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Aquatic Plant Control Research Program

Surveys for Insects that Feed on Eurasian watermilfoil, *Myriophyllum spicatum*, and Hydrilla, *Hydrilla verticillata*, in the People's Republic of China, Japan, and Korea

by Gary R. Buckingham,
U.S. Department of Agriculture - Agricultural Research Service

WES

Prepared for Headquarters, U.S. Army Corps of Engineers

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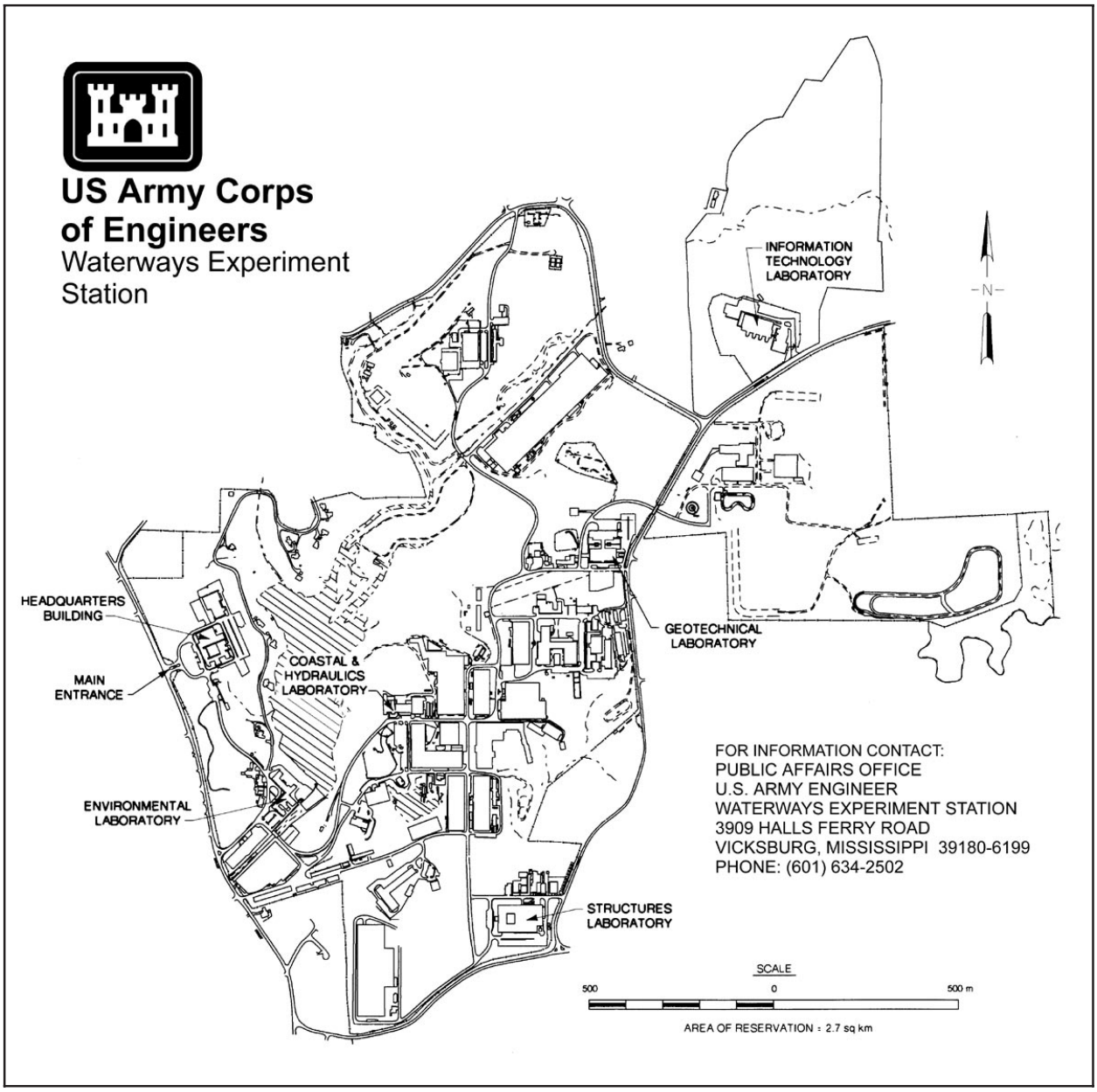

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Contents

Preface

The work reported herein was conducted as part of the Aquatic Plant Control Research Program (APCRP), Work Unit 32730. The APCRP is sponsored by the Headquarters, U.S. Army Corps of Engineers (HQUSACE), and is assigned to the U.S. Army Engineer Waterways Experiment Station (WES) under the purview of the Environmental Laboratory (EL). Funding was provided under Department of the Army Appropriation No. 96X3122, Construction General. The APCRP is managed under the Center for Aquatic Plant Research and Technology (CAPRT), Dr. John W. Barko, Director. Mr. Robert C. Gunkel, Jr., was Assistant Director for the CARPT. Program Monitors during this study were Mr. Timothy Toplisek and Ms. Cheryl Smith, HQUSACE.

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This investigation was performed under the general supervision of Dr. Alfred F. Cofrancesco, Jr., Leader, Biomanagement Team, Aquatic Ecology Branch (AEB), Ecological Research Division (ERD), EL; Dr. Edwin A. Theriot, Chief, AEB; Dr. Conrad J. Kirby, Chief, ERD; and Dr. John Harrison, Director, EL.

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1 Introduction

Many of the most important aquatic nuisance plants are immigrants that arrived in the United States without their respective natural enemies. These include, among others, alligatorweed, waterhyacinth, waterlettuce, water chestnut, hydrilla, and Eurasian watermilfoil. The first two species have been controlled at many sites and reduced throughout much of their range by insects imported from their native homes and released into the environment. This method of control is called classical biological control. Buckingham (1994a) briefly discusses the history and basic principles of this method and summarizes the aquatic nuisance plant projects except the waterhyacinth and waterlettuce projects. They were summarized by Center (1994).

All of the nuisance plants listed above are floating plants except hydrilla (Figure 1) and Eurasian watermilfoil (Figure 2), which are submersed and the targets of the surveys. Insects have been imported and released for control of hydrilla, but not for control of Eurasian watermilfoil. Hydrilla ranges naturally from the Rift Valley region of Africa through Asia to Australia. Small populations are present in Europe and are believed to be relicts from the ice age. Brief surveys for insects have been conducted in Africa, and more extensive surveys and studies have been conducted in Australia, India, and Pakistan (Buckingham 1994b). These surveys were for insects that would be adaptable to the climates of the southern United States, especially the Southeast.

The discovery of hydrilla in Maryland in 1990 and the threat of its expansion across the northern part of the United States increased interest in insects from temperate areas. The People's Republic of China (P. R. China) presents an excellent latitudinal range for surveys because it extends from subtropical southern climates (about 20° N) to very cold northern climates near the Russian border (about 53° N). Balciunas and Chen (1993) reported the distribution of hydrilla in northern P. R. China.

Hydrilla shoots grow rapidly to the water surface during spring and early summer and then grow along the surface intertwining with each other (Figure 3). They form a thick mat that floats just beneath the surface with numerous leaves exposed. Small individual female flowers open right on the surface. Submersed male flowers break loose and float to the

surface where they explosively release pollen. There are two forms of hydrilla: dioecious and monoecious. The first has flowers of each sex on separate plants with only female flowers present in the United States. The second has both sexes on the same plant and is the type found in Maryland and other northern sites plus California. No seeds are produced by the former in pure stands, but can be produced by the latter. It is still unclear how important seeds will be in the population dynamics of hydrilla. In addition to seeds, the plant produces two types of leaf buds, axillary turions and subterranean turions, also called tubers. Tubers help the plant survive periods without water, which are common in many parts of the native range. The crown and roots are relatively small.

Insects (or pathogens) that attack all parts of the plant are desired for importation with the hope that together they can produce sufficient stress to kill or at least control growth of the plant. By 1991, four insects had been released for hydrilla control in Florida and some other States. First released was the Indian tuber weevil, *Bagous affinis* Hustache, that attacks tubers only in exposed soil during periods of drought or man-made drawdowns. Released in Florida in 1987, California in l992, and Texas in 1994, it has not been reported to be permanently established anywhere (Grodowitz, Center, and Snoddy 1995). Second released was the Indian leaf-mining fly, *Hydrellia pakistanae* Deonier. Also released in Florida in 1987, it established there and in Alabama and Texas (Center et al. 1997). Larvae eat the contents of leaves, which become transparent. Stems are rarely damaged, but often disintegrate in laboratory cages after heavy or repeated attack on the leaves. Third released was another leaf-mining fly, *H. balciunasi* Bock, from Australia. It was first released in Florida in 1989. Its damage is similar to that of *H. pakistanae*, but it has only established at two Texas sites (Grodowitz, Cofrancesco, and Freedman 1997). The last released, which was in Florida in 1991, was a stem-boring weevil, *Bagous hydrillae* O'Brien. Larvae attack stems of submersed hydrilla, but the pupae (the resting stage) are only formed when stems are exposed out of water. It has not been reported to be established. No plant pathogens have been imported and released yet, but the native fungus, *Mycoleptodiscus terrestris* (Gerdemann) Ostazeski (Coelomycetes), has been studied extensively for hydrilla control (Shearer 1996). Attacked leaves become chlorotic, and stems break down. Unfortunately, none of the preceding agents has controlled hydrilla, and the insects all originated in mild climates. The desire for new agents from temperate climates stimulated this project.

Eurasian watermilfoil ranges naturally from Europe across Asia. In Asia, it ranges from Thailand north to Russia and Japan. Insect surveys and studies have been conducted by cooperators in Yugoslavia and Pakistan (Buckingham 1994a). Like hydrilla, Eurasian watermilfoil grows quickly to the surface in the spring and early summer (Figure 4). It then grows along the surface forming thick mats just below the surface. Unlike hydrilla, it has an emersed flower stalk approximately 4 to 12 cm tall with both male and female flowers (Figure 5). Seeds are readily produced, but like hydrilla, their importance in the population dynamics is unclear. The

crown and roots are relatively small. Previous foreign surveys highlighted several potential candidates, but no insects have been imported and released for control of Eurasian watermilfoil. Three insects were identified for further study by a Yugoslavian survey, but two of these were already present in the United States; the third had too broad a host range for importation (Buckingham 1994a). None were suggested for further study by a Pakistan survey except two species found on a different species of watermilfoil (Buckingham 1994a). They have not been studied further.

