Annual Report 2024

Biological control of European frogbit, *Hydrocharis morsus-ranae*

Patrick Häfliger, Lauréline Humair, Philip Weyl

April 2025

KNOWLEDGE FOR LIFE

Cover photo: Dr Ian Knight (USACE) with Lauréline Humair and Patrick Häfliger collecting demographic data for European frogbit in Germany.

CABI Ref: IVM10269
Issued: April 2025

Biological control of European frogbit, *Hydrocharis morsus-ranae*

Annual Report 2024

Patrick Häfliger, Lauréline Humair and Philip Weyl

CABI
Rue des Grillons 1, CH-2800 Delémont, Switzerland
Tel: ++ 41 32 421 4870
Email: p.haefliger@cabi.org

Sponsored in 2024 by:
US Army Corps of Engineers

Table of contents

Summary

1. European frogbit, *Hydrocharis morsus-ranae* L. (Hydrocharitaceae) is a free-floating aquatic macrophyte native to Europe which has become invasive in North America (NA). *Hydrocharis morsus-ranae* was introduced into NA as an ornamental in the early 1930s. It is most abundant in eastern NA where it is currently not listed as a federal noxious weed, but it is well established in northern New York and south-eastern Michigan. It is classed as a Class B state noxious weed in Vermont and an invasive aquatic plant in Maine. In Canada it is regulated as a prohibited species in Ontario where it is most prolific. This report summarizes the work conducted at CABI developing a biological control programme for eastern NA in 2024.

2. We started with a literature search on phytophagous arthropods and fungal pathogens associated with European frogbit in Europe. So far, we have found records for one fungal pathogen and 14 insect species: four Coleoptera, four Diptera, one Hemiptera and five Lepidoptera. Two of these insect species are of interest with a potentially restricted host range. These are the weevil species *Bagous puncticollis* and the ephydrid fly *Hydrellia albifrons*.

3. Field surveys were initiated in May 2024. We were able to visit 48 sites in seven countries: Switzerland, Germany, Netherlands, France, Hungary, Serbia and Greece. We found *Hydrellia* flies at 17 sites and *Bagous puncticollis* at one site in Hungary. In addition, we collected genetic material from *Hydrocharis morsus-ranae* at 31 sites, and demographic data and plant chemistry samples at 12 sites.

4. During our rearing trials with *Hydrellia albifrons*, eggs were usually laid on the leaf surface. After about five days, larvae hatched and immediately started mining the leaf. Larval development goes through three instars to the puparium and was completed within two weeks under laboratory conditions. Full development was possible on a single leaf, if the leaf quality was good. Pupation typically occurs within the leaf petioles and adults emerged approximately one week after pupation. We were able to rear two generations between July and September. But since we probably missed one generation in early summer, we expect *H. albifrons* to have at least three generations a year. Unfortunately, since we collected only one *B. puncticollis* individual, we were not able to start a rearing colony with this species.

1. Introduction

Hydrocharis morsus-ranae (European frogbit) is a free-floating aquatic macrophyte with heart-shaped leaves and small white flowers with three petals (Plate 1a) (Catling *et al*., 2003). It can be found in slow-moving waters, typically in bays, ponds, open marshes and ditches, and along protected edges of lakes and rivers (Jacono, 2025). It is native through much of Europe and parts of temperate Asia as well as North Africa (Cook and Lüönd, 1982). In its native range *H. morsus-ranae* has declined or has been extirpated throughout parts of its European range and is of conservation concern in several areas (Preston and Croft, 1997). *Hydrocharis morsus-ranae* was introduced into North America as an ornamental in the early 1930s. The initial introduction into Ottawa is thought to originate from the Zurich Botanical Gardens, Switzerland (Dore, 1968; White *et al*., 1993). From late summer through autumn, winter buds (turions) are formed on the stolons and it is estimated that a single plant can form approximately 100 to 150 turions which favour the plant's spread (Plate 1b) (Dore, 1968; Scribailo and Posluszny, 1984; Nault and Mikulyuk, 2009). Now it is most abundant in eastern North America. It is currently not listed as a federal noxious weed, but it is well established in northern New York and south-eastern Michigan, and is classed as a Class B state noxious weed in Vermont and an invasive aquatic plant in Maine (NRCS, 2023). In Canada it is present in south-eastern Ontario and western Quebec where it is considered one of the five invasive plants that cause major impacts on the natural ecosystem (Catling *et al*., 2003). It is not regulated as a noxious weed in any Canadian province, but is prohibited in Ontario. It has also recently been reported on the west coast of North America, where it is established in Washington, and is an A list noxious weed in California (NRCS, 2023).

Plate 1. Flowering *Hydrocharis morsus-ranae* (a) and overwintering turions (b).

It is continuing to expand its range, becoming more abundant and considered invasive with socio-economic and environmental impacts (Catling *et al*., 2003). The negative impacts are typical for floating macrophytes and include displacing native plant species, reducing biodiversity, decreasing water quality and flow, clogging irrigation pumps, impeding recreational activities, and diminishing aesthetic value. As with many macrophytes, once established, it can be extremely difficult to control. Any mechanical method that fragments plants such as harvesting or hand pulling is likely to favour the growth and spread of this species. Herbicides are difficult to employ due to restrictions in use in the sensitive wetland habitats that it invades (Catling *et al*., 2003). There are no biological control agents already developed for *H. morsus-ranae*, but several herbivores have been recorded in the native range. Thus, the biological control programme was initiated in 2024 with support from the US Army Corps of Engineers to investigate the potential for developing biological control agents against *H. morsus-ranae.* During surveys in the native range, other closely related species such as *Stratiotes aloides*, also introduced in North America, will be considered given the phylogenetic relatedness and the geographic overlap. There are also several cases where both species are thought to be part of the host range of herbivores of interest (Table 1).

2. Work Programme for Period under Report

The work plan for 2024 is outlined below. Results are reported in subsequent sections.

Surveys

- Conduct literature survey on phytophagous arthropods and fungal pathogens associated with *H. morsus-ranae* in Europe;
- Identify specific sites of *H. morsus-ranae* in the native range by cross referencing literature and internet sources for site records;
- Collect genetic material of *H. morsus-ranae* at the sites identified above;
- Collect quantitative demographic data.

Plant cultures

- Initiate plant cultures of *H. morsus-ranae* from different populations and genotypes found in Europe.

Natural enemies

- Collect and identify any natural enemies (insects, mites or fungal pathogens) found during surveys;
- Initiate rearing cultures of promising herbivores.

