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Survey of Insect Herbivores Associated with Aquatic and Wetland Plants in the United States

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PURPOSE: This technical note summarizes the survey and examination, from 2005–2009, of native aquatic and wetland plants in the United States for associated insect herbivores. Information on collection methods, plants, and associated insect herbivores is provided.

BACKGROUND: Aquatic and wetland plants are commonly impacted by insect herbivory. Herbivory can slow growth, reduce standing biomass, facilitate transmission of infectious diseases, and contribute to overall reduced competitive success (Doyle et al. 2002, 2005; Wallace and O’Hop 1985; Nachtrieb and Grodowitz, in preparation). Herbivory, a contributing factor to plant community structure and composition (Lodge 1991, Carpenter and Lodge 1986), should be considered when designing and implementing plant management strategies. Despite its significance, the role of aquatic and wetland plant species as food items for insects is little known in many taxa, due to both the difficulty in sampling and the lack of appropriate identification tools for many insect species. In addition, the effect of insect herbivory on competitive success is mostly unknown in many species of aquatic plants and probably varies depending on plant species, herbivore species, and abundance. Prior to quantifying this effect, surveys are needed to identify potential insect herbivores, and create host plant/insect associations. Once identified, the herbivores’ role in macrophyte community structure, establishment, and competition can be better understood.

Because herbivory plays an important role in determining plant competitive success in aquatic systems, it is important to understand (a) which species impact aquatic plants, and (b) how plant growth and competitive ability are influenced by feeding. A previous paper (Harms and Grodowitz 2009) provided the results of an extensive literature review in which all known insect herbivores of aquatic plants in the United States were reported. Although vertebrate herbivory (i.e. waterfowl, nutria, etc.) can, at times, be significant (Dick et al. 1995, Doyle and Smart 1995, Doyle et al. 1997), this technical note will only discuss insect herbivores collected during an exploratory survey of aquatic plants.

From 2005–2009, a general survey was conducted in order to collect and identify insect herbivores of native aquatic and wetland plants in the United States. While the scope of the project was limited in terms of the number of aquatic species examined, it was hoped that the information collected would provide future researchers as well as aquatic plant managers with a practical reference to

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possible herbivores. The information presented herein is not only intended to augment previous work (Harms and Grodowitz 2009), but to provide a starting point for future ecological studies regarding effects of herbivory on host species. Three species, *Heteranthera dubia* (Jacq.) Macmillan (water stargrass), *Ludwigia peploides* Kuntze (floating primrose willow), and *Hydrocotyle ranunculoides* L.f. (floating pennywort), were examined in more detail and will be discussed in a separate publication.

MATERIALS AND METHODS: From 2005–2009, 18 sites (Table 1) were visited in seven states, including Texas, Florida, Washington, Maine, Oregon, New York, and Wisconsin. Specimens from four other sites were sent for examination in 2005, 2006, and 2009 by personnel in Texas, Washington, and Florida. Leaves and stems of plants were observed in the field for signs of herbivory, including evidence of chewing or tunneling. Darkened plant areas, an indicator of damaged plant tissue, were also examined with a Leica (Bannockburn, IL) Stereozoom 4 microscope (7×–30× magnification), and sometimes dissected to reveal mining insects. Any insects discovered in this manner were preserved in 70 percent ethanol for later identification. In addition, all insects observed feeding were immediately removed from the plant and preserved as previously mentioned.

In addition to collection trips, plants (*Potamogeton nodosus* Poir, *P. illinoensis* Morong and *Vallisneria americana* Michx.) were collected from ponds at the Lewisville Aquatic Ecosystem Research Facility (LAERF, 33° 04'45" N, 96° 57' 30" W), Lewisville, TX in 2008, and processed by both Berlese extraction and insect rearing. Rearing was accomplished by placing the plant material in 3.8-liter plastic containers covered with 500- μ m mesh netting. Containers were filled with approximately 3 L of water to sufficiently cover the plant material and were maintained at 27-28°C with a 14:10 photoperiod for one month or until plant material became badly decomposed. Any reared adult insects were collected and preserved in 70 percent ethanol for subsequent identification.

