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Natural enemies of floating marshpennywort (*Hydrocotyle ranunculoides* L.f) in the southern United States

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INTRODUCTION

Floating marshpennywort (*Hydrocotyle ranunculoides* L.f.; Araliaceae) is a floating, creeping, rhizomatous wetland plant species with deeply lobed leaves and stalked inflorescences (Crow and Hellquist 2000). Floating marshpennywort is thought to be native to the southern United States and Central and South America and has been introduced into Belgium, France, Italy, the Netherlands, Portugal, Spain, the United Kingdom, and Australia (McChesney 1994, Sheppard et al. 2006, EPPO 2010). In the southern United States, floating marshpennywort is a common wetland species and will sometimes form floating mats, often entangled with other floating invasive species such as giant salvinia (*Salvinia molesta* Mitchell), water hyacinth (*Eichhornia crassipes* [Mart.] Solms), and alligatorweed (*Alternanthera philoxeroides* [Mart.] Griseb.).

Although exceptions exist, floating marshpennywort is generally not a problem species in the southern United States but can be highly problematic in its European and Australian ranges (McChesney 1994, Sheppard et al. 2006). In these cases, the plant can form extensive, monotypic stands that may block waterways or shade out native submersed species, depleting dissolved oxygen levels in the process (Klemm et al. 1993). Floating marshpennywort is capable of reproducing by seed or vegetatively by fragmentation (McChesney 1994), posing problems for mechanical control methods that can unintentionally spread viable plant propagules during removal (Ruiz-Avila and Klemm 1996). Its aggressive growth and potential invasiveness has led to its listing on European noxious weed lists (Sheppard et al. 2006, EPPO 2010) and caused researchers to search for viable management strategies.

Traditional techniques for managing floating marshpennywort have been unsuccessful in providing long-term control. Mechanical harvesting tends to be costly and often only provides a short-term solution because floating marshpennywort can rapidly recover (Klemm et al. 1993). Herbicides may be successful if used at high application rates, and success has been reported with glyphosate, diquat (Klemm et al. 1993), and 2, 4-D amine (Newman and Dawson 1999). The combined use of manual removal with subsequent herbicide application has been used with success (Klemm et al. 1993, Ruiz-Avila and Klemm 1996, Kelly 2006). A more sustainable approach may be the use of biological control.

Biological control, the use of natural enemies to control a pest organism, is based on the premise that a lack of natural enemies (e.g., herbivores, diseases) in an invaded range contributes to success of the invader (Williams 1954, Hajek 2004). Floating marshpennywort is often introduced into a new area without the herbivores and diseases that limit the plant's growth in its native range. Biological control has been successfully used around the world for a number of aquatic weed species, including the introduction of the salvinia weevil (*Cyrtobagous salviniae* Calder and Sands, Coleoptera: Curculionidae) for control of giant salvinia (*Salvinia molesta* Mitchell) in the United States, Zimbabwe, South Africa, Senegal, Mauritania, and India (Jayanth 1987, Cilliers 1991, Chikwenhere and Keswani 1997, Pieterse et al. 2003, Tipping 2004, Tipping et al. 2008, Diop and Hill 2009), and the North American weevil (*Stenopelmus rufinasus* Gyllenhal) in South Africa for control of *Azolla filicoloides* Lamarck (Hill 1998, Hill and Cilliers 1999, McConnachie et al. 2003, 2004). In addition to insect agents, pathogens, often of an inundative type, have been used successfully around the world (Charudattan 2001). Implementation of a biological control program begins with the identification of potential insect or pathogen biocontrol agents.

Surveys to identify potential biocontrol agents of floating marshpennywort have been few, and nearly all have occurred in South America (Cordo et al. 1982), in part due to the discovery of *Listronotus elongatus* Hustache, a floating marshpennywort-specific weevil in Argentina (Cordo et al. 1982). In addition to *L. elongatus*, the agromyzid leaf-miner (*Liriomyza huidobrensis* [Blanchard]; Diptera: Agromyzidae) and the semiaquatic grasshopper (*Coryacris angustipennis* Bruner; Orthoptera: Romaleidae) are reported to attack *Hydrocotyle* spp. in Argentina (Salvo and Valladares 1997, Capello et al. 2012). In the United States, exploration for natural enemies of floating marshpennywort has been limited. There have been reports of herbivory by the grasshoppers *Gymnoscirtetes pusillus* Scudder (Orthoptera: Acrididae), *Paroxya atlantica* Scudder, *Paroxya clavuliger* Serville, and *Romalea microptera* Beauvois on a *Hydrocotyle* sp. in Florida (Squitier and Capinera 2002); *Liriomyza munda* Frick (Diptera: Agromyzidae) on *H. umbellata* L. in Florida (Stegmaier 1966); and *Spodooptera eridania* (Cramer) (Lepidoptera: Noctuidae) on *Hydrocotyle* spp. in Florida. (Cuda 1995, Minno et al. 1996).