3. Surveys

3.1 Literature survey

METHODS To obtain an overview of phytophagous organisms associated with *H. morsus-ranae* as host, online databases and papers were searched for host/feeding records on *H. morsus-ranae.*

RESULTS The literature research is ongoing. So far 15 organisms have been found to be associated with *H. morsus-ranae* (Table 1). Most species are reported as oligophagous or polyphagous (Table 1), although there are some that are worth further investigation, especially given the outdated literature. Two insects, *Bagous puncticollis* Boheman and *Hydrellia albifrons* Fallén are of interest as they seem strongly associated with *Hydrocharis morsus-ranae.* The pathogen *Tracya hydrocharidis* Lagerheim is also worth more investigation as it is recorded as monophagous on *H. morsus-ranae.*

Table 1. Phytophagous arthropods and pathogens associated with *Hydrocharis morsus-ranae* in the literature. M = monophagous, O = oligophagous, P = polyphagous.

Taxa	Host range	Plant part attacked	Feeding mode	Host plants	Source
COLEOPTERA					
Curculionidae					
Bagous chinensis	O	Stem?	Borer?	*Hydrilla verticillata, Elodea nuttallii, Egeria densa, Vallisneria natans, Hydrocharis morsus-ranae*	Zhang *et al.* 2012
Bagous limosus	P	Stem	Borer	*Potamogeton* spp., *Hydrocharis morsus-ranae, Myriophyllum*	Labat 2024; Ellis 2001-2025
Bagous puncticollis	O?	Unknown (leaf/ stem)	Unknown (borer)	*Hydrocharis morsus-ranae*, *Stratiotes aloides*, *Elodea canadensis*	Caldara and O'Brien 1998; Sprick 2000; Pešić 2007
Chrysomelidae					
Galerucella grisescens	P	Leaf	External	*Lysimachia, Hydrocharis morsus-ranae, Hypericum, Juncus*	https://dbif.brc.ac.uk
DIPTERA					
Ephydridae					
Hydrellia albifrons	P?	Leaf	Larvae miner	*Potamogeton, Hydrocharis morsus-ranae, Alisma plantago-aquatica*	Kahanpää and Zatwarnicki 2015
Hydrellia cochleariae	P?	Leaf	Miner	*Stratiotes, Potamogeton, Callitriche, Hydrocharis morsus-ranae*	Kahanpää and Zatwarnicki 2015; https://dbif.brc.ac.uk
Hydrellia griseola	P?	Leaf	Miner	Alismataceae, Caryophyllaceae, Chenopodiaceae, Compositae, Cruciferae, Cyperaceae, Gramineae, Hydrocharitaceae (*Hydrocharis morsus-ranae & Stratiotes aloides*), Labiatae, Leguminosae, Lemnaceae, Liliaceae, Polygonaceae, Typhyceae	Hesler 1995; https://dbif.brc.ac.uk
Hydrellia mutata	P?	Leaf	Miner	*Alisma, Stratiotes, Lemna, Hydrocharis morsus-ranae*	Kahanpää and Zatwarnicki 2015; https://dbif.brc.ac.uk
HEMIPTERA					
Aphidinae					
Rhopalosiphum nymphaeae	P	Leaf	External	*Prunus* spp., *Acorus, Alisma plantago-aquatica, Azolla filiculoides, Baldellia*, *Butomus umbellatus, Calla, Callitriche, Ceratophyllum submersum, Echinodorus, Elodea, Glyceria, Hippuris vulgaris, Holcus lanatus, Hydrocharis, Juncus, Lemna* spp., *Marsilea* spp,. *Menyanthes*, *Myriophyllum spicatum, Nasturtium officinale, Nelumbo*, *Nuphar lutea, Nymphaea alba, Nymphoides*, *Pistia*, *Polygonum*, *Potamogeton natans, Ranunculus aquatilis, Sagittaria sagittifolia, Salvinia* spp., *Saxifraga aquatica, Schoenoplectus lacustris, Scirpus, Secale cereale, Sparganium*, *Stratiotes aloides, Trapa*, *Triglochin*, *Typha* spp.	Halder *et al.* 2020; Milenkovic *et al.* 2022; Ellis 2001-2025

Taxa	Host range	Plant part attacked	Feeding mode	Host plants	Source
LEPIDOPTERA					
Crambidae					
Cataclysta lemnata	O	Leaf	External	*Azolla, Lemna,* occasionally *Stratiotes aloides, Hydrocharis morsus-ranae*	Van der Velde 1988; Ellis 2001-2025
Elophila nymphaeata	P	Leaf	Larvae miner	*Alisma plantago-aquatica, Callitriche palustris, Catabrosa aquatica, Hydrocharis morsus-ranae, Leersia, Myosotis laxa, Nuphar lutea, Nymphaea alba, Nymphoides peltata, Persicaria amphibia, Potamogeton* spp.*, Sparganium emersum, Stratiotes aloides, Stuckenia pectinata*	Vallenduuk and Cuppen 2004; Ellis 2001-2025
Munroessa icciusalis	P	Leaf	External	*Eichhornia crassipes, Limnobium spongia, Orontium aquaticum, Potamogeton diversifolius, Sparganium americanum, Hydrocharis morsus-ranae*	Catling *et al.* 2003; Stoops *et al.* 1998
Parapoynx stratiotata	P	Leaf	External	*Alisma plantago-aquatica, Callitriche palustris, Ceratophyllum demersum, Elodea*, *Hydrocharis morsus-ranae, Myriophyllum* spp.*, Nymphaea alba, Potamogeton crispus, Stratiotes aloides, Trapa natans*	Ellis 2001-2025
Synclita occidentalis	O	Leaf	External	*Lemna, Hydrocharis morsus-ranae*	Catling *et al.* 2003; Bashar *et al.* 2007
FUNGI					
BASIDIOMYCOTA					
Doassansiaceae					
Tracya hydrocharidis	M	Leaf	Leaf spot pathogen	*Hydrocharis morsus-ranae*	Van Steenwinkel *et al.* 2022

3.2 Field surveys

Hydrocharis morsus-ranae is present across much of in Europe (Plate 2).

METHODS Based on GBIF and iNaturalist databases (www.gbif.org/ and www.inaturalist.org), we drew maps using QGIS 3.30 Hertogenbosch, and selected sites according to various criteria such as: records of *H. morsus-ranae* between 2020 and 2024, not in a protected site or reserve, herbivores of interest recorded, and also type of water body and accessibility. Between May and July 2024, we conducted six field trips. At each site, plants were checked visually for insects and sampled for dissection in the lab.

RESULTS We were able to visit 48 sites, including ponds, channels and rivers in seven countries: Switzerland, Germany, Netherlands, France, Hungary, Serbia and Greece (Plate 2). We found *Hydrellia* flies at 17 sites relatively widespread between Switzerland, France, Netherlands, Germany and Greece, and *Bagous puncticollis* at one site in Hungary. We collected another *Bagous* species, *Bagous subcarinatus*, at one site in Germany, but this is associated with *Ceratophyllum* spp. and not *H. morsus-ranae*.