Insect specimens were identified to the lowest practical taxon, which in most cases was genus. Chironomid (Diptera) specimens were slide-mounted in CMC-10 mounting media (Masters Co., Wood Dale, IL) prior to identification. Most insects were identified using Merritt and Cummins (1996), Merritt et al. (2008), and Thorp and Covich (2001). Most species identifications were obtained by sending representative specimens to experts in specific taxonomic groups.

In some cases literature was used to verify observational data of food preference of collected insects. In a few instances, such as with *Oxyelophila callista* Forbes, literature simply does not exist and further research is needed.

Plant names are reported with the most current (as of 2009) taxonomic classification recognized by the United States Department of Agriculture/Natural Resources Conservation Service (USDA/NRCS) (2009), and to the best of the authors' knowledge, insect classifications are also current. "Plant part affected" is described based on observations and literature records. All but three plant species examined (*Egeria densa* Planch, *Hygrophila polysperma* (Roxb.) T. Anderson, and *Myriophyllum spicatum* L), are native to the United States.

RESULTS AND DISCUSSION: A minimum of 30 unique insect taxa were collected from 21 plant species (Table 1), representing 53 insect-plant associations. Several insects (i.e. *Synclita oblitteralis* Walker, *Hydrellia* spp., and *Oxyelophila callista* Forbes) were collected from more than

one plant species. In addition, not all specimens were identifiable to species, and so it is not clear whether one or several species were collected (e.g. *Hydrellia* spp. and several Chironomidae).

Aquatic Moths (Lepidoptera:Crambidae). Aquatic moths (Lepidoptera) were commonly collected during the survey. *Synclita oblitalis* was collected from three plant species, including *Nuphar lutea* (L.) Sm., *Potamogeton nodosus* Poir, and *Nymphaea mexicana* Zucc. *Synclita* spp. are known to have a broad diet, feeding on an estimated 60 plant species (Center et al. 1999) and a broad distribution, having been collected from Washington to Florida (Brigham and Herlong 1982).

Paraponyx spp. larvae were found on three species, *H. polysperma*, *Myriophyllum heterophyllum* Michx., and *Vallisneria americana* Michx. *Paraponyx obscuralis* Grote and *P. allionealis* Walker were collected from *H. polysperma* in the San Marcos River, TX and *P. obscuralis* was reared from these plant specimens. *Paraponyx allionealis* larvae were collected but not reared to adult. *Paraponyx* are widely distributed in the United States and are largely polyphagous in their diet, including the host plants *Bacopa caroliniana* (Walter) B.L. Rob., *Brasenia schreberi* J.F. Gmel., *Vallisneria* spp., and *Nymphaea odorata* (Brigham and Herlong 1982). While there is some variation in host plant preference between species, there does not appear to be much specificity in their diet.

Adult *Usingeriessa onyxalis* Hampson were reared from *H. polysperma* plant specimens collected in Texas. Known distribution of the genus is from Peru to California, and Lange (1956) presumed that larvae are associated with rocks in lotic-erosional habitats. Despite this, little is known of the genus *Usingeriessa*, including the morphology of immature stages, and so biology and diet are poorly understood.

Petrophila spp. were collected from *M. spicatum* in the Rio Grande, Texas and from *V. americana* in southwest Shaw Lake, Florida. Although the literature reports *Petrophila* as known scrapers feeding on algae and epiphyton, individuals were collected from within the seed head of *V. americana* during this survey, suggesting a diet of at least some plant tissue. Further research is needed to determine the species of *Petrophila* collected and the extent of herbivory.

Ostrinia penitalis Grote and *Bellura densa* Walker were collected from their known hosts (Vogel and Oliver 1969, Mutuura and Monroe 1970), *Nelumbo lutea* Willd. and *Pontederia cordata* L., respectively.

Oxyelophila callista was collected from *Cabomba caroliniana* A. Gray, *Ceratophyllum demersum* L., *H. polysperma*, and *Potamogeton illinoensis* Morong in the San Marcos River, TX. However, it is not clear to what degree *O. callista* fed on these plants, because similar species of caterpillar rely on periphyton/ algae for food (Solis 2008) and Lange (1956) assumed that *O. callista* was a lotic habitat algal feeder. More work is needed to examine life-history, diet, and range of host plants. The geographic distribution of *O. callista* appears to be limited to Texas (Balciunas and Minno 1985, Solis 2008).

