida Brazilian peppertree. Overholt, W.A.<sup>1</sup>, Williams, D.<sup>2</sup>, Diaz, R.<sup>1</sup>, and V. Manrique<sup>1</sup>. Genotype matching to select the most effective biological control agents of Brazilian peppertree. University of Florida, IFAS, 2199 South Rock Road, Fort Pierce, FL, <sup>2</sup>Texas Christian University, Dept. of Biology, Ft. Worth, TX. (COMPLETED)

**Quarantine risk assessment studies for classical biological control of Brazilian pepper** - The testing of prospective agents and the search for new ones continued to be our top priorities for the Brazilian pepper *Schinus terebinthifolius* biological control project. During this past year, we tested six prospective agents, the thrips, leaf blotcher, three spp. of leaf feeding caterpillars and a leaf-feeding weevil. Additional species still under study include several gall formers: a stem gall wasp, a stem gall caterpillar, and a stem tunneling caterpillar. Although these studies continue and are not all complete, the results to date are included herein. **The Brazilian pepper thrips, *Pseudophilothrips ichini*, now correctly identified with both genetic and morphological methods, is undergoing testing for suitability in quarantine. Most troubling is the finding of adult survival after 14 days when fed *Schinus molle*, *Metopium toxiferum* and**



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### **Dr. Ted Center assumes the lead scientist role in bio-control research of Old World Climbing Fern in Florida**

Because of Dr. Bob Pemberton's retirement this past January (see page 2), Dr. Ted Center has assumed the leadership role in the USDA-ARS's efforts to find and release host-specific insects that target Old World climbing fern (*Lygodium microphyllum*). Dr. Center brings decades of experience in the field of biocontrol research to the Old World climbing fern biocontrol research effort. He has found and released insects targeting melaleuca trees which has become a remarkable management success story. FWC, along with the SFWMD, have funded this long-term *Lygodium* biocontrol research effort and we extend our welcome to Dr. Center to this important research.

## Invasive Plant Management

"Despite widespread availability of information on the internet, each state insists on reinventing the wheel in their state. We need to be more aggressive in getting good science to these state resource managers."

Source: Aquatic Plant Management Society 2010 Annual Meeting, presentation by Dr. John D. Madsen, Mississippi State University.

***Pistacia vera* whereas the adults live at least 30 days on their host *S. terebinthifolius*.** Additionally, complete development occurred on *Schinus molle* and *M. toxiferum*, and eggs (though few) were found on *S. molle*, *M. toxiferum* and *P. vera*. We are determining the suitability of these and other species for thrips larval development. Within this single thrips species, enormous diversity is found indicating the existence of different genetic variants and possible species. The correct name of the thrips species, previously studied at the University of Florida, has been published as *Pseudophilothrips gandolfoi*.

A leaf blotcher, *Leurocephala schinusae* is being described as a new species and testing continues in quarantine. Preliminary results in quarantine suggest this species may not be sufficiently host specific, and field collections from Argentina and Brazil support this broad specificity within the family Anacardiaceae. A second leaf blotcher species, *Eucosmophora schinusivora* has been colonized in quarantine. Testing for specificity of this species will occur as resources allow. Study of the leaf feeding caterpillar *Tecmessa elegans* was nearly completed that tested suitability of North American Anacardiaceae species. These results indicate that the larvae will feed and complete development on numerous North American plant species including *Rhus copallinum*, and *Cotinus obovatus*. We tested the *Tolype* nr *medialis* (Lepidoptera: Lasiocampidae) that defoliates the leaves of Brazilian pepper. Results of this testing indicates that the larvae of this species feed on many species of our native Anacardiaceae. Finally, testing of adults of the broad nosed weevil *Plectrophoroides lutra* indicated a host range that included several valued North American plants: *Rhus sandwicensis*, *Toxicodendron radicans* *Metopium toxiferum* and others.