Relatively few pathogens have been identified on floating marshpennywort in the United States. Farr et al. (1989) listed only five fungal species infecting the plant, including a

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chytrid (*Physoderma hydrocotylidis* Viégas & Teix.), a rust (*Puccinia hydrocotyles* Cooke), two smuts (*Entyloma fimbriatum* G.W. Fisch. and *E. hydrocotyles* Speg.), and an asexual hyphomycete (*Cercospora hydrocotyles* Ellis & Everh.). The chytrid, rust, asexual hyphomycete, and the smut *E. hydrocotylis* are not host specific to floating marshpennywort but occur on other species of *Hydrocotyle*, both in the United States and other parts of the world (Farr et al. 1989). The type species of *E. fimbriatum* was collected in California on floating marshpennywort and has not been reported on any other species of *Hydrocotyle;* however the chances of it being host specific may be small because other species of *Entyloma* have multiple hosts (Fischer 1953).

Due to problems caused by floating marshpennywort and a paucity of reported natural enemies, the objective of this study was to survey floating marshpennywort populations in the southern United States for potential insect herbivore and pathogen species. Information presented here should be useful for identifying biocontrol agents of floating marshpennywort to supplement other plant management strategies.

MATERIALS AND METHODS

From 2007 to 2010, floating marshpennywort plants were collected from 10 sites in states along the Gulf Coast, including three sites in Texas, five in Louisiana, one in Mississippi, one in Alabama, and one in Florida (Table 1). Sites included Sheldon Reservoir, Texas (29°52'53.73"N, 95°9'48.92"W; one visit), Sheldon Slough, Texas (29°53'0.11"N, 95°11'19.51"W; one visit), Lewisville Aquatic Ecosystem Research Facility (LAERF), Lewisville, Texas (33º04'45"N, 96º57'30"W; multiple visits), Golden Ranch, Gheens, Louisiana (29°39'30.57"N, 90°25'52.50"W; three visits), Bayou Vacherie, Louisiana (one visit), an unnamed creek near Gheens, Louisiana (29°49'51.70"N, 90°35'27.21"W; three visits), a plantation pond at Tunica, Louisiana (30º57'05"N, 91°28›50»W; one visit), a pond at the U.S. Army Engineer Research and Development Center (USAERDC) in Vicksburg, Mississippi (32°17'52.71"N, 90°51'56.35"W; two visits), a greenhouse at the USAERDC (32°18'28.15"N, 90°52'1.19"W; one visit), and an irrigation ditch near Indiantown, Florida (27°06'10.9"N, 80º19'07.6"W; one visit). All sites were visited during summer months, from June until September. For the duration of this work, the first author was stationed at LAERF, so multiple collections at this location were possible throughout the growing season of floating marshpennywort. Plants were examined qualitatively in the field at each location for signs of herbivory or pathogenic infection, then collected for subsequent microscopic examination and rearing in the laboratory. The number of plants examined at each site varied according to site accessibility and amount of plant material present. Some sites had large mats of floating marshpennywort while some sites only had a few plants present. Occasionally, a rake was used to collect plants from the shore of waterbodies.

Insect herbivores

Microscopic examination of the plants was conducted with a dissecting microscope and included dissection of stem and leaves and removal of tunneling invertebrates. All individuals collected in this manner were preserved in 70% ethanol.

In addition to microscopic examination, rearing was accomplished for a majority of plant collections. Rearing consisted of placing small amounts of damaged plant material into 4 L plastic containers fitted with mesh (<500 µm) lids. Enough water was added to the containers to submerge the plant roots, and the containers were placed under fluorescent grow lights (14:10 photoperiod) at 25 C for several weeks, or until plant material began to decompose. Rearing containers were monitored once per day and emerged organisms were collected and preserved in 70% ethanol.