A native insect is being evaluated in the northern United States for augmentation. It is *Euhrychiopsis lecontei* (Dietz), a small weevil whose larvae bore into submersed stems. All stages live underwater. Adults clip leaves from the plant while larval stem boring reduces stem buoyancy leading to stem death (Creed and Sheldon 1994). Laboratory and field cage studies have demonstrated the damage potential of this weevil, but the potential has yet to be demonstrated by extensive field augmentation. Large weevil populations have correlated well with natural plant declines in northern lakes. Populations of an immigrant, or possibly native moth, *Acentria ephemerella* (Denis and Schiffermueller), have also been correlated with some plant declines. Although there is interest in its augmentation, none has been reported (Buckingham 1994a). The same native fungus of interest for hydrilla control, *M. terrestris*, has been intensively studied for control of Eurasian watermilfoil, but it has not yet been formulated for commercial use.

In 1988, the United States Department of Agriculture - Agricultural Research Service (USDA-ARS) and the Chinese Academy of Agricultural Sciences (CAAS), Biological Control Laboratory, Beijing, established the Sino-American Biological Control Laboratory (SABCL) for cooperative studies (Figure 6). Aquatic nuisance plant research was included among the initial projects for SABCL, which assigned employees to the aquatic nuisance plant program and provided one to two rooms for their use and the use of visiting American scientists (Balciunas 1990) (Figure 7). The Chinese hosts organized permits and logistics for survey trips, accompanied Americans on the surveys, conducted surveys during periods when the Americans were absent, and conducted limited field and laboratory studies in Beijing throughout the growing season.

Unfortunately, the laboratories and greenhouses were not cooled during the hot Beijing summer, which made successful laboratory studies difficult. Plants rotted quickly even in a large aquarium. An air conditioner was installed in one room during the latter years which helped. During the first couple of years, an attempt was made to establish cooperative programs with other Institutes, but for various reasons this was discontinued. The Institutes continued to host survey trips, however. Through the years, four CAAS employees were assigned directly to the SABCL aquatic nuisance plant program with many others helping when needed, both at SABCL and on surveys. Mr. Yuan Wang (1989-1991) (Figure 8) and Ms. Jiang Hua (1990-1992) (Figure 7) started the program under the direction of Dr. Ren Wang (Figure 8), formerly director of SABCL. Dr.

Ping-Ping Chen, a taxonomist specialized in aquatic Hemiptera, worked at SABCL from 1991 to l992 (Figure 9). In l992, a newly graduated entomologist, Mr. Zhiqun Chen, was assigned to the program and is still actively working with aquatic nuisance plants (Figure 10). Mr. Yuan Wang (1990), Dr. Ren Wang (1990), and Mr. Zhiqun Chen (1993, 1995) received aquatic nuisance plant biocontrol training in Gainesville for 1.5 to 3 months during the winter of each year indicated (Buckingham 1991).

Surveys were conducted annually, mostly from June to August or September. Usually two or more Americans visited individually, one early in the summer and one later, so that coverage included most of the growing season. SABCL staff would often survey earlier or later. Occasionally, a vehicle would be provided by SABCL, but usually vehicles were provided by the cooperating Institute when someone arrived by air. Survey itineraries were constrained by the need for prior approval of the itinerary by local officials, especially during the early years of the program. This often prevented spontaneous travel to sites that seemed promising after talking with local contacts and prevented stopping at many sites driven past. Another constraint during the early years was the need to stick to a tight schedule because of courtesy appointments made with local officials (Figure 11). Even though one might be permitted to stop at an interesting waterway, this was prohibitive because of an appointment “up the road.” This became less of a problem as P. R. China received more foreign visitors and as return was made to areas surveyed previously. However, it was a major constraint during the first few years. Surveys in Korea and Japan were made on the way to and from P. R. China in coordination with Dr. Robert Pemberton, USDA-ARS, who was stationed in Korea and had a project on water chestnut, *Trapa natans* L. (Figure 12).

The objectives of this study were (a) to identify and visit diverse regions of P. R. China, Japan, and Korea that had hydrilla and Eurasian watermilfoil, (b) to collect herbivorous insects on the target species and on related species, (c) to note the life cycles and types of damage for the insects, (d) to carry living specimens of promising species to the Gainesville, FL, quarantine facility, and (e) to establish colonies of the insects in quarantine for companion biology and host range studies.

2 Materials and Methods

Collection Techniques

The diversity of waterways, of logistical support, and of insect herbivores necessitated a variety of collection techniques. Waterways varied from shallow roadside ditches to large deep lakes and wide rivers. Some were located in or near large cities, some at tourist sites, and some at off-road sites large distances from asphalt highways. Most, however, were easily accessible from a highway. Rubber waders carried from the United States were used for wading at the majority of sites. This allowed close examination of the plants and insects without disturbance and allowed both to be easily collected before leaving the site. Usually a jeweler's bifocal head magnifier (Optivisor, No. 5, Donegan Optical Co.) was used to examine the plants (Figure 13). This allowed the hands to be free and the plants to be undisturbed compared with using a hand magnifying lens, which was sometimes used when greater magnification was needed for eggs or other stages. Adult insects were collected with aspirators, by hand (Figure 14), or with a battery-operated aspirator adapted from an L-shaped military flashlight (Hausherr's Machine Works, Toms River, NJ). The latter was used mostly for collection of adult flies from floating leaves or from styrofoam floats placed on the water surface.

Adult insects were occasionally collected from white sheets at ultraviolet "blacklights" set up at night near waterways (Figure 15). Sweep nets were used to collect moths from plants on shore (Figure 16). Internal larvae were collected by field dissection of the plant and examination with the Optivisor, by sun-drying the plants on a screen or mesh above a container of water into which the larvae dropped (Figure 17), by laboratory examination of backlighted plants on a light table (Figure 18), and most commonly by examination with a stereomicroscope in the hotel room at night (Figure 19). Carrying a stereomicroscope, especially a full-sized one, on a foreign survey is logistically troublesome, but it is possibly the most important item for success. It was invaluable for observing eggs and for confirming larval damage by young instars. Plant collections at sites near Beijing were often placed in Berlese funnels to collect internal larvae, especially during the first couple of years (Figure 9). Plants were dried slowly by lightbulbs that forced the larvae out of the plants and into

the funnels where they dropped into jars of water or preservative. Roots were occasionally dug with a shovel in shallow water or pulled by hand, but root examinations were conducted less often than perhaps they should have been. This was one weakness of the survey. Plants were occasionally placed in cloth bags that were closed and sometimes hung. The cloth allowed the plants to dry slowly. Insects, especially weevils, could be collected crawling on the cloth above the plants. The technique was not as successful as hoped and was only used sporadically, but usually at least a few specimens could be collected. Sun-drying of the plants over a container of water was especially useful for collecting live fly larvae.

Sites that were too deep for wading were sampled in a variety of ways. A three-pronged hook was sometimes thrown from shore or dropped from bridges to drag plants to shore. Automobile or small truck inner tubes were purchased locally and used as floats by tying across the center a rope or cloth on which one sat with waders (Figure 20). A more sophisticated fisherman's float tube was carried from the United States (Figure 21). It was more comfortable, but was heavier and bulkier for travel. Fishermen's inflatable safety vests with $C0^2$ cylinders were worn with these floats and while wading. Boats of all sizes were hired or borrowed locally: an inner tube boat (Figure 22), pole boats (Figure 23), row boats, motor boats, and even a large passenger excursion boat (Figure 24).

Rearing Methods

Efforts were made to rear immatures to adults and to keep adults alive during the surveys. Weevil adults and larva or pupae were usually held in 9-, 15-, or 50-dram plastic snap cap vials. Pieces of paper toweling, tissues, or newspaper were always included to absorb moisture. These papers were changed daily to every few days. Inclusion of paper is important for success. Often the plastic caps had a central hole that was plugged tightly with cotton. This also helped control excess moisture. Multiple stem sections or flower stalks were held in the vials—the number varying as per experience of the collector. Too few and they often dried; too many and they rotted unless the papers could be changed often or the cotton plug was sufficiently large. No free water was placed in the vials except sometimes to dampen the paper initially. Larvae of *Bagous myriophylli* O'Brien were collected in long 20- to 50-cm Eurasian watermilfoil stem sections. This provided sufficient food for them to finish development and to pupate inside the stem. Most leaves were pulled off the stems that were held in cloth bags if there were many (100's) or in plastic bags with newspaper if there were few. Multiple bundles of groups of stems wrapped in a single newspaper page were held in the same plastic bag. Both drying and rotting were dangers, but rotting due to excessive humidity was the greater danger, especially if the leaves were not removed from the stems.

The bags were examined daily for new adults. There appeared to be heavy mortality with this technique; but because larvae and pupae are internal, the expected number was uncertain. Only stems that had damage were included. Stems were "candled" by holding them toward the sky or sun in the field or toward a light at the hotel. Larval tunnels were lighter than the undamaged tissue. The larva could rarely be distinguished in the tunnel, but often the prepupa or pupa could be. The pupal chamber was an enlarged area in the larval tunnel, and thus the pupa was probably closer to the surface. To save time in the field, all damaged stems were collected and held together as mentioned above. However, in hindsight, it would have been better to break off a small section of the stem with the pupa as it was found. These sections could have been held in plastic vials for adult emergence. When this was done with the initial small collections, almost all pupae developed compared with what appeared to be less successful development in the longer stems of later mass collections.

Phytobius weevils feeding on the flower stalks of Eurasian watermilfoil were relatively easy to rear during the survey as long as new plant material was added when needed and as long as the vials were kept humid but not so wet that they rotted. Fungus was often heavy on the flowers in the vials, but larvae still developed by eating into the flower stalk. New adults often emerged from vials with the worst looking material. *Eubrychius* weevils that lived completely underwater were more difficult to maintain during the survey. One group collected underwater on *Myriophyllum verticillatum* was held in a 2-L plastic soda bottle with water during the day but with no water at night. The bottle received abundant sunlight in the car during the day, which caused the plants to produce a lot of oxygen, and the weevils thrived. In a darkened room the first night, they became moribund after a few hours, but revived when the water was poured off. They started dying after a couple of days without water, so water was again added. Thereafter, each night the water was removed, and each morning it was added. A group collected a different year while they emerged from the water, possibly to fly to shore for hibernation, was held without water and survived well. A small battery-operated air pump with an air stone was used occasionally to aerate containers. The pump is sold for aerating fishermen's minnow buckets. Chrysomelid leafbeetle larvae in the subfamily Donaciinae that were attached to stems near the crown and to roots became moribund when placed with plants in water. They were thus held without water in vials with moist crowns and roots. New crowns and roots were added as the others deteriorated. Adults were held in vials without water. At SABCL, larvae were held both on plants without water and on plants in water in a greenhouse, but all died.