**Brazil surveys** - Two surveys for Brazilian pepper herbivores were conducted along the Atlantic coast of Brazil. The surveys included both coastal and inland areas of Minas Gerais, Sao Paulo, Rio Grande do Sul, Santa Catarina, and Parana states. The surveys included the more northern states of Bahia, Espirito Santo, Rio de Janeiro and the southern states of Minas Gerais, Sao Paulo, Santa Catarina, and Parana. There was the discovery of several new species, most notably a new stem galling wasp, *Allorhogas* n.sp., (Hymenoptera: Braconidae), a stem galling caterpillar (pos. Tortricidae), a defoliating Tortricidae *Episimus* n. sp., several new Geometridae caterpillars including *Oospila pallidaria*. This latter species has been colonized and is undergoing host range testing. Additionally, we colonized the leaf blotcher *E. schinusivora* (see above). Specimens of the remaining species have been sent to specialists and their identity is under study.

**Argentina survey** - Large numbers of an unidentified leaf-blotcher Gelechiidae (Blotcher N°2) were collected on leaves of *S. terebinthifolius* and *L. molleoides*. Two hundred stem galls of *Crasimorpha infuscata* Hodges (Lepidoptera: Gelechiidae) were collected on the shoots of *S. terebinthifolius* and *S. weinmannifolius*. New findings: Tip-folding damage of *Caloptilia schinusifolia* or near was found on leaves of *Schinus lentiscifolius*. *Eucosmophora schinusivora* or near was found on *Astronium balansae*. One adult specimen of *Omolabus piceus* or near (Coleoptera: Curculionidae), was found feeding on the shoot tips of *Lithrea molleoides*. Wheeler, G.<sup>1</sup>, D. Williams<sup>2</sup>, and F. Mc Kay<sup>1</sup>. Quarantine risk assessment studies and overseas surveys for classical biological control of Brazilian pepper. <sup>1</sup>USDA-ARS, Ft. Lauderdale, FL, <sup>2</sup>Texas Christian University, Ft. Worth, TX.

## Chinese tallow

**Exploration of natural enemies in China for biological control of Chinese tallow *Triadica sebifera* (*Sapium sebiferum*) in Florida** - In 2009-2010, we conducted a complementary host range test for the flea beetle, *Bikasha collaris* (Coleoptera: Chrysomelidae) by including two congeners of Chinese tallow, *Triadica rotundifolia* and *T. cochinchinensis*. Under choice conditions, adults showed a distinct preference

## Poetry and Science

"In science one tries to tell people, in such a way as to be understood by everyone, something that no one ever knew before. But in poetry, it's the exact opposite."

Source: Quote from Paul Dirac (1902 – 1984), a British theoretical physicist, Florida State University, and a Nobel Prize winner.

for *T. sebifera* over the other *Triadica* species. The impact of the above and below ground herbivory at different insect densities on the growth of *T. sebifera* was evaluated in a common garden. *B. collaris* could reduce total biomass, stem height, stem diameter and number of leaves at high density (10 individuals/plant). However, no significant difference was found between adult and larval herbivory treatments. **The results of this study suggested that *B. collaris* is a potential biological control agent of *T. sebifera* although further tests on native North American species are needed.** We also conducted intensive field surveys to search for the insects that feed on tallow fruits or seeds in Guangdong, Hunan, Fujian, Jiangxi, Sichuan, Guizhou, Hunan, Anhui, Zhejiang and Guangxi Provinces. In total, we found three moths and three beetles feeding on the fruit/seeds in 2009. Ding, J.<sup>1</sup>, Wang, Y.<sup>1</sup>, Huang, W.<sup>1</sup>, Zhang, J.<sup>1</sup>, Purcell, M.<sup>2</sup>, and G. Wheeler<sup>3</sup>. Exploration of natural enemies in China for biological control of Chinese Tallow *Triadica sebifera* (*Sapium sebiferum*) in Florida. <sup>1</sup>Invasion Biology and Biocontrol Lab, Wuhan Botanical Institute, Chinese Academy of Sciences, Wuhan, Hubei Province, China, <sup>2</sup>USDA-ARS, Office of International Research Programs, Australian Biological Control Laboratory (ABCL), Indooroopilly, Queensland, Australia, <sup>3</sup>USDA-ARS, Ft. Lauderdale, FL.