Handfuls of plant material were placed in Berlese funnels with 60 watt light bulbs for invertebrate extraction. Plants were allowed to remain in Berlese funnels until dry, and any invertebrates collected in this manner were preserved in 70% ethanol for subsequent identification.

Table 1. Insect herbivores associated with floating pennywort in the southern United States.[1]

Order Family	Species	Life stage	Collection site
Coleoptera			
Curculionidae	*Bagous lunatoides* O'Brien	A	Ditch off Citrus Blvd., near Indiantown, FL
	Listronotus sp.	A	Bayou Vacherie, Gheens, LA
	Listroderes costirostris Klug	A	Lake Guntersville, AL
Scirtidae	*Scirtes tibialis* Guer. *1*	A, L	Bayou Vacherie, Gheens, LA; Ditch near highway 90/182, LA
Diptera			
Chloropidae	*Eugaurax floridensis* Malloch	A, L, P	Ditch off Citrus Blvd., near Indiantown, FL; Bayou Vacherie, Gheens, LA; Ditch near highway 90/182, LA; LAERF, Lewisville, TX; Lake Guntersville, AL; Tunica, LA; ERDC pond, Vicksburg, MS
Hemiptera			
Cicadellidae	*Draeculacephala* sp.[2]	A	Bayou Vacherie, Gheens, LA; LAERF, Lewisville, TX
Pseudococcidae		I,A	ERDC greenhouse, Vicksburg, MS
Lepidoptera			
Noctuidae	*Enigmogramma basigera* (Walker)	L,P,A	Lake Guntersville, AL
Crambidae	*Synclita obliteralis* Walker	L	Lake Guntersville, AL; ERDC pond, Vicksburg, MS

[1]A = adult, L = larva, P = pupa, I = immatures.
[2]Scirtes spp. adults have unknown diets and were not observed actively feeding.

In addition to previously described methods, sweep nets were used at sites in Louisiana, Texas, and Florida to collect insects that might be missed through other examination techniques. A sweep net was randomly moved back and forth through the floating marshpennywort stand for approximately 30 seconds, and collected insects were preserved in 70% ethanol for subsequent sorting and identification.

Insects from all collection techniques were identified to genus and, in some cases to species, by specialists in the respective taxa. Voucher specimens of insects were deposited in various museums and collections, including the Lymann Entomological Museum, McGill University, Montreal, Quebec; the Canadian Museum of Nature Collection, Ottawa, Ontario; the Elm Fork Heritage Museum, University of North Texas, Denton, Texas; and the Biomanagement Team insect collection at the USAERDC.

Pathogens

Floating marshpennywort leaves were washed for approximately 1 minute under running water to remove any debris from the leaf surface. Sections of tissue that appeared to be diseased were excised and inserted into slits cut into Martin's agar (Tuite 1969) plates and incubated in the dark at room temperature (Martin 1950). Fungal isolates that emerged from the diseased tissue were transferred to half-strength corn meal agar (CMA; Difco, Detroit MI) slants and stored at 4 C. Cultures grow slowly and can be preserved longer on half-strength CMA. For identification purposes the isolates were retrieved from storage and plated onto potato dextrose agar (PDA; Difco, Detroit MI) and potato carrot agar (PCA; Dhingra and Sinclair 1995).

RESULTS AND DISCUSSION

Insect herbivores

Ten insect species were identified as feeding on, or potential herbivores of, floating marshpennywort, including one marsh beetle (Coleoptera: Scirtidae), three weevils (Coleoptera: Curculionidae), two caterpillars (Lepidoptera), at least one grass fly (Diptera: Chloropidae), two leaf hoppers (Hemiptera: Cicadellidae), and one mealybug (Hemiptera: Pseudococcidae) (Table 1).

Adults of *Scirtes tibialis* Guerin (Coleoptera: Scirtidae) were collected both by hand and with a sweep net from plants at sites in Louisiana and Texas. In the field, *S. tibialis* adults often were observed on marshpennywort leaves near apparent feeding damage and have been suspected by the authors to feed on other aquatic plant species such as American spongeplant (*Limnobium spongia* [Bosc] Rich. Ex Steud.; Harms and Grodowitz 2010). Larvae also were collected, often from the roots of floating marshpennywort. The larvae have been reported to feed on plant tissue (Kraatz 1918), but they more likely feed on epiphyton (Beerbower 1943). Because the species is widespread and has not been definitively reported to feed on aquatic plants, we report *S. tibialis* as a floating marshpennywort herbivore with caution; further work is necessary to confirm dietary habits.