Hydrilla shoots with leaf-mining fly larvae were held in water in ziplock plastic bags. The bags were exposed to light as much as possible. Sometimes the water was removed before air flights. Fly puparia encountered during microscopic examination were removed with forceps and

placed in 1-oz[1] plastic cups on moist cotton. The plastic lid had a central hole plugged with cotton to reduce humidity. Fly adults were not kept alive during surveys. However, in Beijing, adults were sometimes collected live and set up in jars with hydrilla and styrofoam floats on which a yeast hydrolyzate-sugar mixture was painted. This was done mostly to provide a colony to carry to quarantine. Occasionally, hydrilla or Eurasian watermilfoil tips with midge larvae were held in plastic vials to collect adults. Adults also emerged in the hydrilla leaf-mining fly jars at SABCL. No attempts were made to rear the midges.

Taxonomists

The following taxonomists kindly identified the respective groups:

Tallahassee, FL:

Ingolf Askevold	Coleoptera: Chrysomelidae
John H. Epler	Diptera: Chironomidae
Charles W. O'Brien	Coleoptera: Curculionidae

Gainesville, FL:

Dick Deonier	Diptera: Ephydridae
Dale H. Habeck	Lepidoptera: Pyralidae
Susan E. Halbert	Homoptera: Aphididae

Clemson, SC:

John C. Morse	Trichoptera

[1] To convert ounces (U.S. fluid) to cubic meters, multiply by 0.00002975.

3 Results and Discussion

Surveys

Surveys were conducted throughout most of the range of hydrilla and Eurasian watermilfoil in P. R. China. After 1990, Eurasian watermilfoil was targeted more than hydrilla because four insects had been cleared for release in the United States on hydrilla but none on Eurasian watermilfoil. However, hydrilla surveys continued to be conducted every year, and hydrilla was always examined when found during the Eurasian watermilfoil surveys. From 1989 to 1991, the surveys were conducted to cover as much of the range of the plants as possible during the time available (Balciunas 1990; Balciunas 1991; Buckingham 1992). From 1992 onwards, there were still general surveys, but emphasis shifted to surveys in areas already visited in order to collect species found earlier (Bennett 1994; Buckingham 1993; Buckingham 1995).

There were no surprises during the surveys regarding the groups of insects collected. They were the usual aquatic herbivore groups. However, some species were of greater interest than related species found in other geographic areas because of differing biologies or damage potentials. One example of this is a *Bagous* weevil that completes its life cycle by pupating in the submersed stem of Eurasian watermilfoil, unlike the hydrilla *Bagous* that pupate on shore or in the stem only when it is exposed during droughts. Another example is a donaciine leafbeetle in the genus *Macroplea* that appeared to stunt the growth of hydrilla by feeding on the lower stems and roots. No damage has been apparent when other donaciines have been found on hydrilla and Eurasian watermilfoil. The leaf-mining fly *Hydrellia pakistanae* was found near the Siberian border, which bodes well for its use in the northern United States and Canada as hydrilla spreads. Previously, this species had been collected and released in the United States from much warmer southern India and Pakistan.

The far western province of Xinjiang was surveyed for Eurasian watermilfoil, but only *M. verticillatum* was found (Figures 25-29). Most specimens in the university herbarium at Urumqi, Xinjiang Province, that were labeled Eurasian watermilfoil appeared to be *M. verticillatum*. One of the targets of that survey, *Bagous myriophylli* O'Brien, found earlier in

Kashmir, India, which is south of Xinjiang, was not found but was found the next year in Heilongjiang Province. Two additional species of weevils found in Xinjiang Province on *M. verticillatum* might also be the same as species found in Heilongjiang Province.

Inner Mongolia was surveyed during three trips. Eurasian watermilfoil was common, but hydrilla was not found (Figures 30 and 31). Beijing and its surroundings were surveyed during every visit, although after the first 2 years, most of the collecting was at previously discovered sites (Figures 32-37). Six trips were made to Shenyang in Liaoning Province in a vain attempt to collect adults of the hydrilla attacking *Macroplea* and to confirm the damage potential of this species (Figures 38-42). All were unsuccessful as were attempts to rear the larvae at SABCL and in quarantine. Also unsuccessful were four trips to Hunan and Hubei provinces to look for a *Bagous* that was reported to attack hydrilla. Unsuccessful attempts were also made to collect the *Bagous* during surveys in Heilongjiang Province. These attempts were based on observations made in 1989 that a *Bagous* was reared on submersed hydrilla in jars by Chinese cooperators in Hunan and on a collection in 1991 of *Bagous* larvae from hydrilla samples from Heilongjiang. Unfortunately, no specimens from the Hunan jar rearing were ever provided by the cooperators for examination, and there is a good chance that the Heilongjiang larva was from another plant species contaminating the sample. Both a *Bagous* and another weevil attacked plants associated with hydrilla at the site where the supposed hydrilla *Bagous* was collected. Although it now appears after these repeated surveys that there is no hydrilla *Bagous*, there still remains some question because at every site there was leaf damage similar to the feeding damage made by adults of the Australian *Bagous hydrillae* O'Brien.

Heilongjiang Province was intensively surveyed for Eurasian watermilfoil insects (Figures 43-50). Middle to southern P. R. China produced little during the surveys, although most of the insect species were present but scattered and in small numbers (Figures 51-54). Agriculture was intensive in these areas (Figures 55 and 56), and aquatic plants were often controlled by hand harvesting. There were eight surveys to these areas, but it appears that no species were found that were not found in Beijing and north. Whether this is indicative of the fauna or whether more surveys are needed because of the difficulty locating undisturbed waterways is unknown. Korea (Figure 57) and Japan (Figures 58 and 59) were surveyed during trips to and from P. R. China, although the surveys were very brief and localized. Fewer insect species were found than in P. R. China, but a new undescribed leaf-mining fly was found in Korea on hydrilla. Both countries would need to be surveyed more extensively before they could be eliminated as a potential source of biocontrol agents.

Geographic Ranges and Habitats of Target Plants

Hydrilla was found from the southernmost part of P. R. China to near the Siberian border. It was not found in the westernmost province of Xinjiang nor in the areas surveyed in Inner Mongolia. Near the Siberian border in Heilongjiang Province, it was less common than Eurasian watermilfoil, but it was more common than Eurasian watermilfoil from Beijing southward. It was found in all types of aquatic habitats: dam reservoirs, large and small lakes, large rivers and canals, drainage canals and ponds, ornamental plant and fish ponds, rice and waterchestnut fields, marshes, and prairie potholes. Often infestations were light, but some were dense, especially late in the summer. Most infestations were small, being found only in a portion of the waterway. By late August and early September, farmers and others harvested hydrilla either to utilize it for fertilizer or to clear the waterway. Several times near Beijing, plans to collect a lot of leaf-mining flies to carry to the States at the end of the trip were thwarted when the return to the sites revealed that the heavily infested hydrilla was gone. Hydrilla is reported throughout Japan, but this author was unable to find it at northern sites near Misawa and Niigata, which had been collecting sites for a botanist. It was common, however, at his sites near Kobe in the south. In Korea, it was common near Seoul, but that was the only area surveyed.

Eurasian watermilfoil was also found from southern P. R. China to the Siberian border. It was most common and abundant in Inner Mongolia and was not found in Xinjiang. It is reported from the latter, but most specimens labeled as such in the Urumqi herbarium appeared to be misidentified. Like hydrilla, it was found in a variety of aquatic habitats: dam reservoirs, large and small lakes, large rivers and canals, drainage canals and ponds, ornamental fish and plant ponds, and marshes. Most infestations were small and light, but there were some extensive and dense infestations in the lakes of Inner Mongolia. Even then, the plants covered only a portion of the lakes compared with many United States infestations that cover entire lakes. The large lake at the summer palace in Beijing, a major tourist attraction, had an impressive infestation that was harvested by several men pulling to shore floating booms that surrounded the mat. Some small waterways in Heilongjiang had small but dense infestations. In Korea and Japan, the infestations surveyed were similar to those of hydrilla, small and light.

At a marsh in Heilongjiang Province, Eurasian watermilfoil disappeared over a 3-year period and was replaced by *M. verticillatum.* It is unknown if this were due to insect attack, but the site was heavily infested by three species of weevils. During the last summer of the surveys, the *M. verticillatum* was heavily attacked. It would be interesting to know if perhaps populations wax and wane as they are attacked permitting the other species to repopulate from seeds. A similar variation in milfoil species abundance was noticed at several other sites.

Annotated List of Insect Herbivores

The following herbivores were discovered on hydrilla, Eurasian watermilfoil, or *Myriophyllum verticillatum* during the surveys (Tables 1 and 2). Identifications have not been completed for all of them. Weevils are especially problematic and need additional study. Some species, for example, midges and chrysomelid beetles, appeared to be herbivores on the target plants, but that was not conclusively determined for every species.

Coleoptera (Beetles)
Chrysomelidae (Donaciinae)
Macroplea sp. 1

Found on surveys: 8, 9, 10, 15

Locations: Liaoning Province, near Shenyang, Yu Hong District, Ma Shan Jia, 17/Jul/1992, 5/Aug/1993, drainage ditch along highway (Unidentified larvae that might be this species were also found in 1995 in Guizhou Province, Longli County, Sanyuan and Huaxi district)

Host Plants: *Hydrilla verticillata*

Feeding Damage: Larvae were attached to stems near or in the soil and to roots by their anal hooks (spiracles) (Figure 60). Younger larvae ate holes into the plant about the size of their heads, but remained outside. Older larvae did not appear to feed in captivity. Attacked plants in 1992 had small leaves with a brownish cast compared with the dark green leaves of unattacked plants in the same ditch a short distance away. It appeared that the damage on attacked plants was a reduction in growth after the attack because older leaves near the base of the stems were more normal size. The attacked plants appeared very unhealthy with thin stems (Figure 61). These unhealthy plants were found at two sites in the ditch with larvae but not at a third site between them that lacked larvae. Similar unhealthy plants were infested with donaciine larvae in Guizhou Province in southern P. R. China.

Life History: No pupae or definite adults were found. Two small *Macroplea pubipennis* (Reuter) adults were found at the location in June sitting on *Trapa* sp., but they might not be the same species. Small-to-medium, feeding larvae were found at that time, and larger nonfeeding larvae were found in July and August. The larvae are grublike, white or white with a greenish cast. No larvae were found on other plants in the ditch: *Potamogeton, Ceratophyllum, Trapa, Hydrocharis*. North American donaciines from northern latitudes are reported to either make a cocoon on the plant in the late autumn and overwinter or remain overwintering as a larva and make a cocoon about June, depending upon the species (Hoffman 1940). Thus the thought was that June would be the best time to find cocoons of either type, but they were not found during the one June trip.