Hydrellia (Diptera: Ephydriidae). *Hydrellia* spp., of which larvae, pupae, and reared adults were collected, were found on five plant species. *Hydrellia bilobifera* Cresson and *H. discursa* Deonier were both reared from *V. americana* and *P. nodosus* at the LAERF. In addition, *H. fascitibia* Von Rosen adults were reared from *P. illinoensis* plants collected in the San Marcos River, TX. *Hydrellia fascitibia*, a holarctic species (Hesler 1995), was previously associated with *P. illinoensis* under its

synonym, *H. cruralis* Coquillet. Adult *Hydrellia* spp. were reared from both *Egeria densa* and *Elodea canadensis* collected from an unnamed pond near Portland, OR, and were given the species name of *H. harti* Cresson, but verifications were not obtained. *Hydrellia harti* has previously been associated with *E. canadensis* (Deonier 1998), but not with *E. densa*. Because *E. densa* is an introduced and invasive species, additional collections are warranted to determine impact of *H. harti* on the host plant.

Midges (Diptera: Chironomidae). The chironomids *Glyptotendipes* sp., *Endotribelos* sp., and *Polypedilum illinoense* sp. were collected from three plant species during the survey. *Glyptotendipes* sp. was collected from *P. richardsonii* (Benn.) Rydb. and *P. illinoensis*. *Glyptotendipes dreisbachi* Townes has been reported to feed on *P. richardsonii* (Berg 1949), but it is not clear which species was collected during this survey. *Endotribelos* sp. was collected from tunnels in the leaves of *V. americana*, and tunnels were often seen in *V. americana* leaves during the survey. In addition, the *Polypedilum illinoense* sp. group was also found in tunnels in the leaves of *V. americana*, but appears to have no specificity of diet (Epler 2001). In fact many of the chironomids may only be using the plants as a substrate and feeding on epiphyton or algae. They were included here because of the tunnels they create in the leaves.

Weevils (Coleoptera: Curculionidae). Five weevil species (Coleoptera: Curculionidae) were collected from seven plant species during this survey. These include *Bagous lunatoides* O'Brien, *Listronotus delumbis* Gyllenhal, *L. appendiculatus* Bohemon, *Onychylis nigrirostris* Bohemon, and *Stenopelmus rufinasus* Gyllenhal. *Bagous lunatoides* was collected from *Limnobiium spongia* (Bosc.) Rich. ex Steud., and has been previously associated with that species (O'Brien and Marshall 1979). *Listronotus delumbis* and *L. appendiculatus* were collected from *Sagittaria latifolia* Willd., and *S. graminea* Michx., respectively. Of the two, *L. appendiculatus* is a new association, having not been previously associated with *S. graminea*. *Onychylis nigrirostris* was collected from *Pontederia cordata* and is known to feed on *Sagittaria* spp., *Nuphar advena* (Aiton) Aiton f. and *Eichhornia crassipes* (Mart.) Solms-Laubach (Center et al. 1999) as well. *Stenopelmis rufinasus* was collected from both *H. polysperma* and *Nymphaea odorata* Aiton. This was unusual because *S. rufinasus* is commonly known as the waterfern weevil, as it is reported to feed and reproduce exclusively on waterfern (*Azolla filiculoides* Lam. and *A. caroliniana* Willd.) (Center et al. 1999). It is not clear if *Azolla* spp. were in the vicinity, but the collection of *S. rufinasus* from *N. odorata* probably represents an incidental collection.

Leaf beetles (Coleoptera: Chrysomelidae). *Galerucella nymphaea* L. was collected from two plant species, *Pontederia cordata* and *Brasenia schreberi*. Both adults and larvae were collected and the larvae were observed feeding on leaves of both *P. cordata* and *B. schreberi*. In addition, *G. nymphaea* was observed feeding on leaves of *Trapa natans* L. (water chestnut) in Saratoga Lake, NY, but was not collected.