Three weevil species were collected from floating marshpennywort. Adult *Bagous lunatoides* O'Brien were collected from floating marshpennywort leaves at a site near Indiantown, Florida, and are known from American spongeplant (O'Brien and Marshall 1979, Haag et al. 1986, Harms and Grodowitz 2010) and denseflower knotweed (*Polygonum glabrum* Willd; O'Brien and Marshall 1979). Adult *Listroderes costirostris* Schoenherr (Coleoptera: Curculionidae) were collected from Guntersville Reservoir, Alabama, and were observed feeding on floating marshpennywort stolons, stems, and leaves. Unfortunately, we were unable to recover many specimens, so little was determined about the feeding habits of this species on floating marshpennywort. *Listroderes costirostris*, commonly known as the vegetable weevil, is of South American origin and is adventive in North America, Australia, New Zealand, South Africa, Japan, and Europe (Morrone 1993). It is considered a serious pest in these countries (Marvaldi 1998), feeding on many plant species in several families (High 1939, Jenkins 1944). Based on other reports of *Listroderes*, it is unclear whether the larvae would be likely to feed on floating marshpennywort as well. Apparently, the larvae remain in the soil during the day and emerge to feed on foliage at night (Marvaldi 1998). Because floating marshpennywort and adult *L. costirostris* were collected near a shoreline, it is possible that larvae could have had access to these plants. In addition, a *Listronotus* sp. was collected from Bayou Vacherie, near Gheens, Louisiana. Only one specimen was recovered and was unidentifiable to species due to damage likely incurred during collection. We were unable to recover additional specimens due to subsequent lack of access to the site, although *L. lodingi* Blatchley and *L. latinasus* Blatchley have been recovered from the same area and similar habitat since our original sampling trips. Because *L. lodingi* and *L. latinasus* are lacking host records in the literature, it is unclear whether the individual collected in our survey might have been either of these species. Additional collections are needed to make a positive identification and to determine host plant and niche.

Two moth species were collected from floating marshpennywort at sites in Alabama and Mississippi. *Synclita obliteralis* Walker (Lepidoptera: Crambidae) larvae were collected and reared from distinctive leaf cases made from floating marshpennywort leaves, which they use as protection while feeding on the plant. However, *Synclita* are known to feed on more than 60 aquatic plant species, including water stargrass (*Heteranthera dubia* Michx.), watershield (*Brasenia schreberi* J.F. Gmel.), duckweed (*Lemna* spp.), spatterdock (*Nuphar* spp.), blue waterlilly (*Nymphaea odorata* Aiton), smartweed (*Polygonum* spp.), and floating pondweed (*Potamogeton natans* L.; Center et al. 1999, Harms and Grodowitz 2009, Harms et al. 2011). Additionally, *Enigmogramma basigera* (Walker) larvae (Lepidoptera: Noctuidae) were collected and reared from plant material collected at Guntersville Reservoir, Alabama. The caterpillar of this moth was observed feeding on floating marshpennywort stems and leaves in the laboratory, where it seemed to prefer leaf tissue over stems. Plants were completely defoliated in the laboratory, leaving bare stems emerging from the water's surface. Pupation occurred on the lid of the rearing container; in the field, pupation probably occurs on the underside of a floating marshpennywort leaf or on other emergent vegetation. Host-specificity of *E. basigera* is unclear; Schweitzer (2007) reports that *E. basigera* is likely a specialist on *Lobelia*, and that *Hydrocotyle* is unlikely a suitable food plant, despite a previous report to the contrary (LaFontaine and Poole 1991). Food-choice tests were not conducted during our surveys, but floating marshpennywort seemed to be a suitable host plant because early instars were able to complete development, pupate, and eclose. However, we cannot discount the importance of *Lobelia* in the diet of *E. basigera* because *L. cardinalis* is a common and widespread shoreline plant at Guntersville Reservoir where specimens of *E. basigera* were collected; however, none were observed in close proximity to our collection sites. In addition, the native range of *E. basigera* seems to overlap with both floating marshpennywort and *L. cardinalis* (Lafontaine and Poole 1991, USDA-NRCS 2010). Unless future work shows *E. basigera* to be a generalist herbivore, this species may have some value in the management of floating marshpennywort due to the extensive damage it can cause and its ability to complete its life cycle on the plant.