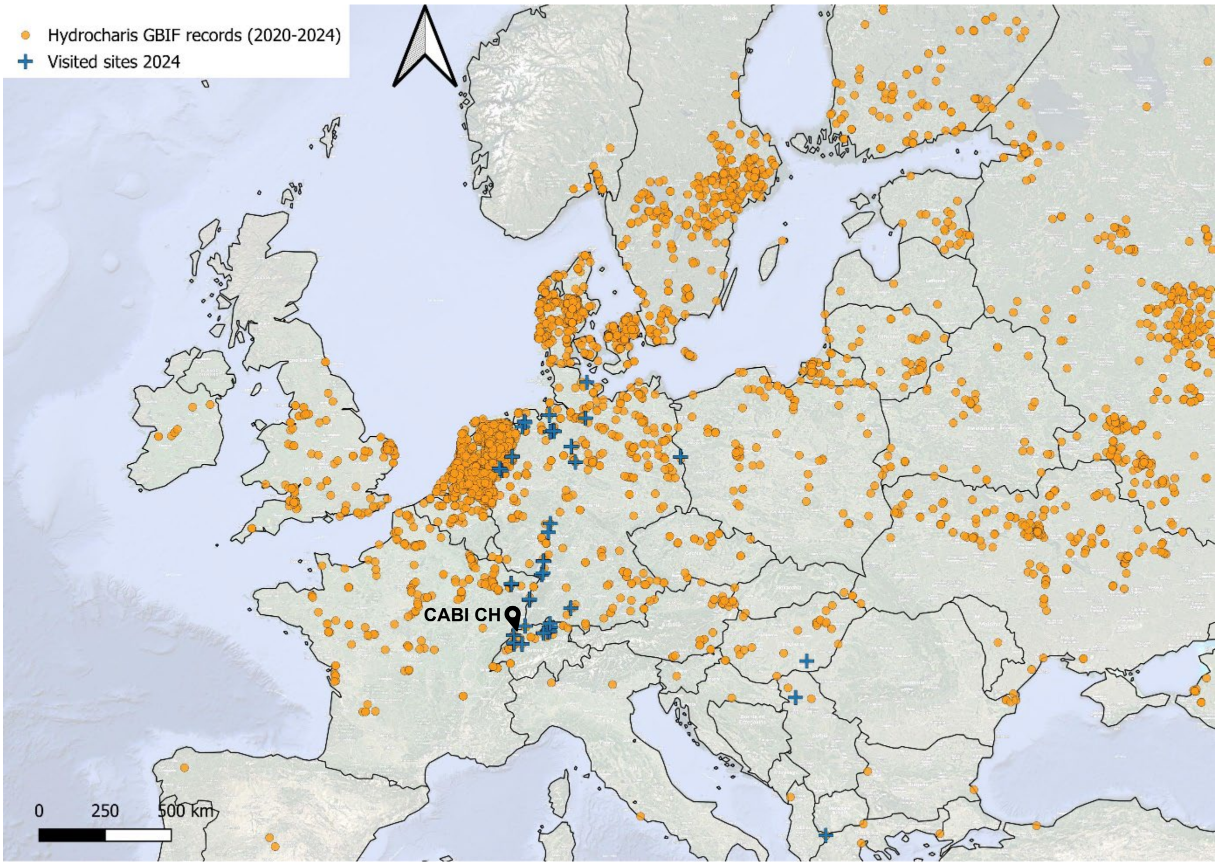

Plate 2. *Hydrocharis morsus-ranae* distribution throughout Europe. Records from 2020 to 2024 are shown in orange. Blue crosses represent sites visited during the field season in 2024.

3.3 Genetic study

The geographic source of introduced populations can be extremely useful to understand the history of invasion to guide future surveys for appropriate natural enemies. This is investigated through molecular matching of introduced with native populations, in which plant tissues from introduced populations are sampled, and their

DNA extracted, analyzed and then compared. It is especially important when the species has a large native geographic range because potential biological control agents may be locally adapted to a particular plant genotype.

METHODS At each site, between five and ten plants were sampled. Up to three leaves were taken per plant, cleaned and dried with paper towelling and placed individually in a plastic bag with silica gel and labelled with the site name and the date. These samples were then sent to Prof. Ryan Thum, Montana State University, Department of Plant Sciences and Plant Pathology for analysis.

RESULTS We were able to collect genetic material at 31 sites and all samples were sent to Prof. Thumb in October 2024. These are yet to be analysed, and results will be available at a later date.

3.4 Demographic study

METHODS In order to understand the demography of the plants at sites visited, the patch size of the site was estimated as well as the total *H. morsus-ranae* coverage. We recorded visually if any of the *H. morsus-ranae* were flowering and what other plant species were present at the site.

Five quadrats were placed along a 25-m transect where possible. The first quadrat contained *H. morsus-ranae* and quadrats were spaced 5 m apart. The quadrat size was 0.25 m^2 and each was subdivided into four equal quadrants (Plate 3a). We estimated the distance of the quadrat center from the shore, water depth, and percentage cover of target and non-target plants. We took a picture of each quadrat and counted the number of flowers and fruits. We took three plants per quadrat to record whether turions were present. Once quadrat sampling was completed, we collected six leaves from six different plants randomly collected in the site for leaf chemistry analysis (Plate 3b). A picture of the leaves was taken and then they were placed separately in bags of silica gel and sealed in an envelope or plastic bag.

RESULTS We took demographic data and chemistry samples at 12 sites. The raw data as well as samples for plant chemistry were sent in October 2024 to Dr Ian Knight, US Army Corps of Engineer for analysis.

Plate 3. (a) An example quadrat at the site "Etang des Royes" (47.2520247° N, 7.031159° W), close to CABI in Switzerland. The quadrat is subdivided into four (1.1, 1.2, 1.3, 1.4) and *Hydrocharis morsus-ranae* cover is estimated (80%–90%–100%–95%, respectively). (b) Leaf chemistry sample collection; leaves were saved in silica gel for future analysis.

4. *Hydrellia albifrons* (Fallén) (Diptera, Ephydridae)

4.1 Introduction

Four shore fly species are recorded as herbivores on European frogbit (Table 1). However, since identification of *Hydrellia* species is difficult, many of the old records may be misidentified. It is most likely that *H. albifrons* is the only *Hydrellia* species developing on *Hydrocharis morsus-ranae*, and *H. morsus-ranae* is likely to be *Hydrellia albifrons*'s only host (Jens-Hermann Stuke, pers. comm., ephydrid specialist, University of Bremen). *Hydrellia albifrons* is widespread in Europe and also known from North Africa and Pakistan (Kahanpää and Zatwarnicki, 2015).