Table 1
Surveys for Hydrilla and Eurasian Watermilfoil Insects

Survey No.	Start Date	End Date	Researchers	Provinces	Major Cities	Plant Species	
						Hydrilla	EWM
People's Republic of China							
1	9/89	7/95	All	Beijing	Beijing	X	X
2	9/6	9/21	J. Balciunas, Y. Wang	Sichuan Hunan	Chengtu, Chungking YueYang, Changsha	X X	X X
3	7/9	8/6	J. Balciunas, Y. Wang, R. Wang	Liaoning Inner Mongolia Hunan Guangdong	Shenyang Hohhot YueYang, Changsha Guangzhou	X O X O	O X X O
4	9/10	9/19	G. Buckingham, Y. Wang, R. Wang	Liaoning Inner Mongolia Jiangsu	Shenyang Hohhot Yangzhou	X O X	X X O
5	7/3	7/20	J. Balciunas, Y. Wang, P.-P. Chen	Liaoning Inner Mongolia Heilongjiang	Shenyang Hohhot Harbin	X O X	X X X
6	8/25	9/7	G. Buckingham, P.-P. Chen	Xinjiang	Urumchi, Altay	O	O
7	9/22	9/27	P.-P. Chen	Hunan	Changsha	X	X
7A	10/14	10/20	P.-P. Chen	Hubei	Wuhan	X	X
8	7/8	7/18	G. Buckingham, R. Pemberton, Z. Q. Chen, (C. Bennett-Beijing)	Heilongjiang Liaoning	Harbin, QiQiHar Shenyang	X X	X X
9	5/93	7/93	W. Durden, Z. Q. Chen	Hunan Hubei Liaoning	Yueyang Wuhan Shenyang	X X X	O O X
10	7/12	8/6	C. Bennett, Z. Q. Chen	Heilongjiang Liaoning	Harbin Shenyang	X X	X X
11	6/94	6/94	Z. Q. Chen	Heilongjiang Liaoning	Harbin Shenyang	X X	X X
12	7/94	7/94	W. Durden, Z. Q. Chen (J. Shearer-Beijing)	Liaoning	Shenyang	X	X
13	8/6	8/29/94	G. Buckingham, Z. Q. Chen	Heilongjiang	Harbin, QiQiHar	X	X
14	6/95	7/95	C. Bennett, J. Ding	Heilongjiang	Harbin, QiQiHar	X	X
15	7/95	7/95	M. Grodowitz, J. Shearer, Z. Q. Chen, W. Z. Liu	Liaoning Jiangsu Hubei	Shenyang Nanjing Wuhan	X X X	X X X
16	8/21	9/8	Z. Q. Chen	Yunnan Guizhou Sichuan	Kunming Guiyang Chengdu	O X O	X X O
17	9/21	10/17	Z. Q. Chen	Guangxi Zhuangzi Guangdong Fujian Zhejiang	Nanning Guangzhou Fuzhou Wenzhou, Hangzhou	X O X X	O O O X
Korea							
1	8/11	8/19	G. Buckingham, R. Pemberton	Kyonggi-Do KangWan-Do	Seoul	X X	X X
Japan							
1	7/27	8/8	G. Buckingham, R. Pemberton, Y. Kadono	Aomori Niigata Hyogo	Misawa Niigata Kobe	O X X	O O X

Table 2
Insects That Fed on Hydrilla or Watermilfoils

Order	Family	Subfamily	Species	Author	Target Host Plant	Plant Part Attacked	Rarity	Country
Coleoptera	Chrysomelidae	Donaciinae	*Macroplea* sp. 1		Hyd	Lower stem, root	Rare	PRC
			Macroplea sp. 2 ?		Mlf, Hyd	Lower stem, root	Locally common	PRC
			Donacia sp. ?		Hyd	Root	Occasional	PRC
	Curculionidae	Bagoinae	*Bagous myriophylli*	O'Brien	Mlf	Stem	Locally common	PRC
			Eubrychius sp. 1		Mlf	Leaves	Locally common	PRC
			Eubrychius sp. 2 ?		Mlf	Leaves	Locally common	PRC
			Phytobius sp. 1 (spp.?)		Mlf	Flower stalk	Common	PRC
			Phytobius sp. 2		Mlf	Flower stalk	Locally common	PRC
Diptera	Chironomidae	Orthocladiinae	*Cricotopus myriophylli*	Oliver	Mlf	Meristems	Common??	PRC
		Orthocladiinae	*Cricotopus sylvestris grp.* sp.		Hyd	Meristems	Common	PRC, Korea, Japan
		Chironominae	*Glyptotendipes* sp.		Hyd	Meristems?	Common??	PRC, Japan
		Chironominae	*Polypedilum* ChL-1		Hyd	Meristems	Common??	PRC
	Ephydriidae	Hydrellinae	*Hydrellia pakistanae*	Deonier	Hyd	Leaves	Common	PRC, Japan
			Hydrellia sarahae sarahae	Deonier	Hyd	Leaves	Common	PRC
			Hydrellia sp.		Hyd	Leaves	Common	Korea, Japan
Homoptera	Aphididae		*Rhopalosiphum nymphaeae*	(L.)	Mlf	Flower stalks	Occasional	PRC
Lepidoptera	Pyralidae	Nymphulinae	*Parapoynx vittalis*	(Bremer)	Hyd, Mlf	Leaves	Occasional	PRC
Trichoptera	Leptoceridae		*Leptocerus* ? sp.		Mlf	Leaves	Locally common	PRC
	Hydropsychidae		?		Mlf	Leaves	Locally common	Japan

Hyd = Hydrilla; Mlf = Watermilfoils (Myriophyllum spicatum, M. verticillatum)

Adults in the closely related North American genus *Neohaemonia* are reported to overwinter on shore (Askevold 1988).

Field Populations: Larvae were very abundant at the site when first discovered in 1992. Almost every plant in shallow water nearshore had multiple larvae. No larvae were on plants downstream a short distance away, but larvae were on plants a short distance beyond that. Only three larvae were found at the same site in 1993, but it had been a very rainy season with water so high that it prevented collecting at other waterways. Larvae were again abundant in 1995, but only at the same site.

Laboratory Rearing: Larvae were carried to SABCL where some were placed on hydrilla crowns in containers with high humidity but no water, and others were placed in jars with rooted hydrilla. All died.

Prognosis: The damage potential of this species is unknown. It appeared to stress the plants near Shenyang; but if it is the same species as those near Qiqihar, it did not stress them there. Additional field observations are needed to obtain adults for identification, to confirm the damage, and to confirm the host range. Four additional visits to the Shenyang site to do this were made after the initial discovery, but they were unsuccessful in large measure because of heavy rains. There are no literature reports of laboratory rearing of these external root-crown *Macroplea* species for guidance. A stem-boring species was reared in France from field-collected Eurasian watermilfoil and sago pondweed (Grillas 1988). Damage of that species was locally important.

Macroplea sp. 2? (possibly same as sp. 1)

Found on surveys: 8, 10, 13, 15

Locations: Heilongjiang Province, 44 km NE of Qiqihar, Long An Qiao, 12/Jul/92, river marsh; NW of Harbin, near Daqing, Wo-Li-Tun, 29/Jul/93, Shi-er-li-pao marsh**;** Daqing to Qiqihar, Kmstones 802 and 806, Qi Lin Dao Chun, 15/Aug/94, marsh and reservoir; 50 km N of Harbin, road to Suei Hua City, kmstone 50, Xu Bao, 22/Jun/95, drainage canal (Unidentified larvae that might be this species were also found in Guizhou Province, Huaxi district)

Host Plants: *Myriophyllum spicatum, M. verticillatum, Potamogeton* spp., *Nymphoides* ?

Feeding Damage: No larval damage was apparent. Adults ate holes in leaves and stems of milfoil in vials.

Life History: Adults were swept from the underwater plants in late June (Figure 62), and both adults and cocoons were present in mid-July. If the unidentified donaciines are this species, then larvae and cocoons are most abundant in August. The sites were not surveyed in September or

May. Larvae and cocoons were attached to the roots' lower stems. Adults sit on the plant underwater and are good swimmers (Figure 63). The whitish larvae are grublike and appear similar to those of Species 1 (Figure 64). Cocoons are parchmentlike, dark, and tightly attached to the plant, which supplies it with air (Figure 65). Adults are elongate with long antennae. They appear similar to terrestrial long-horned wood borers in the family Cerambycidae. They are creamish colored with black stripes composed of small black punctures.

Field Populations: Larvae and cocoons were very abundant at Qi Lin Dao Chun and Shi-er-li-pao marsh on various plant species. One *Potamogeton* plant had at least 20 larvae attached. It appeared that there might be two species involved, but too few adults were obtained from the larvae and cocoons held at SABCL to confirm this.

Laboratory Rearing: No attempt was made to rear this species.

Prognosis: Because no plant damage was apparent, it is difficult to assess the biocontrol potential. It cannot be completely dismissed because *M. spicatum* populations appeared to fluctuate at sites where it and other agents were present.

Curculionidae (Bagoiinae)
Bagous myriophylli O'Brien (O'Brien and Askevold 1995)

Found on surveys: 8, 10, 13, 15

Locations: Heilongjiang Province, NW of Harbin, near Daqing, Wo-Li-Tun, 10/Jul/92, 29/Jul/93, 13/Aug/94, 14/Aug/94, 20/Aug/94, 24/Jun/95, 27/Jun/95, Shi-er-li-pao marsh**;** Daqing to Qiqihar, Kmstone 802, Qi Lin Dao Chun, 15/Aug/94, marsh**;** 50 km N of Harbin, road to Suei Hua City, Kmstone 50, Xu Bao, 19/Aug/94, drainage canal. This species was also found in Kashmir, India, during surveys for another program.

Host Plants: *Myriophyllum spicatum, M. verticillatum*

Feeding Damage: Adults (Figures 66 and 67) made small holes in the submersed stems and flower stalks in the laboratory, but adult feeding was not distinguished from that of other species in the field. Larvae tunneled lengthwise through the submersed stems. Plants with tunnels remained alive and some had flowers, but they appeared to be more common among the stems floating at the surface than among the anchored stems. This suggests that damaged stems might break more readily. One *M. spicatum* population that was infested with this and with the phytobiines for at least 2 years was replaced the next 3 years by *M. verticillatum*, which suggests a possible insect effect on the population.