## Downey Rose Myrtle

**Biological control of Downey Rose Myrtle (*Rhodomyrtus tomentosa*)** - Preliminary genetic analyses of plant samples from various areas within the native range and in Florida have been completed, but results are inconclusive at this point. Much remains to be done. Foreign surveys of herbivores were conducted between June 2009 and May 2010 in Singapore, Thailand, Hong Kong and mainland China. Specimens of a flower bud and stem feeder, *Agriothera* sp., were sent to Dr. David Adamski at the USDA Systematic Entomology Laboratory in Washington and they have been renamed as *Idiophantis* (Lepidoptera: Gelechiidae). **In 2009, *Idiophantis* sp. was selected as the first candidate for quarantine evaluation.** In early May 2010, field collections of *Idiophantis* were made in Hong Kong and imported to Gainesville, Florida FDACS DPI quarantine facility for colonization and host range studies conducted by the USDA. Establishment of colonies is underway. No specimens of the weevil *Sternuchopsis reticulatus* could be found in Hong Kong, mainland China or Thailand though several leaf-feeding/flower-feeding Lepidoptera were collected. Of most interest were specimens of *Carea varipes* whose larvae were found in both Hong Kong and mainland China. Center, T.<sup>1</sup>, Wright, S.<sup>2</sup>, Makinson, J.<sup>3</sup>, Purcell, M.<sup>3</sup>, and P. Madeira<sup>1</sup>. Biological control of Downey Rose Myrtle (*Rhodomyrtus tomentosa*). <sup>1</sup>USDA/ARS Invasive Plant Research Lab, Ft Lauderdale, FL, <sup>2</sup>USDA/ARS Invasive Plant Research Lab, Gainesville, FL., <sup>3</sup>USDA/ARS Australian Biological Control Lab, Brisbane, Australia.

## Lygodium

**Host range testing in U.S. quarantine of potential insect agents for biological control of Old World climbing fern (*Lygodium microphyllum*)** - Host range testing data for the lygodium sawfly, *Neostromboceros albicomus*, was finalized during the reporting period and compiled into a release petition which was submitted to the Technical Advisory Group for biological control of weeds (TAG) in July 2009. The sawfly was tested against 41 species of fern and fern allies in 21 fern families, against four species of Florida crop plants in two angiosperm families, against one Florida gymnosperm species and against six congeners in the genus *Lygodium*, as well as the primary host, *L. microphyllum*. In general, young sawfly larvae failed to feed on non-lygodium fern species, the Florida crop species or the Florida gymnosperm species tested. Small amounts of feeding were observed on four of the 41 species of non-lygodium fern tested, but larvae in these studies died after four days. Late instar sawfly larvae were able to feed modestly on some of the non-lygodium fern species tested, but larvae were unable to complete development to adult on these species. In oviposition studies, female sawflies failed to lay eggs on the Florida crop species tested, the Florida gymnosperm, or on the majority of non-lygodium fern species tested. The exception was Royal fern, which was moderately accepted as an oviposition host, although prior studies had indicated that sawfly larvae failed to survive or develop on this host.



FWC photo

**The hydrilla invasion in Florida began when six newspaper wrapped bundles of hydrilla were shipped to Tampa in 1950 or 1951 from St. Louis, Missouri.**

Source: Personal communication between Mr. Don Jennings and Mr. Don C. Schmitz, August, 1988.