Eugaurax floridensis Malloch (Diptera: Chloropidae) were reared from floating marshpennywort collected from all Gulf Coast states and were the most commonly encountered species. Larvae were commonly recovered from leaf mines and stems through plant dissection and Berlese extraction of plant material. Late-instars recovered from stems were likely preparing for pupation; pupae were exclusively recovered from stem tissue, and oftentimes several pupae were found in close proximity within the stem. Another species of *Eugaurax* has recently been discovered feeding on floating marshpennywort in South America, although it seems to feed primarily in the stem as opposed to the leaves. *Eugaurax floridensis* eggs were collected from mines within stems of the plants. It is not clear whether female *E. floridensis* created cavities in the stem prior to oviposition, but clusters of eggs were recovered from what appeared to be previous larval excavations in the stem. First instars also were collected from within and external to the stem near the sites of oviposition.

A single parasitoid specimen, *Chaenusa* sp. (Hymenoptera: Braconidae), was apparently reared from floating marshpennywort collected in a ditch near Indiantown, Florida. *Chaenusa* spp. thus far are known exclusively from *Hydrellia* (Diptera: Ephydridae) hosts, so additional collections and rearings need to be made to determine the association with *Eugaurax*. No *Hydrellia* spp. were reared, and *E. floridensis* was the only dipteran species reared from plants in this study, so it is unclear what species *Chaenusa* sp. parasitized in this case. In addition, another parasitoid, *Polynema needhami* Ashmead (Hymenoptera: Mymaridae), was reared from plant material at sites in Louisiana, Texas, and Alabama. Although an egg parasitoid, it is unlikely that it was parasitizing *E. floridensis* eggs because *P. needhami* is known only from odonate hosts.

Two species of leafhopper were collected from floating marshpennywort leaves. *Draeculacephala* sp. was collected from sites in Mississippi, Texas, and Louisiana. *Draeculacephala* spp. are common on grasses in the United States (Young 1959) and have been previously reported from aquatic plants (McGaha 1952, Haag et al. 1986). The other leafhopper was not identified because it was a nymph, and distinguishing characters were not fully developed.

Mealybugs (Hemiptera: Pseudococcidae) were collected from the underside of floating marshpennywort leaves in greenhouse cultures. Mealybugs are a common pest of greenhouse plant cultures so it was not unexpected to find them on floating marshpennywort. Identifications were not made because the specimens were immature, and no mealybugs were observed at any field sites; they probably colonized the plants in the greenhouse.

In addition to the above, several pygmy grouse locusts (Orthoptera: Tetrigidae) were collected with a sweep net from floating marshpennywort in Louisiana. Although the ecology of these insects is mostly unknown, they are generally considered to be algivorous (Kočárek et al. 2008) and were probably only using the plants as resting or breeding sites. As such, tetrigid specimens were not identified and are excluded from discussion here.

Pathogens

None of the fungi listed in Farr et al. (1989) were found on floating marshpennywort in our study (Table 2). Fungi isolated from plant material included *Alternaria alternate* (Fr.: Fr.) Keissl., *A. tenuissima* (Nees & T. Nees : Fr.) Wiltshire, *Pestalotiopsis guepinii* (Desm.) Steyaert, *Trichoderma harzianum* Rifai, *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc., a *Phoma* sp., a *Septoria* sp., and two moniliaceous Ascomycetes. Most

Table 2. Fungi associated with floating marshpennywort in the southern United States.

Class Species	Potentially pathogenic?	Collection site
Hymenoascomycetes		
Colletotrichum gloeosporioides Penz.	Y	Golden Ranch, Houma, LA
Pestalotiopsis maculans (Corda) Nag Raj	Y	Sheldon Slough, TX; Tunica, LA; ERDC pond, Vicksburg, MS
Trichoderma harzianum Rifai	N	Sheldon Slough, TX
Loculoascomycetes		
Alternaria alternata (Fr. : Fr.) Keissl.	N	Golden Ranch, Houma, LA; Tunica, LA; ERDC pond, Vicksburg, MS, Lake Guntersville, AL
Alternaria tenuissima (Nees & T. Nees : Fr.) Wiltshire	Y	Sheldon Slough, TX
Septoria sp.[1]	Y	Golden Ranch, Houma, LA
Phoma sp.	Y	Golden Ranch Canal, Houma, LA; Lake Guntersville, AL

[1]Septoria was observed sporulating on leaf lesions but a pure culture could not be obtained.

of the isolates do not qualify as potential classical biological control agents because they lack host-specificity, occurring on numerous plant species as saprophytes or secondary invaders. Although it is unknown if the two moniliaceous Ascomycetes are host-specific, it seems unlikely considering none of the other species mentioned above are host-specific. They seemed to be secondary invaders in the leaf lesions. Completion of Koch's postulates in the future would provide a more complete picture of the potential pathogens and the type of damage they cause to the plant.