Life History: Females lay eggs in the stems mostly near a node. It appeared that some eggs in the field were laid in the flower stalk or near it because small larvae were found in the upper part of the stem near the stalk. Larvae hatch and tunnel through the stem eating the septae that run lengthwise connecting the outer wall with the central bundle of phloem tubes (Figure 68). Volume between the septae, which is most of the stem volume, is filled with air. As the larva grows, the tunnel becomes larger but usually does not damage the central bundle. The pupal chamber is in a larval tunnel. It is noticeably enlarged and can usually be distinguished by looking at the stem towards the light or by holding the stem just below the water surface. In strong sunlight the stem becomes more transparent when submersed than when held in the air. This is because of the air inside the stem and wetting of the cuticle. There are three or four larval instars. Total time from egg to adult in the laboratory at 27 °C was about 20 days. New adults were found sitting in the pupal chamber in the field. They probably remain several days while hardening before exiting. The largest numbers of adults were found in late June and in mid-August. The June adults had probably recently immigrated from the hibernation sites since no larvae were found. The August adults emerged from the water about noon and were probably going to hibernation sites. September is cold at Harbin.

Field Populations: Populations were never high. The maximum of 20 adults were collected in August while they exited the water from *M. verticillatum*. They were collected by two persons during 2 to 3 hr of plant examination and general weevil collection at Shi-er-li-pao marsh. Sixteen adults were collected from *M. verticillatum* by two people during 2.5 hr of plant examination in June. Undoubtedly, more would have been found if they had been the only target of the search, but still the numbers were quite low. Only 2 to 6 adults and a maximum of 28 immatures were collected at any one time on *M. spicatum* during three summers in July and August at Shi-er-li-pao and another marsh in the vicinity. Immatures were more common on *M. verticillatum* during the late August population peak. Sixty immatures were isolated in stem sections for emergence with at least an equal number in stems collected with damage but not isolated. These were collected by two persons during 2 days of collecting for 3 and 4 hr each day. Either the weevil was absent at other sites in the region or populations were so low that they could not be detected by two persons in 1 to 3 hr of searching.

Laboratory Rearing: Quarantine colonies were established from two importations. The first colony went into winter diapause (obligatory rest period). The second colony was held in a temperature cabinet at 16h light, which prevented diapause and allowed the colony to be reared continuously. A continuous supply of milfoil stems was needed for the rearing, which made it difficult during the winter since the milfoil was field collected. However, enough milfoil was collected, grown, and “borrowed” (from the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS) to keep a small population alive through winter. Because the larvae feed on the septae in the stems, the colony did best with thick stems (light

colored with large air spaces), which were most common from midsummer onwards. If most field-collected stems were thin, the stem section just below a flower stalk was often used. This section was thicker with more air to provide buoyancy for the emersed flower stalk. Flower stalks were also used sometimes. Unfortunately, most winter stems in Florida were green and narrow with small septae and very little air space and no flowers.

Because detached stems floating in water declined in quality before the larvae matured and because sufficient greenhouse space was not available to grow a good supply of thick-stemmed plants, the larvae were reared on field-collected stems in boxes without water. Soft plastic refrigerator boxes of various sizes were used, but mainly 1.5 L (23 by 15 by 5 cm). Approximately 25 g of fresh stems, three flattened paper towels moistened with 11 to 13 ml of Benomyl fungicide solution (one-half label rate for fruits and vegetables), three crumpled dry paper towels, and usually 10 to 70 mixed adults were placed into each box. The crumpled towels were placed near the corners of each box to absorb excess humidity from the air. Twice weekly, the adults were removed, the dry towels replaced, and the boxes held for about 21 days until the new adults began emerging. New adults were usually removed twice weekly. The box contents were destroyed after 30 days or more. New stems were placed beneath the old stems for the larvae about 7 days after parent removal. Almost all leaves were pulled from stems before the stems were used. If this was not done, the leaves quickly rotted with the stems following. The stems also rotted if there was too much humidity. Thus, it was important to be careful with the amount of Benomyl solution used, to remove leaves, and to include and change the dry towels. Whenever a decline in weevil production occurred with a new employee, these were usually the steps not closely followed. Boxes were held in a greenhouse set at 27 °C with natural light and in a temperature cabinet at 27 °C and 16h light. All were held in the cabinet during winter to prevent diapause. Numbers of adults emerging from the larval rearing boxes varied greatly, but about 25 was common.

Sexing of adults was difficult, but the usual weevil character of a more concave underside of the male abdomen was valid. The concavity was less pronounced and noticeable than on many other weevils; thus successful differentiation was less, perhaps 60 to 70 percent. Inexperienced persons should examine mating pairs to form a “search image” for the difference.

Prognosis: This species was of special interest because it pupates underwater in the stem and thus does not need a dry season. All *Bagous* found to date on hydrilla pupate out of water either in the soil or in the exposed stem during dry periods. Unfortunately, *B. myriophylli* does not appear to kill the plants directly. Any stress or death that it might cause was not readily discernible in the field, especially during the few days of a survey. Indicators of plant damage were the large number of detached *M. verticillatum* stems floating above the infested mat one year, the appearance that the damaged *M. spicatum* + *M. verticillatum* mat had sunk below the surface another year, and the possible disappearance of

M. spicatum from the infested site after 3 years. It is possible that none of these were caused by weevils, but yet they might be subtle weevil effects. Attacked stems declined in the laboratory aquaria, but so did many nonattacked stems.

The natural host range of *B. myriophylli* is incompletely known because only two species of milfoils were found in P. R. China. Two additional species, *M. humile* Morong and *M. ussuriense* Maxim., are also supposed to be in northern P. R. China. The natural host, *M. verticillatum*, is native also to North America and would probably be attacked if this species were released. Adults were produced in the companion quarantine studies on three native and one introduced species of milfoil and on one native close relative, *Prospepinaca palustris* L. (one adult). However, no evidence was found during the field studies in P. R. China that *B. myriophylli* would attack any species other than milfoils.

Because of the heightened interest at this time in development of the native weevil *Eurhychiopsis lecontei* for augmentation to control *M. spicatum* (Creed and Sheldon 1994) and the resistance to importation of agents that might attack native plants, there are no plans to continue studies with this species. If interest in it does arise, more in-depth field studies of damage and the milfoil host range should be made in P. R. China. The North American *M. verticillatum* should also be tested in quarantine.

Curculionidae (Phytobiinae) *Eubrychius* sp(p?).

Found on surveys: 6, 8, 13, 15

Locations: Xinjiang Province, Burqin, bridge over Burqin River, 29/Aug/91, small streams, potholes near river; Heilongjiang Province, near Harbin, 2.9 km N of Jian Guo Village, 13/Jul/92, drainage ditch; 44 km NE of Qiqihar, Long An Qiao, 11/Aug/94, river marsh; NW of Harbin, near Daqing, Wo-Li-Tun, 13/Aug/94, 14/Aug/94, 24/Jun/95, 27/Jun/95, Shi-er-li-pao marsh; 50 km N of Harbin, road to Suei Hua City, Kmstone 50, Xu Bao, 19/Aug/94, 22/Jun/95, drainage canal.

Host Plants: *Myriophyllum verticillatum*; *M. spicatum* ?

Feeding Damage: Both larvae and adults feed on the submersed leaves, especially the young developing leaves surrounding the apical meristem. The meristem is also eaten. One tip turned black from heavy feeding. The cocoon is usually in the stem near the tip causing mild distortion of the stem. Any effect that the feeding damage might have had on the plant other than possibly slowing growth was not obvious.

Life History: All stages develop underwater. Adults are excellent swimmers and remain principally underwater (Figure 69). In a small clear stream in Xinjiang Province, adults were observed swimming from one tip

directly to another bypassing other vegetation. They appeared to be able to recognize the milfoil from a distance. Solarz and Newman (1996) reported that the related American species *Euhrychiopsis lecontei* orients to a chemical produced by the host plant. Eggs are laid on the submersed leaves near the meristem. Neonates feed among the apical leaves, which provide them some protection. Older larvae, which are yellowish in color, feed on the tips and on fully developed older leaves, especially those near the tips. A spherical parchmentlike cocoon is formed partially inside the stem. About one-third to one-half of the cocoon projects outside the stem. It is very dark brown or black, unlike the lighter brown cocoons of *Phytobius.* Adults were collected both in and out of water. Large numbers were collected emerging from the water at noon in mid-August presumably to migrate to hibernation sites. Adult color differed somewhat for the two populations, Xinjiang Province versus Heilongjiang Province, but Dr. C. W. O'Brien has tentatively identified them as one species, which also was collected by this author in Kashmir, India, along with *B. myriophylli*. It is unclear if they are the European species, *E. velatus* (Beck) (Urban 1929).

Field Populations: The populations appeared to be generally low (1 to 18 adults collected at one time). Adults might have been easily overlooked if they fled the plants as they were pulled from the water, but the larvae should have been found in the tips, which were always examined for midge larvae and leafminer damage. Adults were common and easily observed in the small clear streams of Xinjiang Province in late August (57 collected) and in the Shi-er-li-pao marsh of Heilongjiang Province in mid-August when they exited the water (240 collected). Only once were adults collected with *M. spicatum* (two adults). Those were collected in a holding bag and might have been contaminants because the plants had been collected with *M. verticillatum*, which was separated into another bag. The adults exiting the water might have been on *M. spicatum* underwater, but only *M. verticillatum* was noticed at that time. Previously, the site had a mixed plant population.

Laboratory rearing: Three importations were made into quarantine: one from Xinjiang Province and two from Heilongjiang Province. Only one generation was obtained from each of two importations and two from the other. Adequate quality *M. spicatum* was not provided for very long because the importations were at the end of August to early September. Plant quality was low by the time the first-generation adults emerged. It appeared that even good quality *M. spicatum* was only marginally acceptable because the tips are much more open with fewer leaves enclosing the meristem than on the tips of Chinese *M. verticillatum.* There was no native *M. verticillatum.* The aquarium water was aerated continuously. Holding of the adults during the survey demonstrated the need for aeration as mentioned in Materials and Methods.

Prognosis: Unless this species is found associated with *M. spicatum*, it has little or no potential for biological control. Even if found to attack *M. spicatum*, it currently would have no potential for the reasons

discussed for *B. myriophylli*: attack on a native plant species and the competing augmentation program for a similar native weevil.