At least five species of *Donacia* spp. were collected on six floating and emergent plant species. *Donacia* species collected included *D. cincticornis* Newman, *D. rufescens* Lac., *D. aequalis* Say, *D. rugosa* LeConte, and *D. piscatrix* Lac. *Donacia cincticornis* was collected from *Nuphar lutea* and *N. odorata*. Although *N. odorata* is a known host of *D. cincticornis*, the collection from *N. lutea* represents a new association. *Donacia rufescens* and *D. piscatrix* were also collected from *N. odorata* and *N. lutea*, respectively, but only *D. piscatrix* had previously been reported from

N. lutea. While feeding was not always observed by the *Donacia*, specimens were collected and associated with certain plants if signs of *Donacia* ovipositing were apparent. *Donacia* have a distinct method of ovipositing in which females chew holes in floating leaves in order to oviposit on the underside. In fact, only two species (i.e., *D. aequalis* and *D. rugosa*) were collected from a non-floating leaf plant, *P. cordata*. Although only adult *Donacia* were collected, larvae are known to feed on the roots of aquatic plants. In addition, the related *Neohaemonia* sp. was collected from *N. odorata* at Carr Lake, FL.

SUMMARY: The current survey strengthens the conclusion previous authors have made; i.e., aquatic and wetland plants are subject to herbivory from a variety of insect species (Lodge 1991). While this type of exploratory survey provides additional information regarding which insect species may be feeding on plants, additional work should focus on a single genus or species of plant and sample throughout the growing season because, depending on the insect species and location, herbivory may intensify at different times of the year. While some information is available regarding insect herbivores and their host plants (Harms and Grodowitz 2009), there is a paucity of information for certain plant species, including the effects of herbivory on growth and competition; in that regard, further work is warranted.

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Table 1. Collection information from surveys conducted 2006-2009. Part of the plant affected was determined from observation and literature records, which are included, if available.¹

Host Plant	Insect Order: Family	Insect species	Part of Plant Affected	Life Stage	Collection Site	Literature Citation (if available)
<i>Brasenia schreberi</i> J.F. Gmel.	Coleoptera: Chrysomelidae	<i>Gallerucella nymphaeae</i> L.	floating leaves	A, L	Lake George, NY, Upper Narrows Pond, ME	Center et al. (1999)
<i>Cabomba caroliniana</i> A. Gray	Lepidoptera: Crambidae	<i>Oxyelophila callista</i> Forbes	?	L	San Marcos River, TX	
<i>Ceratophyllum demersum</i> L.	Homoptera: Aphidae	<i>Rhopalosiphum</i> sp.	leaves	A	San Marcos River, TX	
<i>C. demersum</i>	Lepidoptera: Crambidae	<i>Oxyelophila callista</i> Forbes	?	L	San Marcos River, TX	
<i>Elodea canadensis</i> Michx.	Diptera: Ephydriidae	<i>Hydrellia</i> sp. prob. <i>harti</i> Cresson	leaves	L, A	Pond near Portland, OR	Deonier (1998)
<i>Egeria densa</i> Planch.	Diptera: Ephydriidae	<i>Hydrellia</i> sp. prob. <i>harti</i> Cresson	leaves	L, A	Pond near Portland, OR	Deonier (1998)
<i>Hygrophila polysperma</i> (Roxb.) T. Anderson	Coleoptera: Curculionidae	<i>Stenopelmus rufinasus</i> Gyllenhal*	?	A	Sewell Park, San Marcos, TX	
<i>H. polysperma</i>	Lepidoptera: Crambidae	<i>Paraponyx allionealis</i> Walker	leaves, stem	L	San Marcos River, TX	
<i>H. polysperma</i>	Lepidoptera: Crambidae	<i>Paraponyx obscuralis</i> Grote	leaves	L, A	San Marcos River, TX	
<i>H. polysperma</i>	Lepidoptera: Crambidae	<i>Usingeriessa onyxalis</i> Hampson	leaves	L, A	San Marcos River, TX	
<i>Limnobium spongia</i> (Bosc) Rich. ex Steud.	Coleoptera: Curculionidae	<i>Bagous lunatoides</i> O'Brien	leaves	A	Lake Miccosukee, FL	O'Brien and Marshall (1979)
<i>L. spongia</i>	Coleoptera: Scirtidae	<i>Scirtes</i> sp.	leaves	A	Lake Miccosukee, FL	
<i>Myriophyllum heterophyllum</i> Michx.	Lepidoptera: Crambidae	<i>Paraponyx</i> sp.	leaves, stem	L	Belgrade Wetlands, ME	Habeck (1974)
<i>Myriophyllum spicatum</i> L.	Lepidoptera: Crambidae	<i>Petrophila</i> sp.	?	L	Rio Grande, TX, between Del Rio and Eagle Pass	
<i>Nelumbo lutea</i> Willd.	Lepidoptera: Crambidae	<i>Ostrinia penitalis</i> Grote	leaves, petiole	L	Lake Gaston, NC	Mutuura and Monroe (1970)
<i>Nuphar lutea</i> (L.) Sm.	Coleoptera: Chrysomelidae	<i>Donacia cincticornis</i> Newman	roots, leaves	A	Lake George, FL	
<i>N. lutea</i>	Coleoptera: Chrysomelidae	<i>Donacia piscatrix</i> Lac.	roots, leaves	A	Lake Gaston, NC	Hoffman (1940)
<i>N. lutea</i>	Lepidoptera: Crambidae	<i>Synclita oblitalis</i> Walker	leaves	L	Lake George, FL	
<i>Nymphaea mexicana</i> Zucc.	Lepidoptera: Crambidae	<i>Synclita oblitalis</i> Walker	leaves	L	LAERF, Lewisville, TX	
<i>Nymphaea odorata</i> Aiton	Coleoptera: Chrysomelidae	<i>Donacia cincticornis</i> Newman	roots, leaves	A	Carr Lake, FL	McGaha (1952)