Oviposition occurred on all six of the lygodium congeners tested, although oviposition was low on *L. venustum* and almost zero on the native North American climbing fern *L. palmatum*. Sawfly larvae were not able to complete development on *L. palmatum*, *L. venustum* or *L. cubense*. Sawfly larvae were able to complete development to adult on *L. japonicum* and *L. oligostachyum* although survival to adult was only about 30% of that observed on the primary host *L. microphyllum*. Oviposition, feeding and survival to adult were similar on the Caribbean species *L. volubile* to rates observed on *L. microphyllum*. **These results indicated that the sawfly is a specialist on ferns in the genus *Lygodium*, and is unable to complete development on plants outside this small group.** Survival and development of *N. albicomus* on *L. japonicum* is not viewed as problematic, since this species is a naturalized invasive weed in the United States. Meanwhile, the only other developmental hosts of *N. albicomus*, *L. oligostachyum* and *L. volubile* are restricted to the Caribbean, and as such are protected by an oceanic barrier in the form of the Florida Straits, from the proposed area of sawfly introduction. Currently we are awaiting comments and recommendations from TAG regarding the sawfly petition, but hope these will be forthcoming in the near future. T. Center and A. Boughton. Host range testing in U.S. quarantine of potential insect agents for biological control of Old World climbing fern (*Lygodium microphyllum*). USDA-ARS Invasive Plant Research Lab, Fort Lauderdale, FL.

**Host range testing in Australian quarantine of potential insect agents for the biological control of old world climbing fern (*Lygodium microphyllum*)** - Colonies of both the leaf-feeding pyralid moths were established and maintained in Brisbane to support shipment to quarantine facilities in Gainesville and the subsequent field release of insects in south Florida. Following the successful establishment of *Neomusotima conspurcatalis* at field sites in Florida, a supplemental supply of fresh larvae were shipped to Ft. Lauderdale in July 2009. **Lygodium quarantine research in 2009/2010 in Australia focussed on new techniques for the quarantine rearing of the Hong Kong stem-boring pyralid, *Ambia* sp 'H'.** Several new methods were trialed with promising results. The *Lygodium* weevil from north Queensland was found to be likely the same species as specimens found feeding within a second fern, probably *Dicranopteris* sp. Center, T.<sup>1</sup>, Makinson, J.<sup>2</sup>, and R. Zonneveld<sup>2</sup>. Host range testing in Australian quarantine of potential insect agents for the biological control of old world climbing fern (*Lygodium microphyllum*). <sup>1</sup>USDA/ARS Invasive Plant Research Lab, Ft Lauderdale, FL, <sup>2</sup>USDA/ARS Australian Biological Control Lab, Brisbane, Australia

**Exploration for biological control agents of old world climbing fern (*Lygodium microphyllum*) in Southeast Asia** - Australian *Lygodium* exploration research in 2009/2010 focused on the continued collection and of the Hong Kong stem-boring pyralid, *Ambia* sp 'H'. New field sites continue to be found across Hong Kong, though numbers at field sites were very low during surveys in April/May 2010. A field survey of *Lygodium* was conducted in Malaysian Borneo at the end of June 2009. Stem-borers were found around Sandakan, Sabah, and larvae were sent for comparative genetic analysis. Observational surveys of the seasonal fluctuations of the Singapore stem-borer, *Lygomusotima* sp., continued. Genetic analysis of a range of *Lygodium* stem-borers by our new collaborators at the University of Queensland met with mixed results: the species from southern China was confirmed as the same species as that in Hong Kong, extending our potential for mass collections; comparison of a stem-borer found in Sabah with the Singapore species, *Lygomusotima* sp., was unsuccessful because the PCR had double-banding and there was a weak messy signal in amplification. Center, T.<sup>1</sup>, Makinson J.<sup>2</sup>, Purcell, M.<sup>2</sup>, and R. Zonneveld<sup>2</sup>. Exploration for biological control agents of old world climbing fern (*Lygodium microphyllum*) in Southeast Asia. <sup>1</sup>USDA/ARS Invasive Plant Research Lab, Ft Lauderdale, FL, <sup>2</sup>USDA/ARS Australian Biological Control Lab, Brisbane, Australia.