Phytobius sp(p?). 1

Found on surveys: 1, 3, 4, 5, 6, 8, 10, 13, 15

Locations: Beijing Province, Beijing, August 1st Lake, 1/Sep/90, small lake; Beijing, San Jia Dian Reservoir, 30/Jul/92, large reservoir in river; Inner Mongolia, Hohhot, BaBai Lake, 15/Sep/90, small lake; 49 km SW of Hohhot, Ha-su-Hai Lake, 16/Sep/90, large lake; SE of Hohhot, Dai Lake, 17/Sep/90; Xinjiang Province, Burqin, bridge over Burqin River, 29/Aug/91, small streams, potholes near river; Heilongjiang Province, NW of Harbin, near Daqing, Wo-Li-Tun, 10/Jul/92, 29/Jul/93, 13/Aug/94, 20/Aug/94, Shi-er-li-pao marsh; 44 km NE of Qiqihar, Long An Qiao, 12/Jul/92, river marsh; near Harbin, 3.9 km N of Jian Guo Village, 9/Aug/94, drainage ditch; Daqing to Qiqihar, Kmstone 806, Qi Lin Dao Chun, 12/Aug/94, reservoir; Daqing to Qiqihar, Kmstone 802, Qi Lin Dao Chun, 15/Aug/94, marsh; 78 km N of Harbin, on road to Suei Hua City, 19/Aug/94, small lake; 50 km N of Harbin, road to Suei Hua City, Kmstone 50, Xu Bao, 19/Aug/94, drainage canal; Daqing to Qiqihar, near Kmstone 802, Qi Lin Dao Chun, 25/Jun/95, river; Daqing to Qiqihar, near Kmstone 810, Qi Lin Dao Chun, 26/Jun/95, drainage canal; Liaoning Province, Shenyang, Hun He Qiao (Bridge), 15/Jul/92, small gravel pit ponds near river.

Host Plants: *Myriophyllum spicatum, M. verticillatum*

Feeding Damage: Adults (Figure 70) and larvae feed on the flower stalk, the bracts, the ovaries, the male flowers, and the flower buds (Figure 71). They also eat the meristems and surrounding leaflets on submersed shoots.

Life History: Eggs are laid mostly in the flowers and the flower buds (Figure 73). They are also laid on the flower stalk and on or near a meristem on the submersed shoot. Neonates feed on the meristem, but also mine inside the midvein of a leaf. Those hatching on the emersed flower stalk feed inside the ovaries, the male flowers, and the buds. Often they eat an ovary and then tunnel into the next by tunneling through the stalk at the node rather than exiting and entering the new ovary from an exposed position. Larger larvae feed externally (Figure 74) and also into the flower stalk. They appear to exit and reenter several times rather than tunneling long distances in the stalk, at least in laboratory colonies. Mature larvae (third instars) enter the water and form a cocoon in the stem (Figure 75). The spherical parchmentlike cocoon is embedded halfway in the stem (Figure 76). New adults sit for a day or two in the cocoon before exiting. They mate within a few days. The entire life cycle takes about 1 month. All stages were found from June through August. Mating pairs were common. Adults readily dropped from the flower stalks or flew when disturbed.

Adults also remained submersed for long periods feeding on leaves and ovipositing on tips. Hibernation sites are probably on shore as are those of related weevils. Parasites commonly emerged from cocoons in August. One sample of 11 eggs yielded no parasites.

Field Populations: Several times damage was so extensive that the flower stalks were almost completely destroyed, especially on *M. verticillatum* (Figure 72). This was the most commonly collected species of weevil. Collections of 20 to 50 adults were common even though there was usually not a major effort to collect them.

Laboratory Rearing: They were reared mostly in 50-dram vials with 3 to 4 cm of water in the bottom and with a plastic snap-cap lid with a central hole. A piece of no-see-um mesh was placed over the vial mouth before the lid was snapped on. The hole, which varied from about 2 to 4 cm in diameter, allowed air movement. Several flower stalks were exposed in the vials. From June until November, they were fed *M. spicatum* flower stalks, but the rest of the time they were fed *M. aquaticum* (Velloso) Verdc., usually emersed stalks without flowers. New plant material was added as needed. During the oviposition period, the adults were removed weekly and the stalks held for larval development. When cocoons were found, the water was usually poured out to prevent the pupa from drowning by water entering the short piece of stem. The vials were held in a temperature cabinet at 27 °C and 16h light.

Prognosis: Like *B. myriophylli,* this species has the native American species *M. verticillatum* included in its natural host range. It is specific to milfoils, but damage to native milfoils would most likely prevent its introduction. Initially, it was thought that there might be more than one species separated by host plant, but Dr. O'Brien has tentatively identified them as one species. If they prove someday to be two species, one might still be of interest. The biology is similar to that of the holarctic *P. leucogaster* Marsham (Buckingham and Bennett 1981), which attacks Eurasian watermilfoil in the northern United States. However, this author believes that it is more damaging because it feeds more underwater and because larvae feed more readily inside the flower stalk than do larvae of *P. leucogaster*.

Phytobius sp. 2

Found on surveys: 13, 15

Locations: Heilongjiang Province, 50 km N of Harbin, Kmstone 50, road to Suei Hua City, Xu Bao, 19/Aug/94, 22/Jun/95, drainage canal; NW of Harbin, near Daqing, Wo-Li-Tun, 24/Jun/95, 27/Jun/95, Shi-er-li-pao marsh.

Host Plants: *M. spicatum* ?, *M. verticillatum*

Feeding Damage: Almost identical to that of *Phytobius* sp. 1.

Life History: Almost identical to that of *Phytobius* sp. 1. This species, however, forms the spherical cocoon attached to the leaves not embedded in the stem. This species is readily distinguished from *Phytobius* sp. 1 by the noticeably shorter snout. Additionally, light-colored scales form a broad stripe dorsolaterally along the body.

Field Populations: Heavy in June. Almost every flower at one site had adult feeding. Fifty-one and ninety-three adults collected in June 1995 at Shi-er-li-pao where *Phytobius* sp. 1 had been dominant in August 1994, although not at the exact site.

Laboratory Rearing: This species was reared the same way as *Phytobius* sp. 1 on *M. spicatum*. However, it did better than the other species during the winter when fed *M. aquaticum*.

Prognosis: This species developed in the field on *M. verticillatum*. It thus has little chance of being approved for introduction.

Diptera (Flies)
Chironomidae
Cricotopus sylvestris (Fabricius) grp. sp(p?).
Polypedilum sp. ChL-1 (prob. *P. pseudotritum* (Ree & Kim))
Glyptotendipes (*Caulochironomus*) sp.

Found on surveys: Midge damage was observed on almost all surveys and was probably due often to a complex of species.

Locations: Almost all locations where hydrilla was present had one or more species.

Host Plants: *Hydrilla verticillata*, *Hydrocharis dubia* (P. ChL-1), *Potamogeton natans* (P. ChL-1)

Feeding Damage: Hydrilla stem tips are damaged. A blackened channel in the stem immediately below the tip leads to the apical meristem, which is eaten. Also, a hole is eaten through the leaflets covering the apical meristem, and the meristem is eaten with no stem channel formation. Lateral meristems are also attacked, and channels are eaten occasionally in stems away from the tips. Short tunnels used as shelters were common in stems, but were made by algae feeders.

Life History: The life histories were not studied. Damages by these species were not confirmed by larval transfers; but these were the species most commonly dissected from the damaged areas, and they are in groups known to be plant feeders. It is unknown if the two types of damage are species specific, i.e., access to the meristem via a channel in the stem and via boring directly through the leaflets. The most common midge identified was the *Cricotopus sylvestris* group sp., which might be more than one species. Two additional species of *Polypedilum*, ChL-2 and KL-1,

might also be plant feeders. Three other possible plant feeders were *Cricotopus tricinctus* (Meigen), *Endochironomus* sp., and *Glyptotendipes* (*Caulochironomus*) sp. Many other species were recovered from dissections of damaged tips and stems and from emergence jars with hydrilla, but they were in groups not known to be plant feeders.

Field Populations: Midge damage was generally common on hydrilla and occasionally very abundant. One sample in Korea had 87 percent (n = 30) of the tips attacked, and one in Beijing had 68 percent (n = 120) attacked. Often almost every tip was damaged. Larvae, however, were uncommon or difficult to collect. Each larval specimen collected represented many tips searched.

Laboratory Rearing: None were reared.

Prognosis: Hydrilla is heavily damaged by native midges in Florida. More extensive field studies overseas and in North America are needed before the biocontrol potential of these species can be assessed. Taxonomic revisions would also be needed to clarify host relationships.

Cricotopus myriophylli Oliver (Oliver 1984)

Found on surveys: 4, Korea 1 ?

Locations: Inner Mongolia, SE of Hohhot, Dai Lake, 17/Sep/90, large lake; Korea, KangWon-Do Province, near Seoul, Uiam Lake, 3 km N of dam on W side of lake near restaurants, 15/Aug/91, reservoir (similar damage but species not confirmed).

Host Plants: *Myriophyllum spicatum*

Feeding Damage: Feed on the stem tip destroying the apical meristem. This has been reported to stunt the plant, thus preventing surface mats and flowering in North America (MacRae, Winchester, and Ring 1990; MacRae and Ring 1993).

Life History: The life history has been studied in British Columbia, Canada, where this species also occurs (Kangasniemi 1983; MacRae and Ring 1993). There appears to be one generation per year with possibly a small second generation. Larvae feed on the stem tip. They live in a silk case constructed with plant parts over a channel in the stem and feed on more than one tip. They appear to overwinter as a third instar (there are four instars). Dissected females had a mean of 189 eggs (MacRae and Ring 1993).

Field Populations: Forty of sixty tips were eaten in a sample in Inner Mongolia. An unidentified sample in Korea, which was probably this species, had only 2 of 30 tips eaten.

Laboratory Rearing: This species was not reared, and successful laboratory rearing has not been reported in North America.

Prognosis: The species already occurs in North America. There might be potential for augmentation of existing populations, especially from the northern United States to the southeastern United States, but not for importation.

Ephydridae (Hydrellinae)
Hydrellia pakistanae Deonier (Deonier 1993)
Hydrellia sarahae sarahae Deonier (Deonier 1993)

Found on surveys: 1, 4, 5, 8, 9, 10, 12, 13, 15, 16, 17; **Japan** 1

Locations: All locations where hydrilla was found had either one or both species.

Host Plants: ***H. pakistanae***: *Hydrilla verticillata*; ***H. sarahae sarahae***: *Hydrilla verticillata, Potamogeton crispus, P. cristatus, P. nutans, P. pusillus, Vallisneria spiralis*.

Feeding Damage: The damage was indistinguishable. Leaves were mined, which left them mostly transparent. Some uneaten material was usually present in each leaf, but most of the contents were eaten.