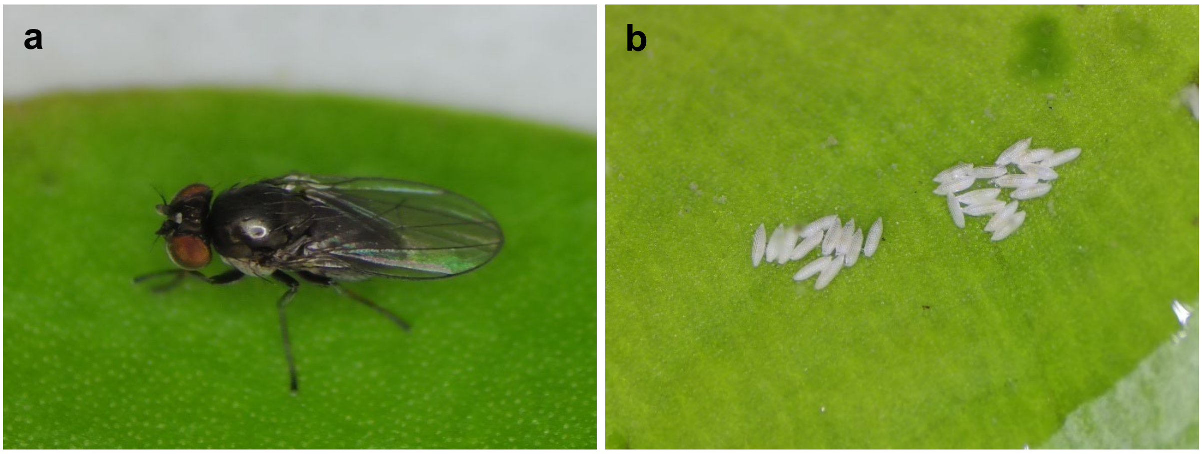

Plate 4. Adult *Hydrellia albifrons* (a) and eggs on leaf surface (b).

Most *Hydrellia* species are associated with aquatic habitats and several species have been considered in other weed biological control programs (Grodowitz *et al*., 1997; Wheeler and Center, 2001; Martin *et al*., 2013; Moffat *et al*., 2024), and some species are also known as pests on cultivated rice (Viajante and Heinrichs, 1986; Pathak and Khan, 1994; El-Habashy, 2011).

4.2 Biology

According to Kahanpää and Zatwarnicki (2015), larvae of *H. albifrons* are recorded to feed on pondweeds (*Potamogeton*), on European frogbit (*Hydrocharis morsus-ranae*), and possibly also on water plantains (*Alisma plantago-aquatica*). However, Jens-Hermann Stuke (ephydrid specialist, University of Bremen) is convinced that European frogbit is the only host of *Hydrellia albifrons*. We plan to start our host-specificity tests in 2025 with pondweeds and water plantains, to quickly clarify this point.

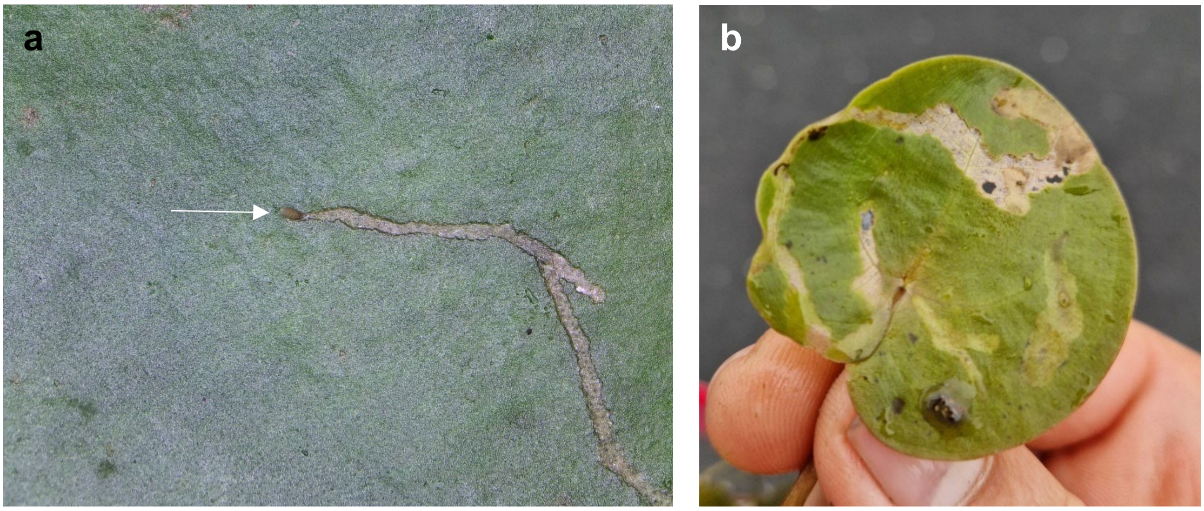

Plate 5. *Hydrellia albifrons* mine of first instar larva starting from the egg (white arrow) (a), and *Hydrocharis morsus-ranae* leaf mined by mature larva (b).

The following observations were collected during our rearing trials. The adults are usually found closely associated with the plant and often walking on the surface of the leaves (Plate 4a) (Stuke, 2011). Eggs were usually laid on the leaf surface, often close to the water surface (Plate 4b). In the rearing cylinders eggs were also observed on the ridges of the container used to provide yeast hydrolysate and sugar and many eggs were also laid on the cylinder wall. After about five days, larvae hatched and immediately started mining the leaf (Plate 5a). Development through three instars to the puparium was completed within two weeks under lab conditions at 21°C. Full development was possible on a single leaf, if the quality of the leaf was good. However, if the leaf started wilting prematurely, or if *Hydrellia* densities and mining were high, larvae would willingly move to another leaf by crawling or swimming, irrespective of instar. Pupation usually occurred in leaf petioles (Plate 6c), but if petioles were too thin or otherwise inappropriate, pupation was also successful underneath a leaf (Plate 6b). Adults emerged approximately one week after pupation. We were able to rear two generations between July and September. But since we probably missed one generation in early summer, we expect *H. albifrons* to have at least three generations at our latitudes.

During the winter we found several puparia floating in the water in our rearing trays that had not emerged. We suspect that these are overwintering pupae; however, we have yet to see whether these are the overwintering stage of the fly that will emerge as adults in spring 2025, or whether they simply failed to emerge before winter. We also plan to dissect overwintering turions for potential overwintering larvae or puparia of *H. albifrons*.