**Assessing the timing and sequence of prescribed fire and herbicide applications on the control of the invasive Japanese climbing fern in Florida's natural areas** Japanese climbing fern (*Lygodium japonicum*) is a non-native, invasive fern that is widespread in North and West Florida. It poses both economic and ecological threats to forest systems managed for a variety of products and ecosystem services. Herbicide

**“Our survey found that invasive plant species and habitat fragmentation were the leading problems, affecting 55 percent and 44 percent of (U.S. Fish and Wildlife Agency) refuges, respectively, and both were increasing on more than half of refuges in the U.S.”**

*Source: WILDLIFE REFUGES: Changes in Funding, Staffing, and Other Factors Create Concerns about Future Sustainability, U.S. GAO Report, 2008*

treatments can provide at least short-term control of the fern, but prescribed burning, also an integral part of forest management throughout the southeast, may actually stimulate fern regrowth. The objective of this multi-year project is to evaluate how timing and sequence of herbicide and burning may affect the control Japanese climbing fern in longleaf pine forest ecosystems. Preliminary trials investigated Fall applications of Accord (2-4% v:v) applied either before dormant season burning or after summer burning on individual rootstocks of climbing fern. Complete eradication of the herbicide treated rootstocks have been observed up to two growing seasons following treatments, regardless of whether burning took place in winter or summer. Summer burning initially resulted in significantly faster growth rates of fern than in unburned areas in the few months following burning (July to October 2008). However, following winter die-back of most of the above-ground portion of the fern, growth rates of the non-herbicide treated rootstocks were not significantly different between the winter and summer burn areas by the end of the first full growing season the following year (April to October 2009). The current project evaluates timing and sequence of herbicides and burning on more heavily infested, matted fern areas. **Preliminary results indicate that plots treated with 4% v:v Accord did not completely eradicate fern mats, though percent cover is only about 1% and significantly below untreated, burn-only plots.** At this time, it is too early in the first growing season to determine if timing of burn effects non-herbicide treated plots differentially and how significantly the herbicide treated plots will recover. These results will be available at the end of this multi-year project in June 2011. Bohn, K.<sup>1</sup> and P.J. Minogue<sup>2</sup>. Assessing the timing and sequence of prescribed fire and herbicide applications on the control of the invasive Japanese climbing fern in Florida’s natural areas. <sup>1</sup>University of Florida, WFREC, Milton, FL., <sup>2</sup> University of Florida, NFREC, Quincy, FL

**Controlling Japanese climbing fern (JCF) spores with residual herbicides** - Two trials were established in September 2009 in Calhoun County, Florida. One of the trials was established in a 12 year old pine plantation that had not been thinned. Another trial was established in a 20 year old pine plantation that had been thinned (every 5<sup>th</sup> row removed). Plots were made 50 feet long and 30 feet wide. The design was a randomized complete block (RCB) with four replications. Treatments were applied with a CO<sub>2</sub> backpack sprayer at 20 gallons per acre. The spray nozzle was mounted on a pole-spray-boom 11 feet off the ground to ensure coverage of the Japanese climbing fern (JCF). Plots were evaluated at 30, 60, 90, 120, 150, 180, and 260 days after application for a visual rating of weed control. Plots were monitored for new JCF seedlings at each rating date. Low JCF populations at the 260 day evaluation dictated that all JCF seedlings in the measuring area (10’x 50’) were tallied.