¹ Under the life stage column, A = Adult, L = Larva, P = Pupa. An asterisk (*) denotes a probable incidental collection.

Host Plant	Insect Order: Family	Insect species	Part of Plant Affected	Life Stage	Collection Site	Literature Citation (if available)
<i>N. odorata</i>	Coleoptera: Chrysomelidae	<i>Donacia rufescens</i> Lac.	roots, leaves	A	Carr Lake, FL	
<i>N. odorata</i>	Coleoptera: Chrysomelidae	<i>Neohaemonia</i> sp.	leaves	A	Carr Lake, FL	
<i>N. odorata</i>	Coleoptera: Curculionidae	<i>Stenopelmus rufinasus</i> Gyllenhal	?	A	LAERF, Lewisville, TX	
<i>Pontederia cordata</i> L.	Coleoptera: Chrysomelidae	<i>Donacia aequalis</i> Say	roots, leaves	A	Dunham Bay, Lake George, NY	
<i>P. cordata</i>	Coleoptera: Chrysomelidae	<i>Donacia rugosa</i> LeConte	roots, leaves	A	Upper Narrows Pond, ME	Marx (1957)
<i>P. cordata</i>	Coleoptera: Chrysomelidae	<i>Gallerucella nymphaeae</i> L.	leaves	L, A	Dunham Bay, Lake George, NY; Upper Narrows Pond, ME; Lake Gaston, NC	
<i>P. cordata</i>	Coleoptera: Curculionidae	<i>Onychylis prob. nigrirostris</i> Boheman	leaves, stems	A	Lake Gaston, NC	Haag et al. (1986)
<i>P. cordata</i>	Coleoptera: Curculionidae	<i>Onychylis</i> sp.	leaves, stems	A	Upper Narrows Pond, ME	
<i>P. cordata</i>	Lepidoptera: Noctuidae	<i>Bellura densa</i> Walker	stems, petioles	L	Dunham Bay, Lake George, NY	Vogel and Oliver (1969)
<i>Potamogeton amplifolius</i> Tuck.	Diptera: Chironomidae	sp.	leaves	A	Lavender Lake, Kittitas Co., WA	Berg (1949)
<i>Potamogeton illinoensis</i> Morong	Diptera: Chironomidae	<i>Glyptotendipes</i> sp.	leaves, midribs	L	Lake Wapagasset, WI	
<i>P. illinoensis</i>	Diptera: Ephydriidae	<i>Hydrellia fascitibia</i> van Roser	leaves, petioles	A	San Marcos River, TX	Berg (1949)
<i>P. illinoensis</i>	Diptera: Ephydriidae	<i>Hydrellia</i> sp.	leaves	A, L	Lee Co., FL	
<i>P. illinoensis</i>	Diptera: Ephydriidae	<i>Hydrellia</i> sp.	leaves	P	SW Shaw Lake, Lee Co. FL	
<i>P. illinoensis</i>	Diptera: Ephydriidae	<i>Hydrellia</i> sp.	leaves	P	Lake Wapagasset, WI	
<i>P. illinoensis</i>	Diptera	sp.	leaves	L	Rodman Reservoir, FL	
<i>P. illinoensis</i>	Lepidoptera: Crambidae	<i>Oxyelophila callista</i> Forbes	?	L	San Marcos, TX	