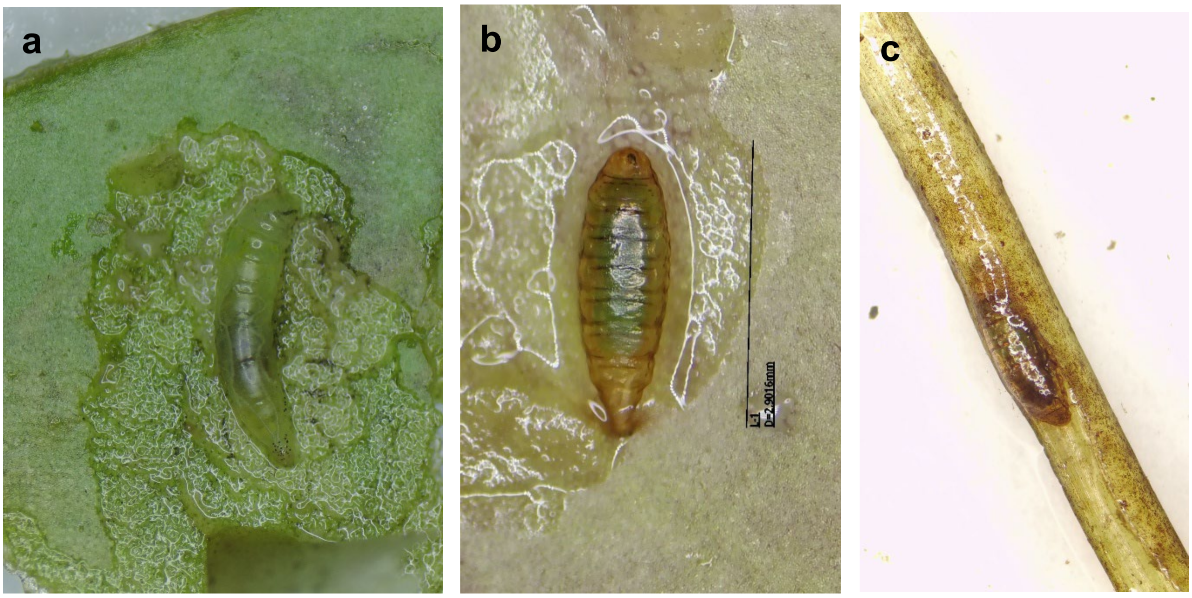

Plate 6. Third instar larva of *Hydrellia albifrons* (a), puparium underneath the leaf (b), and puparium in the leaf petiole (c).

4.3 Rearing

METHODS Between 20 and 31 July 2024, first oviposition trials were conducted in four 1.3-litre cylinders covered with a gauze lid, filled to about three-quarters full with water and containing 2–3 *Hydrocharis morsus-ranae* plants. In each cylinder 6–10 adult flies were released. In first trials, oxeye daisy flowers were offered as a food source, resulting in only random oviposition. The addition of yeast hydrolysate mixed with sugar (4:7) (Buckingham and Okrah, 1993; Martin *et al*., 2013) offered in a yellow bottle lid significantly boosted egg production. Eggs were distributed on several cylinders and plants. Cylinders were checked regularly for mines and larvae, and plants replaced and leaves with larvae moved to another cylinder, if plant quality deteriorated, or larval density became too high. Once puparia were found, they were moved to Petri dishes lined with a damp filter paper. Between 14 and 30 August, emerging adults were used to set up 23 additional cylinders for the next generation (Plate 7a).

Plate 7. Cylinders (a) and larger containers (b) for rearing of *Hydrellia albifrons*.

To test mass-rearing techniques, on 28 August we also transferred 126 and 242 eggs respectively into two larger trays (38 × 30 × 20 cm) filled with *Hydrocharis morsus-ranae* plants and covered with gauze (Plate 7b). And between 3 and 9 September we transferred leaves infested with 121 first instar larvae onto an additional tray.

RESULTS In our first rearing attempts in cylinders from the end of July, about 50% of eggs obtained developed successfully to adults (*n* = 162). For the trial with 121 first instar larvae set up on a larger tray early September, 105 puparia were found in February 2025. This is a very good development rate of nearly 87%. Of these puparia, 82 were empty (= had emerged) and 23 had not emerged. Two trials were setup in larger trays with eggs at the end of August. In the first trail with 265 eggs, 49 puparia were found in March 2025, which is a development rate of about 19%. Of these puparia, 42 were empty and seven had not emerged. In the second trial with 126 eggs, 37 puparia were found in April 2025, which is a development rate of about 29%. Of these puparia, 29 were empty and six had not emerged. We are overwintering puparia which had not emerged and will check regularly whether adults emerge from them.

4.4 Discussion

Rearing of *Hydrellia albifrons* seems to be straightforward during the summer months, when it is possible to let flies oviposit on a tray with healthy *Hydrocharis morsus-ranae* and to obtain at least 100 adult flies roughly one month later. The success and mode of overwintering will only become evident in early summer 2025. However, whatever that outcome is, we will be able to start host-specificity tests in 2025, since we are not reliant on overwintering puparia and can easily field collect adults. This will allow us to focus on clarifying whether literature records that this species is able to develop on several plant species are correct or whether these were misidentifications.

5. *Bagous puncticollis* Boheman (Coleoptera, Curculionidae)

Most literature records consider *Bagous puncticollis* as oligophagous, with *Hydrocharis morsus-ranae*, *Stratiotes aloides* and *Elodea canadensis* as host plants (Dieckmann, 1983; Caldara and O’Brien, 1998; Sprick, 2000). However, records of *Stratiotes* and

Elodea as hosts seem to be based on a single old reference, Hoffmann 1954 (cited in Bogusch, 2017). And since larval development was never observed (Sprick, 2000), these records are questionable.

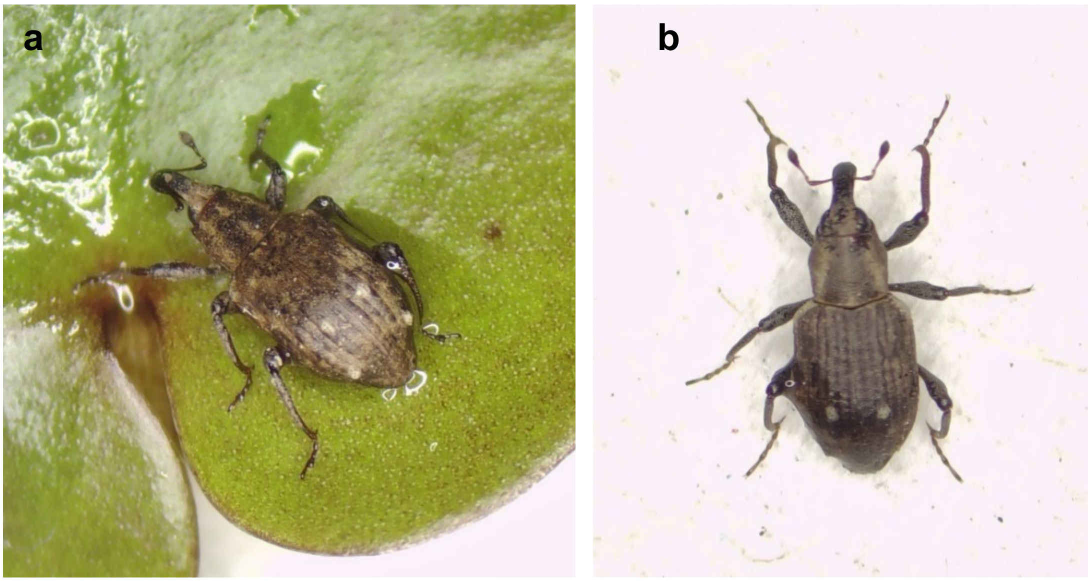

Plate 8. Adult *Bagous puncticollis* collected on European frogbit in Hungary (a), and *B. subcarinatus* collected on water soldier in Germany (b).