Un-Thinned Area – Evaluation at 30 days indicated that imazapic plus glyphosate and pendimethalin plus glyphosate resulted in better control of JCF than asulam plus glyphosate. No treatment resulted in greater than 75% control at the 30 day evaluation. Control among treatments at the 60 day evaluation ranged from 60 to 88% control of JCF with no difference among treatments. Results of the 90-day evaluation revealed 82 to 95% control of JCF with no difference among treatments. By 120 days after application, only treatments containing simazine or asulam provided less than 90% control of JCF. Evaluations at 150 days revealed that herbicide treatments and severe cold weather resulted in no green JCF in treated plots. Green JCF was observed in non-treated areas around plots at 150 and 180 days after application.

Thinned Area – In 30-day evaluations, asulam plus glyphosate and glyphosate alone resulted in 35 and 30% control of JCF respectively. This control was lower than other treatments in the trial. Imazapyr and imazapic plus glyphosate provided the best control of JCF at the 60-day evaluation. These treatments were higher than asulam plus glyphosate or glyphosate alone, which provided the lowest control of JCF. The 90-day results indicated JCF control ranged from 75 to 97%. Treatments with imazapyr, imazapic, imazamox, metsulfuron, pendimethalin, and isoxaben provided

**"It is a capital mistake to theorize before one has data."**

Source: Sir Arthur Conan Doyle (1859-1930) (via Sherlock Holmes)

better control than glyphosate alone. Control with asulam plus glyphosate was lower than glyphosate alone which may indicate antagonism between the two herbicides. In the 120 day evaluation JCF control with asulam was lower than glyphosate alone in addition to being the worst treatment. JCF control with imazapyr, imazapic, imzamax, metsulfuron, and pendimethalin was near 100% and greater than glyphosate alone. At the 150 and 180 day evaluations, there was no green JCF in the herbicide-treated plots while there was an abundance of JCF growing outside the plots.

**No spore germination was identified in either trial up to the 260 day evaluation.** Spore germination was low in all plots but some differences were noted. In the un-thinned experiment, glyphosate applied alone resulted in 9 new JCF sprouts. Similar results were observed when simazine and asulam were applied with glyphosate. Treatments with imzapyr, imazapic, and sulfometuron had the lowest number of JCF per plot and were significantly lower than glyphosate alone.

The thinned-trial producer similar results but had fewer JCF plants overall. Glyphosate alone or with asulam had the most JCF sprouts with a mean of 8 and 7.3 respectively. All other treatments had fewer JCF sprouts with several averaging less than one JCF plant per plot. Smith, C. Controlling Japanese Climbing Fern Spores with Residual Herbicides. Marianna, FL. (COMPLETED)

## Paragrass

**Use of glyphosate and imazapyr to control paragrass (*Brachiaria mutica*) in combination with flooding and burning** - Non-native paragrass (*Brachiaria mutica*) is no longer used as a fodder and has invaded Florida wetlands. In 2008-2009, field studies were conducted at TM Goodwin Waterfowl Management Area to compare the different rates of imazapyr and glyphosate as well as the effect of water level on paragrass control. Herbicide treatments were applied prior to burning and flooding. At one month after herbicide treatment, all three rates of glyphosate provided at least 91% paragrass control, regardless the initial water level and glyphosate provided greater control as compared to imazapyr. Water level at the time of application had an effect on paragrass control with imazapyr one month after treatment as control was better when no standing water was present. There were no significant differences among imazapyr rates or initial water levels at 6 and 12 months after treatment, which was 2 and 8 months after burning, respectively. Additionally, it was observed that burning followed by immediate flooding appeared to have an impact on paragrass re-growth in the untreated checks and provided at least 62 and 97% paragrass control at 12 months after treatment in first and second field experiments, respectively. Greenhouse experiments were conducted to determine the effect of water depth on paragrass re-growth followed by burning or cutting. **Overall, burning had more impact on stolon re-growth as compared to cutting, regardless of the water-level treatments.** At 5 weeks after treatment, stolon lengths were reduced by at least 75% when burned plants were subjected to either water treatment compared with cut and either water treated plants. Similarly, the numbers of stolons were at least 90% lower when burned plants were subjected to either water treatment compared to cut plants. These data indicate that excellent control of paragrass can be obtained using 1.12 kg ai/ha glyphosate and 0.86 kg ai/ha imazapyr in combination with burning followed by flooding. Student paper - Chaudhari, S., working with Sellers, B.A., MacDonald, G., and S. Rockwood; University of Florida, Gainesville, FL.