In all, nine insect and eight fungal species were found to be potentially harmful to floating marshpennywort in our surveys of the southeastern Unites States. In instances where floating marshpennywort can become problematic in the United States, surveys should be conducted to identify which of these insects or pathogens, if any, are present. If absent, for instance with a recent spread of the plant to a new waterbody, insect agents could be introduced ahead of their natural spread, thus reducing the lag time between plant introduction and natural enemy colonization, although this may be unnecessary in many cases, particularly where herbivores such as *E. floridensis* are known to be present and would likely colonize naturally very quickly. For instance, floating marshpennywort appeared in 2010 after being previously absent from a pond at the USAERDC. Our initial surveys of the plants in this pond revealed the presence of both *E. floridensis* and *S. obliteralis*, indicating that the insect species either colonized very quickly after introduction of floating marshpennywort or were introduced simultaneously as infested plant material.

Although not common, we have observed floating marshpennywort forming extensive waterway-clogging mats in the United States, even in areas where natural enemies may be found. This typically takes place early in the growing season, probably before herbivore species populations have had a chance to increase and impact plants. As with another creeping wetland plant, floating primrose willow (*Ludwigia peploides* [Kunth] P.H. Raven), temporal and spatial partitioning of resources likely allow multiple herbivore species to feed on floating marshpennywort (Harms and Grodowitz 2012). In the case of floating primrose willow, the authors observed lush, dense plant growth early in the growing season followed by the appearance of large numbers of insect herbivores, which reduced plant biomass to defoliated stems within a few months (unpubl. data). Although we were unable to document similar phenomena on floating marshpennywort due to our sampling schedule, there may also be temporal partitioning of resources among floating marshpennywort herbivore species. In the case of releasing agents for control of floating marshpennywort, it would be beneficial to make releases of biocontrol agents early in the season before plant populations become problematic. This would allow insects to feed on actively growing, highly nutritious plant tissue and likely provide the best opportunity for control.

Currently, the intricate and probably complex relationship between floating marshpennywort herbivores and their parasitoids and predators is not well understood, so any domestic biological control program should take care during agent introduction to not also introduce their natural biotic limiting factors. Domestically, it might be prudent to allow natural colonization of natural enemies, at least in the southeast, where they are common. In other regions of the country where floating marshpennywort has been reported as a nuisance, it will be important to not purposefully spread an insect species or pathogen to a geographic area where they are not likely to occur naturally (such as those found in the southeast that may not occur in the western United States), at least without prior host-range assessment. Further research is needed to fully understand the ecological associations of floating marshpennywort and its natural enemies. With several of the insect species apparently possessing polyphagous diets, it would be ecologically disruptive to artificially increase their populations at sites where other, potentially more palatable plant species are present. This domestic consideration is substantially more complicated than in foreign countries where it is less likely to have such complex interactions because both the plant and natural enemies did not co-evolve there.

Although foreign research is currently focused in South America, there is some potential to further explore species identified in this current study for use as biocontrol agents overseas. Both *E. floridensis* and *E. basigera* exhibited the ability to severely damage plants in the laboratory, although their effect on field populations of floating marshpennywort is not yet known. We have observed that plants infested with high levels of *E. floridensis* in the field tend to appear "droopy" and yellow, similar to senescing plants late in the season (unpubl. data). Additional collections of related *Hydrocotyle* should be accomplished in the United States to explore the field host range of *E. floridensis*, in addition to laboratory host range testing of *E. basigera* to determine its host specificity and feeding habits. Currently, so little is known of the insect herbivores that it is not possible to speculate on the degree of specialization in diets.

The lack of fungal pathogens collected in our surveys could be explained several ways. It is possible that an insufficient number of samples were collected to identify specialized pathogenic fungi; additional surveys may yet discover pathogenic species. Another explanation may be that floating marshpennywort is a more recent introduction to the United States than previously thought. If the plant evolved in Central or South America and was recently introduced into the United States, it would be expected to find few or no host-specific pathogenic fungi.

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