Bagous puncticollis is reported as rare and endangered in most European countries (Sprick, 2000; Bogusch, 2017). However, in May 2024 we found one weevil on one of our first field trips at a sparse *H. morsus-ranae* site in Hungary (Plate 8). Unfortunately, this single weevil was lost while changing the food plant. Our experience with *Bagous nodulosus* on flowering rush, also reported as rare in the literature, keeps us optimistic that we will find more weevils, if we specifically look at sites where the species has been reported before. Given this, we plan to focus future surveys to areas where recent records are available such as Denmark, France, Estonia, Finland, Poland, Romania, Serbia, Sweden and UK (Pešić, 2007; www.gbif.org/). Older reports were found in addition from Austria, Belgium, Bosnia-Herzegovina, Belarus, the Czech Republic, Germany, Greece, Hungary, Italy, Netherlands, Slovakia, Slovenia, Spain, Switzerland, Ukraine and western Siberia (Alonso-Zarazaga *et al*. 2023), although there is some risk that the species has indeed become rare or even extinct due to habitat loss at some sites.

Plate 9. *Bagous puncticollis* with typical feeding holes on a leaf of *Hydrocharis morsus-ranae* (from Sprick 2001).

The main activity of adults seems to be in May and June (possibly to July) (Freude *et al*., 1983). Adult feeding creates characteristic holes in the leaves (Plate 9). According to Lutz Behne (Senckenberg Society for Nature Research) the weevil must be able to fly, since it has been found in light traps (Sprick, 2000).

At a site in northern Germany, we found 12 *Bagous* eggs inserted in petioles of *H. morsus-ranae* (Plate 10). Hatching larvae were transferred into petioles, but the larvae remained in the first instar even after 20 days, when they were dissected out and preserved in ethanol for molecular identification. Unfortunately, the genetic results were inconclusive due to the amplification of pseudogenes. We assume that *H. morsus-ranae* cannot be the main host of this *Bagous* species and development may occur in another aquatic plant species at this site.

We also searched for weevils on water soldier, *Stratiotes aloides*, another plant recorded as host for *B. puncticollis*. However, so far we have only found *Bagous subcarinatus*, a weevil recorded from *Ceratophyllum submersum* and *Myriophyllum* species (Caldara and O'Brien, 1998) (Plate 8b).

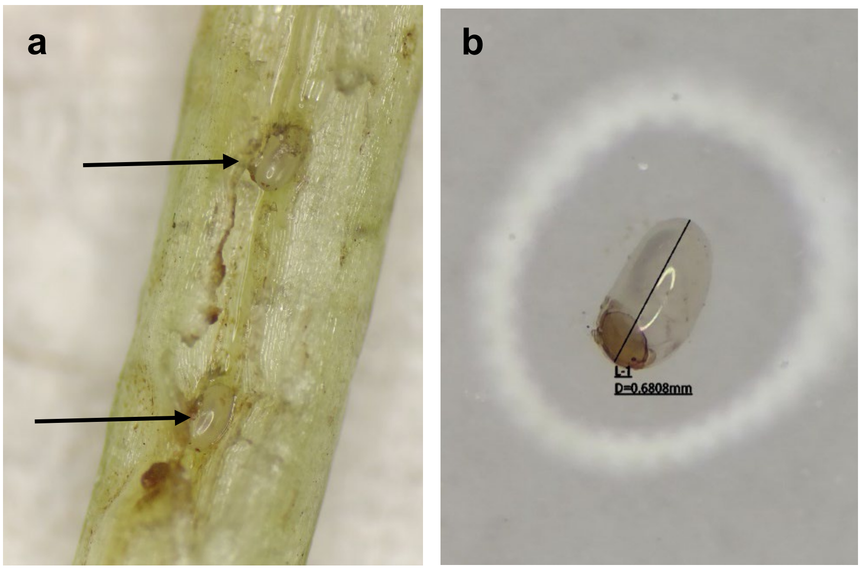

Plate 10. Eggs of unknown *Bagous* species found on *Hydrocharis morsus-ranae* (a) and extracted and magnified (b).

6. Other herbivorous species

We commonly found crambid larvae causing considerable damage to *H. morsus-ranae* leaves. However, all five crambid species found as herbivores on European frogbit are polyphagous (Table 1). The two larvae that were sent for barcoding to Ivo Toševski (Belgrade) were identified as *Elophila nymphaeata* (Linnaeus, 1758) (Lep.: Crambidae) a species recorded from several aquatic plant species and genera covering multiple families.

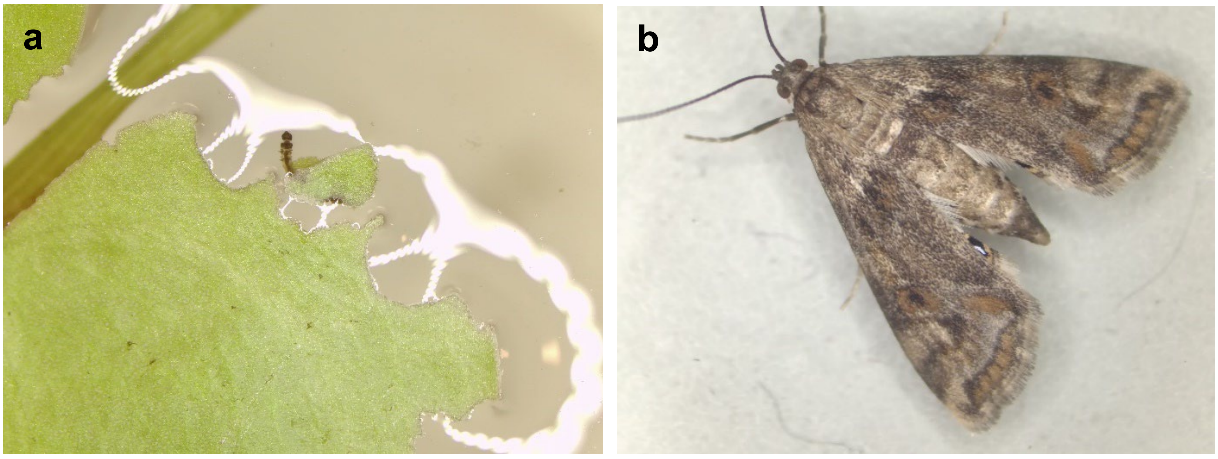

Plate 11. First instar crambid larva cutting off leaf piece of *Hydrocharis morsus-ranae* (a), and crambid emerged from larva collected in Greece (b).