## Phragmites

**Detecting cryptic invasions of *Phragmites australis* in Florida waterways using genetic markers** - Stem texture and panicle architecture did not vary between locations. All stems examined were very smooth and the panicle architecture was open. These characters suggest that the plants were the Gulf Coast type, as the

invasive Eurasian plants reportedly have ribbed stems and dense, compact panicles. The estimated size of *P. australis* patches ranged from 10-10,000 m<sup>2</sup>, and averaged 1445 m<sup>2</sup>. The largest stands were found in the St. Johns River system, and along the Gulf Coast in the panhandle. Stem density varied between 8 and 448 stems/m<sup>2</sup> with an average of 116 stems/m<sup>2</sup>. Similar to patch size, density tended to be highest along the St. Johns River and in the panhandle. Height varied from 2.4 to 4.5 m, with an average of 3.33 m. All of the sequenced individuals were the Gulf haplotype. **Genetic tests suggest that the invasive M haplotype has not yet reached Florida waterways or has a localized distribution and occurs in areas we did not sample.** Overholt, W.A.<sup>1</sup>, Williams, D.<sup>2</sup>, and R. Diaz<sup>1</sup>. Detecting cryptic invasions of *Phragmites australis* in Florida waterways using genetic markers University of Florida, IFAS, 2199 South Rock Road, Fort Pierce, FL, <sup>2</sup>Texas Christian University, Dept. of Biology, Ft. Worth, Texas.

## FWC Funded Invasive Plant Outreach and Education

### Southern Hospitality:



***Invasive species and year introduced at the Port of Mobile, Alabama:***

***Torpedo grass (1876)***

***Alligator weed (1897)***

***Cogon grass (1918)***

***Fire ants (1930)***

**Maintenance and expansion of the APIRS online database, the Florida Upland Invasive Plants Library, and the Florida Aquatic Plants Library** - Since the early 1980s, the Aquatic, Wetland and Invasive Plant Information Retrieval System (APIRS) has been developed and expanded as a guide to the scientific literature for both aquatic and natural area invasive plant researchers, managers, graduate students and others around the world. The APIRS team has collected, cataloged and made available more than 75,000 citations in an online database of the published scientific literature on aquatic and wetland plant species world-wide, and invasive plant species in Florida. APIRS is the only database dedicated exclusively to the topic of aquatic and wetland plants world-wide and natural area invasive plant species listed by the Florida Exotic Pest Plant Council (FLEPPC). It contains historical sources and grey literature (government and NGO reports, conference abstracts and other published material) in addition to current peer-reviewed research journal citations, books, and digital media such as DVDs, CDs and videos. This project continues the efforts of APIRS staff to maintain and expand the searchable online database, and to promote the resource both to researchers publishing their results and to those reviewing the literature for research purposes or to aid in their management decisions. Brown, K. Maintenance and Expansion of the APIRS Online Database, the Florida Upland Invasive Plants Library, and the Florida Aquatic Plants Library. Center for Aquatic and Invasive Plants, University of Florida, Gainesville, FL,