<i>Potamogeton nodosus</i> Poir.	Diptera: Ephydriidae	<i>Hydrellia bilobifera</i> Cresson	submersed leaves, petioles, stems	A	LAERF, Lewisville, TX	Deonier (1971)
<i>P. nodosus</i>	Diptera: Ephydriidae	<i>Hydrellia discursa</i> Deonier	submersed leaves, petioles, stems	A	LAERF, Lewisville, TX; Bear Creek, FL	Deonier (1971)
<i>P. nodosus</i>	Diptera: Ephydriidae	<i>Hydrellia</i> sp.	submersed leaves, petioles, stems	A	LAERF, Lewisville, TX	
<i>P. nodosus</i>	Lepidoptera: Crambidae	<i>Synclita oblitalis</i> Walker	floating leaves	L	LAERF, Lewisville, TX	Brigham and Herlong (1982)
<i>Potamogeton richardsonii</i> (Benn.) Rydb.	Diptera: Chironomidae	<i>Glyptotendipes</i> sp.	leaves	L	Evergreen Reservoir, WA	Berg (1949)
<i>Sagittaria graminea</i> Michx.	Coleoptera: Curculionidae	<i>Listronotus appendiculatus</i> Bohemon	leaves	A	LAERF, TX	
<i>Sagittaria latifolia</i> Willd.	Coleoptera: Curculionidae	<i>Listronotus delumbis</i> Gyllenhal	leaves	A	Rooster Rock State Park Wetland, OR	O'Brien (1997)

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Host Plant	Insect Order: Family	Insect species	Part of Plant Affected	Life Stage	Collection Site	Literature Citation (if available)
<i>Vallisneria americana</i> Michx.	Diptera: Chironomidae	<i>Endotribelos</i> sp.	leaves	L	Upper Narrows Pond, ME	
<i>V. americana</i>	Diptera: Chironomidae	<i>Polypedilum illinoense</i> sp. group	leaves	L	Hudson River, NY	
<i>V. americana</i>	Diptera: Chironomidae	sp.	leaves	L	Spearfish Lake, WA	
<i>V. americana</i>	Diptera: Ephydriidae	<i>Hydrellia bilobifera</i> Cresson	leaves	A, L	LAERF, Lewisville, TX	
<i>V. americana</i>	Diptera: Ephydriidae	<i>Hydrellia discursa</i> Deonier	leaves	A, L	LAERF, Lewisville, TX	
<i>V. americana</i>	Diptera: Ephydriidae	<i>Hydrellia</i> sp.	leaves	A	Upper Narrows Pond, ME	
<i>V. americana</i>	Diptera: Ephydriidae	<i>Hydrellia</i> sp.	leaves	A	Lake Cobossee, ME	
<i>V. americana</i>	Diptera: Ephydriidae	<i>Hydrellia</i> sp.	leaves	L	Hudson River, NY	
<i>V. americana</i>	Lepidoptera: Crambidae	<i>Paraponyx</i> sp.	leaves	L	Lake George, FL	
<i>V. americana</i>	Lepidoptera: Crambidae	<i>Petrophila</i> sp.	leaves	L	SW Shaw Lake, Lee Co. FL	