7. Work Programme Proposed for 2025

The following work programme is being proposed for 2025.

Surveys

- Extend field surveys to Sweden, UK, Hungary, and Serbia or the Czech Republic.

***Bagous puncticollis* (Coleoptera, Curculionidae)**

- Survey specific sites known for this weevil in the Czech Republic, Hungary, Sweden and UK;
- If successful with collections, study biology and establish a rearing colony;
- Initiate preliminary host-specificity tests on hosts recorded in the literature, *Stratiotes aloides* and *Elodea canadensis*.

***Hydrellia albifrons* (Diptera, Ephydridae)**

- Maintain a rearing colony at CABI;
- Continue studying the biology to try and understand the overwintering of this fly;

- Initiate preliminary host-specificity tests on hosts recorded in the literature, *Potamogeton* species and *Alisma plantago-aquatica*;
- Set up an experiment to explore the potential impact this fly may have.

8. Acknowledgements

We would like to thank the US Army Corps of Engineers for the financial support of the project, for which we are grateful. We extend our gratitude to Jens-Hermann Stuke for his assistance and sharing his extensive experience and sites around Leer (Germany) and for identifying *Hydrellia albifrons*. We also thank Petr Bogusch and Peter Sprick for sharing site information for *Bagous puncticollis,* which will prove invaluable in the 2025 field season. We thank Lea Emery for her help in the field and Ivo Toševski for the molecular analysis of the insect specimens provided, allowing us to make informed decisions based on these identifications. The Office of Environment in the Canton of Jura is thanked for providing permits to collect specimens from the Etang des Royes.

9. References

Bashar, M.A., Parveen, N. and Quraishi, S.B. (2007) Larval adaptations of a pyralid insect pest (*Synclita occidentalis*) to its host-plant in pond ecosystem. *Bangladesh Journal of Zoology* 35, 357–366.

Bogusch, P. (2017) Distribution and ecology of the weevils of the tribe Bagoini (Coleoptera: Curculionidae) in the Czech Republic. *Klapalekiana* 53, 193–270.

Buckingham, G.R. and Okrah, E.A. (1993) Biological and host range studies with two species of *Hydrellia* (Diptera: Ephydridae) that feed on *Hydrilla*. Technical Report, US Army Corps of Engineers, 58 pp.

Caldara, R. and O'Brien, C.W. (1998) Systematics and evolution of weevils of the genus *Bagous*. VI. Taxonomic treatment of the species of the Western Palearctic Region (Coleoptera Curculionidae). *Memorie della Società Entomologica Italiana* 76, 131–347.

Catling, P.M., Mitrow, G., Haber, E., Posluszny, U. and Charlton, W.A. (2003) The biology of Canadian weeds. 124. *Hydrocharis morsus-ranae* L. *Canadian Journal of Plant Science* 83, 1001–1016.

Cook, C.D.K. and Lüönd, R. (1982) A revision of the genus *Hydrocharis* (Hydrocharitaceae). *Aquatic Botany* 14, 177–204.

DBIF (undated) Database of Insects and their Food Plants. Biological Records Centre, CEH, Wallingford, UK. Available at: https://dbif.brc.ac.uk (accessed 5 March 2024).

Dieckmann, L. (1983) Beiträge zur Insektenfauna der DDR: Coleoptera – Curculionidae (Tanymecinae, Leptopiinae, Cleoninae, Tanyrhyncinae, Cossoninae, Raymondionminae, Tanysphyrinae). *Beiträge zur Entomologie* 33, 257–381.

Dore, W.G. (1968) Progress of the European frog-bit in Canada. *The Canadian Field-Naturalist* 82, 76–84.

El-Habashy, M.M. (2011) Effect of rice leafminer infestation on rice yield, and correlation between leaf plant chemical components and insect severity. *Journal of Plant Protection and Pathology, Mansoura University* 2, 1071–1079.

Ellis, W.N. (2001–2025) Plant parasites of Europe: leafminers, galls and fungi. Available at: https://bladmineerders.nl (accessed 27 March 2025).

Freude, H., Harde, K.W. and Lohse, G.A. (1983) *Die Käfer Mitteleuropas; Band 11.* Goecke & Evers, Krefeld, 340 pp.

Grodowitz, M., Center, T.D., Cofrancesco, A.F. and Freedman, J.E. (1997) Release and establishment of *Hydrellia balciunasi* (Diptera: Ephydridae) for the biological control of the submersed aquatic plant *Hydrilla verticillata* (Hydrocharitaceae) in the United States. *Biological Control* 9, 15–23.

Halder, J., Rai, A.B., Chakrabarti, S. and Dey, D. (2020) Distribution, host range and bionomics of *Rhopalosiphum nymphaeae* (Linnaeus, 1761) a polyphagous aphid in aquatic vegetables. *Defence Life Science Journal* 5, 49–53.

Hesler, L.S. (1995) Bibliography on *Hydrellia griseola* Fallén (Diptera: Ephydridae) and review of its biology and pest status. *Insecta Mundi* 9,1–2.

Hoffmann, A. (1954) Coléoptères Curculionides (deuzième partie). *Faune de France* 59, 487–1208.

Jacono, C.C. (2025) *Hydrocharis morsus-ranae*. USGS Nonindigenous Aquatic Species Database, Gainesville, Florida. Available at: https://nas.er.usgs.gov/queries/greatlakes/FactSheet.aspx?Species_ID=1110.

Kahanpää, J. and Zatwarnicki, T. (2015) Notes on shore flies (Diptera: Ephydridae) from Finland and north-western Russia. *Biodiversity Data Journal* 3.

Labat, F. (2024) Identification des genres de Curculionoidea aquatiques ou amphibies de France continentale (Curculionidae, Erirhinidae). *Bulletin de la Société Linnéenne de Bordeaux* 52, 61–73.

Martin, G.D., Coetzee, J.A. and Baars, J.-R. (2013) *Hydrellia lagarosiphon* Deeming (Diptera: Ephydridae), a potential biological control agent for the submerged aquatic weed, *Lagarosiphon major* (Ridl.) Moss ex Wager (Hydrocharitaceae). *African Entomology* 21, 151–160.

Milenković, D., Žikić, V., Stanković, S.S., Lazarević, M., Petrović-Obradović, O. and Milošević, M.I. (2022) Secondary host plants of water lily aphid, *Rhopalosiphum nymphaeae* (Hemiptera: Aphididae) in Serbia. *Facta Universitatis, Series: Medicine and Biology* 24, 40–43.

Moffat, R., van Noort, S., Coetzee, J.A. and Hill, M.P. (2024) Biotic resistance towards *Hydrellia egeriae*, a biological control agent for the aquatic weed *Egeria densa*, in South Africa. *African Entomology* 32.

Nault, M.E. and Mikulyuk, A. (2009) European frog-bit (*Hydrocharis morsus-ranae*). A technical review of distribution, ecology, impacts, and management. PUB-SS-1048 2009. Wisconsin Department of Natural Resources Bureau of Science Services, Madison.