**Maintenance and Structural Upgrade of the UF/IFAS/CAIP Websites** - Websites are now accepted as the predominant tool for sharing information and reaching a wide variety of user groups. The UF/IFAS Center for Aquatic and Invasive Plants (CAIP) and FWC Invasive Plant Management Section have long collaborated to utilize this technology for communicating with both the public sector and management professionals about invasive plant issues. Since 1995 when the CAIP website was launched, this resource has been an effective mechanism for bridging the gap between researchers, plant managers, and citizens who often question various plant management techniques. Today, the website has grown and evolved to encompass more information for a wider group of users, from land managers to field professionals to citizens to schoolteachers and students. The primary CAIP site currently includes three companion websites or “portals”, one of which is undergoing an overhaul in structure. Providing these services requires a commitment of personnel, equipment and flexibility to keep up with rapidly changing computer technologies, while continuing to present material in innovative formats that appeal to broad audiences with varying levels of knowledge. Brown, K. Maintenance and Structural Upgrade of the UF/IFAS/CAIP Websites. Center for Aquatic and Invasive Plants, University of Florida, Gainesville, FL,

**Florida Invasive Plant Education Initiative and Curriculum** - Together, the UF/IFAS Center for Aquatic and Invasive Plants (CAIP) and the Invasive Plant Management Section of the Florida Fish and Wildlife Conservation Commission developed a unique partnership with Florida educators to develop and distribute

**“In the worst instances, the absence of population biological data can be an excuse for inaction, when a prudent decision or quick and dirty operation might have excluded or eliminated an invader.”**

Source: Simberloff, D. 2003. How much information on population biology is needed to manage introduced species? *Conservation Biology* 17(1): 83-92.

educational curricula about aquatic invasive plant management in Florida. Now that the core curriculum is in place, a number of tasks were completed this year that are less glamorous but equally important (and time consuming).

In addition to the continued delivery of audio-visual presentations and related activities for each of the four main modules on the [Florida Invasive Plant Education Initiative](#) website, several supplemental resources were developed and/or further revised in an effort to enhance the curricula and provide additional incentives for teachers to use the materials. This included the completion of FCAT-style questions for each module; continued ‘linkage’ of lessons/activities to the Florida Sunshine State Standards and further development of *Manage This!* - the new multi-faceted classroom activity that provides students a chance to stretch their critical thinking skills, practice civil responsibility while learning just how difficult it can be to make plant and wildlife management decisions.

This year also provided an opportunity to step back and develop an evaluation instrument that is being used to assess the impacts of our outreach efforts among the 200-plus teachers who attended workshops that CAIP has held or co-hosted since 2006. Results of the evaluation will guide the future direction for this initiative, including the development of lessons, activities, materials, and workshops.

In an effort to cost-share and further leverage limited resources during the current economic climate, the FWC-CAIP Education Initiative has fostered a number of partnerships with other groups and agencies. For example, CAIP staff work continue to work with Project WILD (FWC’s environmental education program) and also the Osceola County Cooperative Extension Service to organize and co-host a number of teacher workshops this year. As well, the CAIP-Osceola County partnership resulted in the development and production of numerous outreach print materials about aquatic invasive plants, and an online student “Invasive Plant Video Festival” project, that is currently underway.

Continued cooperation between CAIP, FWC and the Florida Department of Environmental Protection resulted in the production of invasive plant brochures for fourteen more state parks and yet another partnership between staff from CAIP, the Aquatic Plant Management Society, and FWC resulted in the production and publication of an online interactive booklet, [Understanding Invasive Aquatic Weeds](#), using the latest “flash” technology. Richard, A. Florida Invasive Plant Education Initiative and Curriculum Center for Aquatic and Invasive Plants, University of Florida, Gainesville, FL

**Atlas of Florida Vascular Plants website database** - *The Atlas of Florida Vascular Plants* includes online data ([ISB: Atlas of Florida Vascular Plants](#)) and images of over 47,000 specimens of 199 (82%) of the 243 Florida plant families from the USF Herbarium. Data includes county by county distribution documented by herbarium specimens and complete nomenclature for all Florida taxa. This is fully integrated with herbarium specimen images. Wunderlin, R.P. Non-native species in the *Atlas of Florida Vascular Plants* website database. Department of Cell Biology, Microbiology, and Molecular Biology, University of South Florida, Tampa, FL.

**Don C. Schmitz, Editor**

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