Life History: Eggs are placed on leaves or stems projecting from the water. They can also be placed on other plant species or objects. Neonates emerge and enter the leaf if on hydrilla or crawl in search of hydrilla. Initially the mines are serpentine, but soon they become blotch mines as more leaf tissue is eaten. Often all the leaves at several nodes will be mined. The puparium, which is the hardened larval skin containing the pupa, is formed at the base of the leaf and attached to the stem by two sharp spines (Figure 77). The spines are breathing tubes through which air moves from the stem to the puparium. Adults emerge from the puparia and float to the surface. Adults are commonly found on broad-leaved floating plants, which they use as a courtship arena and where they mate. The life cycle took 3 to 4 weeks in the laboratory (Bennett 1993). The life history of an Indian population of *H. pakistanae* was reported by Buckingham and Okrah (1993).

Field Populations: The two species were not distinguished in the field, and after the first year, close records were not kept of infestations on hydrilla. Emphasis was on collecting adults as they emerged in jars and setting them up in colonies to carry to the United States.

Laboratory Rearing: Both species were reared with the same techniques. They were reared in 3.8-L (1-gal) glass jars capped with nylon no-see-um mesh held by rubber bands and filled about three-fourths with water. Hydrilla sprigs loosely filled the water column but touched the

bottom of the jar so that any larvae dropping to the bottom could still contact hydrilla. If light was not clearly visible through the hydrilla when it was held up to the light, the hydrilla was too dense. Hydrilla that was too dense depleted the oxygen at night, and many larvae died.

A liquid diet of 4 g yeast hydrolyzate, 7 g sucrose, and 10 ml water was painted on small styrofoam floats. About 50 to 100 mixed adults were placed in the jars for 3 days or until they all died. The jars were held in a greenhouse at about 27 °C with natural lighting supplemented for 16h in winter with fluorescent lighting. Jars were observed occasionally as larvae matured. If leaf mining was heavy, new hydrilla was added to the jar below the old hydrilla. Newly emerging adults were removed daily with an aspirator made from glass tubing. The tubing, 3- to 3.5-mm ID, was about 15 cm long with a fine mesh placed over or inserted into one end. Rubber tubing was attached at the end with the mesh. This aspirator allowed the flies to be sexed or identified in the tube under a microscope and then blown into a new jar.

The sexes could be easily separated by the shape of the end of the abdomen. Females have structures (cerci) projecting from the end, whereas males are bluntly rounded (Buckingham and Okrah 1993). Deonier (1993) has detailed drawings of these structures and keys for species identification. Removal of adults from the jars was performed in a light box (Figure 78). This was a modified wooden boxlike structure with one end removed where the researcher sat covered behind by a black cloth. The other end was covered by a translucent white plastic sheet illuminated from behind by fluorescent lights. The white plastic attracted most flies to the side of the jar closest to the light so they could be easily aspirated and also attracted escapees.

The jars with hydrilla were sterilized with a strong bleach solution when fly emergence stopped or about 6 weeks after oviposition. The hydrilla was also autoclaved afterwards. Bleaching the jars after each use was imperative to prevent the plants from rotting and to protect the flies from *Beauveria bassiana* fungus infection. This fungus was always present in the colony, but could be kept under control by effective use of bleach. When there was a fungus epidemic, care was taken to remove dead flies quickly before spores were formed.

When colonizing a shipment received in quarantine, dead flies were removed daily for at least the first two generations. This prevented fungus and allowed confirmation of fly identification by examination of genitalia. The oviposition jar was also modified so that it was filled only about one-fifth with water. This allowed more leaves on the hydrilla sprigs to project from the water to provide more oviposition sites. About 3 days after all ovipositing adults died or were removed, the jar was filled three-fourths with water, and additional hydrilla was added below the original.

Prognosis: *Hydrellia pakistanae* from China has been released in Florida and Alabama, but there have been no evaluation data reported. It was hoped that the Chinese flies would be released in the northern United States with little rearing, but that has not been done. When hydrilla begins to spread more widely in the north, this population should be released at some sites and the Indian population at others to determine if origin is important for establishment in temperate areas. The Indian population readily established in northern Alabama (Grodowitz, Center, and Snoddy 1995).

Hydrellia sarahae sarahae had too broad a laboratory host range to be released without more field host records. It was recovered from four species associated in P. R. China with hydrilla although in very low numbers. These flies might have transferred from hydrilla, or perhaps other hosts can be utilized for short periods by small numbers of larvae. This is the most common species on hydrilla in northern P. R. China and should be considered a potential biocontrol agent awaiting additional field studies.

Hydrellia n. sp.

Found on surveys: Korea 1, **Japan** 1

Locations: Korea: KangWon-Do Province, near Seoul, Yongsari, 2.1 km N inters. Hgwys 45 and 6 on Hgwy 45, 16/Aug/91, bay in river**;** Kyonggi-Do Province, near Seoul, 1 km N Yongsari, 12/Aug/91, 16/Aug/91, small lake along river; N of Seoul, Lake Chongpyong, 12/Aug/91, reservoir lake; near Seoul, 2.5 km W of Yongsari on Hgwy 6, 16/Aug/91, bay in river.

Host Plants: *Hydrilla verticillata*

Feeding Damage: Leaf mining indistinguishable from that of *H. pakistanae*. Stem damage was associated with one puparium which, if caused by this species, would differ from that of *H. pakistanae*, which only attacks leaves.

Life History: This was not studied, but it is probably similar to that of *H. pakistanae*.

Field Populations: Populations appeared to be small although little survey time was spent examining hydrilla for flies. Parasites emerged from puparia.

Laboratory Rearing: Small numbers of the Japanese population were reared in quarantine for two generations, but they did not successfully colonize.

Prognosis: The host range should be studied in the field to determine if it has potential for biocontrol, especially if hydrilla continues to spread in the northern United States and if *H. sarahae sarahae* is not used.

Homoptera
Aphididae
Rhopalosiphum nymphaeae L. (Palmer 1952)

Found on surveys: 4, 6

Locations: Inner Mongolia, Hohhot, BaBai Lake, 15/Sep/90, small lake; Xinjiang Province, Burqin, bridge over Burqin River, 29/Aug/91, small streams, potholes near river

Host Plants: *Myriophyllum spicatum, M. verticillatum*

Feeding Damage: Not apparent. However, aphids typically cause death of the plant structure with heavy feeding. They were feeding on the flower stalks.

Life History: This species is distributed worldwide and is the most common aphid on the emersed structures of submersed plants. They reportedly migrate seasonally between aquatic plants and trees.

Field Populations: They were uncommon and not abundant.

Laboratory Rearing: It was not reared.

Prognosis: It has no potential as an imported biocontrol agent.

Lepidoptera (Moths)
Pyralidae (Nymphulinae)
Parapoynx vittalis Bremer (Park 1983)

Found on surveys: 1, 13,

Locations: Beijing Province, Beijing, Qiao Zhuang, 23/Jul/92, small drainage pond; Heilongjiang Province, 44 km NE of Qiqihar, Long An Qiao, 11/Aug/94, river marsh; Daqing to Qiqihar, Kmstone 806, Qi Lin Dao Chun, 12/Aug/94, drainage canal; 50 km N of Harbin, road to Suei Hua City, Kmstone 50, Xu Bao, 19/Aug/94, drainage canal.

Host Plants: *Hydrilla verticillata, Myriophyllum verticillatum*

Feeding Damage: Eats the submersed leaves.

Life History: Larvae tie excised leaves together with silk forming a tubular case, which they carry with them for shelter. The cocoon is formed on the stem inside the case, which is attached tightly by silk to the stem. No additional details were determined for this well-known polyphagous species. *Parapoynx diminutalis* (Snellen) might have been found on the southern surveys, but the identification was never confirmed. It is already an immigrant in the southern United States.

Field Populations: Larvae were observed at many sites, but were never abundant.

Laboratory Rearing: It was not reared.

Prognosis: This species is known to be polyphagous and thus is not a potential biocontrol agent.

Trichoptera (Caddisflies)
Hydropsychidae
Leptoceridae

Found on surveys: 8, 13; **Japan** 1

Locations: Heilongjiang Province, 44 km NE of Qiqihar, Long An Qiao, 12/Jul/92, river marsh; 50 km N of Harbin, road to Suei Hua City, Kmstone 50, Xu Bao, 19/Aug/94, drainage canal; Japan: Hyogo Pref., near Kobe, Ono City, Awo, Manganji River, 4/Aug/92, river.

Host Plants: *Myriophyllum spicatum; M. verticillatum*

Feeding Damage: Damage was not confirmed. Lower leaves appeared to have been eaten, but they might have fallen off due to senescence.

Life History: Unknown. Larvae of Leptoceridae were in elongate parchmentlike conical cases, and those of Hydropsychidae were in cases covered with milfoil leaf fragments.

Field Populations: Cases were very abundant at the three sites although the majority were empty.

Laboratory Rearing: None were reared.

Prognosis: There is probably little chance that these are potential bio-control agents.

4 Conclusions and Recommendations

Both hydrilla and Eurasian watermilfoil were common in many areas of the three countries, although not in all. Rarely did they dominate a waterway as they do in the United States. When they were most abundant, usually other species were also abundant. Dense monocultures were not common. Neither species was found in the far western Xinjiang Province, and only Eurasian watermilfoil was found in Inner Mongolia. Eurasian watermilfoil was generally more common than hydrilla in the northern Heilongjiang Province and vice-versa from Liaoning Province south. Cultural control of both species, but especially hydrilla, by hand pulling from the waterways was noticed in midsummer to late summer. This undoubtedly contributed to the reduced weediness observed in that season, but it might have had the opposite effect over the long term. If insects and pathogens do control the plants, then cultural control would reduce the effects at that site the next year and lead to a continuing need for cultural control. An example of this was a small drainage canal at Hsing Hua University in Beijing where hydrilla was pulled onto shore every late August or early September just as the population of leaf-mining flies was peaking.

The surveys demonstrated that the same insect orders and families discovered elsewhere were active in temperate Asia on hydrilla and watermilfoils. Weevils and flies were the most common and abundant groups. Donaciine chrysomelids (leafbeetles) were more apparent on these surveys than on previous ones, but they are generally most common in temperate climates. Larvae of the donaciine *Macroplea* sp. 1 were associated with unhealthy looking hydrilla, but damages were not apparent, except for small feeding holes in some stems. More intensive field collections and plant examinations would be needed to confirm that the damage was made by *Macroplea.* The weevils on watermilfoils appeared to be damaging, but they also appeared to include both Eurasian and whorled watermilfoil as hosts. Unless future taxonomic and biological studies indicate that the weevils differ according to host plants, there is probably little chance they will be used because of concern about nontarget effects on native populations of whorled watermilfoil. Confirmation was not made of observations made during early surveys that a stem-boring *Bagous* weevil attacks hydrilla in P. R. China. This was in spite of a concerted effort to find

the weevil in both northern and southern P. R. China. However, the conclusion cannot be made with certainty that the agent does not exist, because at various sites feeding damage was found that was similar to that made by the stem-boring Australian *B. hydrillae*. If the creature does exist, it certainly does little damage and possibly comes from another host plant.