NRCS (2023) The PLANTS Database. United States Department of Agriculture, Natural Resources Conservation Service (NRCS), The National Plant Data Center. Available at: http://plants.usda.gov (archived at PERAL).

Pathak, M.D. and Khan, Z.R. (1994) *Pests of Rice.* International Rice Research Institute, Manila, Philippines, 89 pp.

Pešić, S. (2007) *Bagous puncticollis* Boheman, 1845 – new weevil species (Coleoptera, Curculionidae) for the fauna of Serbia. *Kragujevac Journal of Science* 29, 149–154.

Preston, C.D. and Croft, J.M. (1997) *Aquatic Plants in Britain and Ireland*. Harley Books, Colchester, UK, 365 pp.

Scribailo, R.W. and Posluszny, U. (1984) The reproductive biology of *Hydrocharis morsus-ranae*. I. Floral biology. *Canadian Journal of Botany* 62, 2779–2787.

Sprick, P. (2000) Eignung einer Insektengruppe für die Fauna-Flora-Habitat-Richtlinie der EU (92/43/EWG, 21. Mai 1992) am Beispiel der Rüssekäfer-Unterfamilie Bagoinae (Col., Curculionidae). *Insecta* 6, 61–96.

Sprick, P. (2001) Suitability of an insect group for the Habitats Directive of the EU. The weevil subfamily Bagoinae (Coleoptera: Curculionidae). Contributions to the ecology of phytophagous beetles VII. *Snudebiller* 2, 7–40.

Stoops, C.A., Adler, P.H. and McCreadie, J.W. (1998) Ecology of aquatic Lepidoptera (Crambidae: Nymphulinae) in South Carolina, USA. *Hydrobiologia* 379, 33–40.

Stuke, J.-H. (2011) Eine kritische Liste der aus Deutschland nachgewiesenen Ephydridae mit der Beschreibung einer neuen Art (Diptera). *Entomologische Zeitschrift* 121, 119.

Vallenduuk, H.J. and Cuppen, H.M. (2004) The aquatic living caterpillars (Lepidoptera: Pyraloidea: Crambidae) of Central Europe. A key to the larvae and autecology. *Lauterbornia* 49, 1–17.

Van der Velde, G. (1988) *Cataclysta lemnata* L. (Lepidoptera, Pyralidae) can survive for several years consuming macrophytes other than Lemnaceae. *Aquatic Botany* 31, 183-189.

Van Steenwinkel, C., Fraiture, A. and Vanderweyen, A. (2022) Four smut fungi new for Belgium. *Sterbeeckia* 37, 15–21.

Viajante, V.D. and Heinrichs, E.A. (1986) Rice growth and yield as affected by the whorl maggot *Hydrellia philippina* Ferino (Diptera: Ephydridae). *Crop Protection* 5, 176–181.

Wheeler, G.S. and Center, T.D. (2001) Impact of the biological control agent *Hydrellia pakistanae* (Diptera: Ephydridae) on the submersed aquatic weed *Hydrilla verticillata* (Hydrocharitaceae). *Biological Control* 21, 168–181.

White, D.J., Haber, E. and Keddy C. (1993) *Invasive Plants of Natural Habitats in Canada: an Integrated Review of Wetland and Upland Species and Legislation Governing their Control.* Canadian Wildlife Service. Available at: https://publications.gc.ca/collections/collection_2016/eccc/CW66-127-1999-eng.pdf

Zhang, J., Purcell, M., Tian, B. and Ding, J. (2012) Progress report on field surveys to identify biocontrol agents of *Hydrilla verticillata* in China during 2011. APCRP-BC-28. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

Distribution list

Matthew Bolding

Rob Bourchier

Janine Brooke

Al Cofrancesco

Michael Greer

Nathan Harms

Ian Knight

Valerie Miller

European Frogbit Collaborative

Africa

Ghana

CABI, CSIR Campus
No.6 Agostino Neto Road
Airport Residential Area
P.O. Box CT 8630,
Cantonments
Accra, Ghana
T: +233 (0)302 797 202
E:westafrica@cabi.org

Kenya

CABI, Canary Bird
673 Limuru Road,
Muthaiga
P.O. Box 633-00621
Nairobi, Kenya
T: +254 (0)20 2271000/20
E:africa@cabi.org

Zambia

CABI, Southern Africa
Centre
5834 Mwange Close
Kalundu, P.O. Box 37589
Lusaka, Zambia
T: +260 967619665
E: southernafrica@cabi.org

Americas

Brazil

CABI, UNESP-Fazenda
Experimental Lageado,
FEPAF (Escritorio da
CABI)
Rua Dr. Jose Barbosa De
Barros 1780
Fazenda Experimental
Lageado
CEP: 18.610-307
Botucatu, San Paulo, Brazil
T: +55 (14) 3880 7670
E: y.colmenarez@cabi.org

Trinidad & Tobago

CABI, 59 Gordon Street,
Curepe, St. Augustine
TUNAPUNA 331323
Trinidad & Tobago
T: +1 868 6457628
E: caribbeanLA@cabi.org

USA

CABI, One Lincoln Street
24th Floor
Boston, MA 02111
T: +1 (617) 682 9015
E: h.jansen@cabi.org

Asia

China

CABI, Beijing
Representative
Office
Internal Post Box 85
Chinese Academy of
Agricultural Sciences
12 Zhongguancun Nandajie
Beijing 100081, China
T: +86 (0)10 82105692
E: china@cabi.org

India

CABI, 2nd Floor, CG Block,
NASC Complex, DP
Shastri Marg
Opp. Todapur Village,
PUSA
New Delhi – 110012, India
T: +91 (0)11 25841906
E: india@cabi.org

Malaysia

CABI, PO Box 210
43400 UPM Serdang
Selangor, Malaysia
T: +60 (0)3 894329321
E: cabisea@cabi.org

Pakistan

CABI, Opposite 1-A,
Data Gunj Baksh Road
Satellite Town, PO Box 8
Rawalpindi-Pakistan
T: +92 51 9292062/ +92 51
8434979
E: cabi.cwa@cabi.org

Europe

Netherlands

CABI, Landgoed Leusderend 32
3832 RC Leusden
The Netherlands
T: +31 (0)33 4321031
E: netherlands@cabi.org

Switzerland

CABI, Rue des Grillons 1
CH-2800 Delemont
Switzerland
T: +41 (0)32 4214870
E: europe-CH@cabi.org

UK

CABI, Nosworthy Way
Wallingford, Oxfordshire
OX10 8DE, UK
T:+44 (0)1491 832111
E: corporate@cabi.org

CABI, Bakeham Lane
Egham, Surrey
TW20 9TY, UK
T: +44 (0)1491 829080
E: microbialservices@cabi.org
E: cabieurope-uk@cabi.org