Leaf-mining flies appear to be good candidates for a hydrilla biocontrol program because *Hydrellia pakistanae* from India and Pakistan established readily in Florida and has spread throughout the State. The impact of the damage on hydrilla has not been quantified with regard to hydrilla population dynamics, but often impacts of biocontrol agents are subtle and take many years to be noticed. The Chinese population of *H. pakistanae* was released from quarantine in 1992. The second species, *H. sarahae sarahae*, was more common in northern P. R. China than *H. pakistanae* and needs more documentation of its field host range. Only a few adults emerged from other plant species, although in quarantine it developed on other plant species. More needs to be learned about a third species that was found in both Korea and Japan. Surveys in both countries were brief, and little is known. It was more common in Korea than Japan, but more sites were surveyed there. It was not abundant anywhere. Control of the floating weed *Salvinia molesta* was successful in Australia only after a second very closely related species of weevil was introduced to complement the first unsuccessful species (Room 1990).

Extensive surveys in P. R. China are difficult because access is still somewhat restricted. To engage a vehicle and wander at will throughout the country as one would like to do is not possible. On the other hand, there is an extensive network of cooperators who generously provide time to arrange local travel and often to travel with surveyors. This local help is very valuable, but it does reduce the coverage of the survey by restricting it to areas with cooperators. Still, good coverage of the country was provided, and the majority of agents have probably been discovered. Undoubtedly, others still remain to be discovered, but probably not many unless they are along the southern border. Intensive surveys were not made in the south because the search was for temperate species. Continued studies would need to integrate additional survey work with longer periods of field study at sites where potential agents have been discovered. The goals of the field studies would be to clarify host relationships, to briefly describe insect and plant population dynamics, and to document insect damage. Laboratory research at SABCL is difficult because of high summer heat in the greenhouses and because of limited air-conditioned laboratory space. To conduct the field studies alone, Mr. Zhiqun Chen would need additional training, preferably Ph.D. training in Florida. Summer field studies in P. R. China could be used for his dissertation, with winter laboratory studies in Florida.

Recommendations are listed below:

a. The field host range of *Hydrellia sarahae sarahae* should be investigated further.

b. The field host range of the undescribed *Hydrellia* in Japan and Korea should be investigated**.**

c. More extensive surveys should be conducted in Japan and Korea.

d. The host relationships and damage potential of the insects on Eurasian watermilfoil in Heilongjiang Province should be studied intensively in the field.

e. The unidentified *Macroplea* on hydrilla should be studied to determine its identity and the type of damage.

f. Limited surveys should be continued in P. R. China in areas missed earlier, especially in the southern half of the country, with emphasis on undisturbed natural waterways.

g. Ph.D. training for Mr. Zhiqun Chen should be provided in Florida so that he will be able to conduct long-term field studies of aquatic agents in P. R. China and other parts of Asia.

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Figure 1. Hydrilla, *Hydrilla verticillata*, infestation, Orange Lake, Florida

Figure 2. Eurasian watermilfoil, *Myriophyllum spicatum*, infestation, Crystal River, Florida

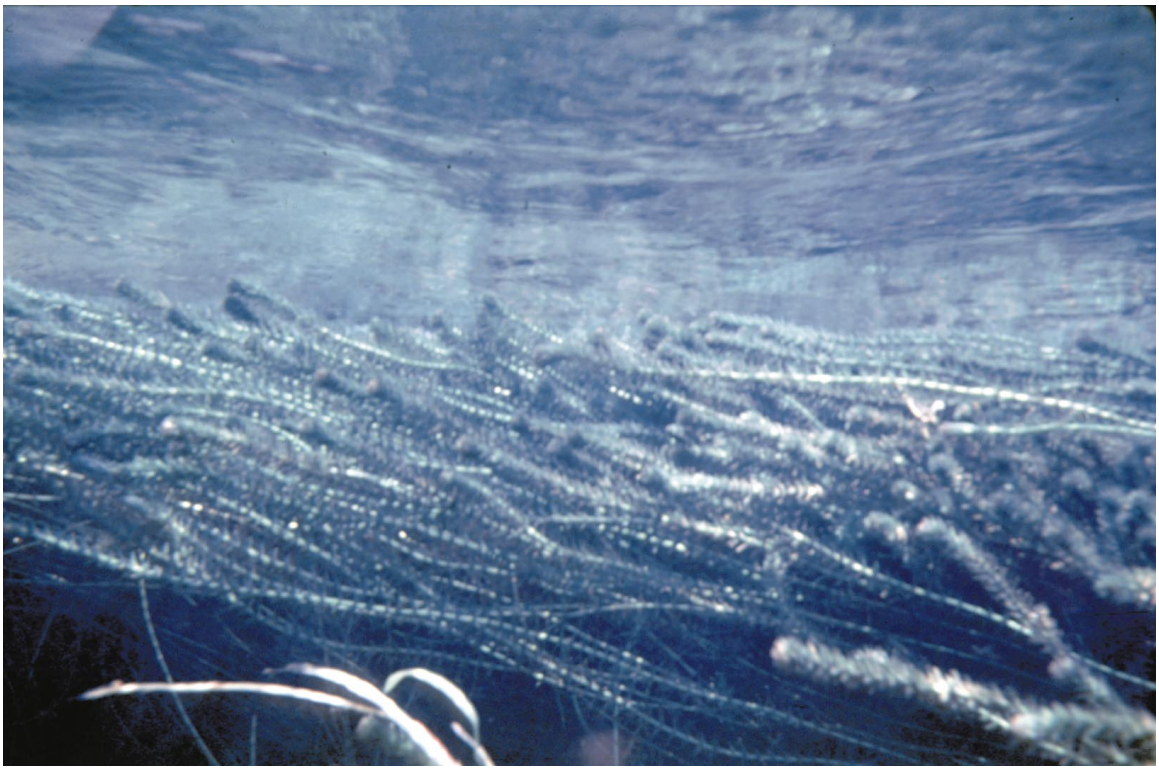

Figure 3. Hydrilla, *Hydrilla verticillata*, submersed view, Manatee Springs, Florida

Figure 4. Eurasian watermilfoil, *Myriophyllum spicatum*, in laboratory pool

Figure 5. Eurasian watermilfoil, *Myriophyllum spicatum*, female flowers open, male flowers begin

Figure 6. Sino-American Biocontrol Laboratory, CAAS, Beijing, P.R. China, Lab's Jeep Cherokee

Figure 7. Gary Buckingham teaching a short course at SABCL; Jiang Hua, Professor Guan facing camera

Figure 8. Left to right: Ren Wang, Chris Bennett, Yuan Wang, Charlie O'Brien collecting weevils, Panacea, FL

Figure 9. Dr. Ping-Ping Chen examining Berlese funnel, SABCL, Beijing, P.R. China

Figure 10. Zhiqun Chen from SABCL during training at Florida Biocontrol Laboratory, Gainesville, FL

Figure 11. Gary Buckingham at Jin Hu Lake, Jiangsu Province, with officials from Jiangsu Agricultural University and local officials

Figure 12. Bob Pemberton and Professor Y. Kadono surveying aquatic plants near Kobe, Hyogo Pref., Japan

Figure 13. Examining plants and insects with a head magnifier, Chris Bennett, Daqing, Heilongjiang Province, P.R. China

Figure 14. Collecting flies with a vial, Weizhen Liu, Tsing Hua University, Beijing, P.R. China

Figure 15. Collecting insects at an ultraviolet blacklight, Ren Wang and Yuan Wang (kneeling), Beijing, P.R. China

Figure 16. Collecting aquatic moths on shore with a sweep net, Ya Zhou Wang, Qi Lin Dao Chun, Qiqihar, P.R. China

Figure 17. Sun-drying fly-infested plants over water at SABCL, Ping-Ping Chen and Gary Buckingham

Figure 18. Examining plants on a light table at SABCL, Zhiqun Chen in the aquatic nuisance plant program laboratory

Figure 19. Examining plants and insects in a hotel room, typical setup with microscope and specimen vials

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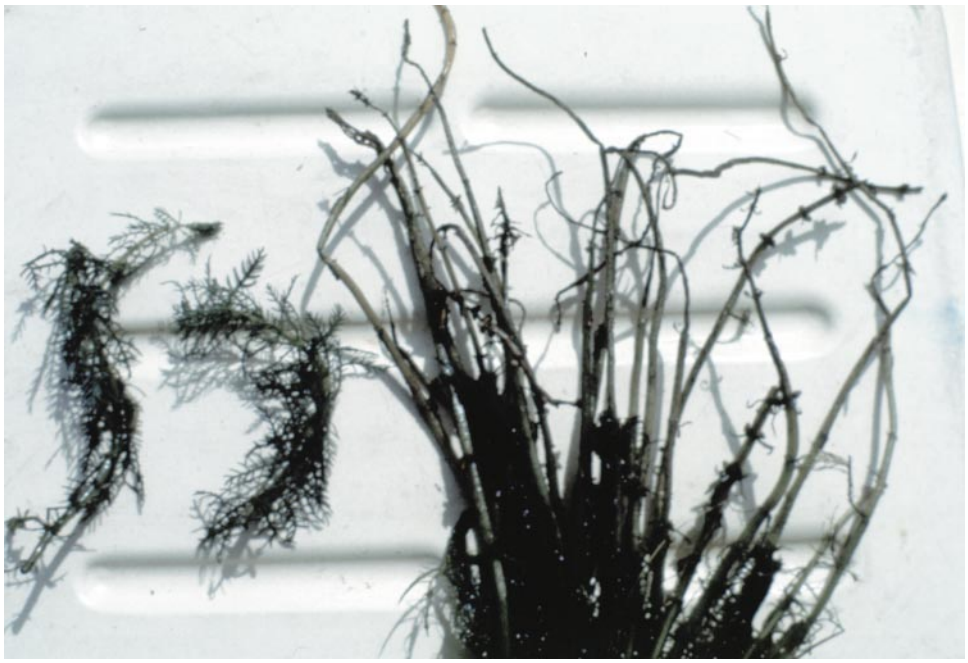

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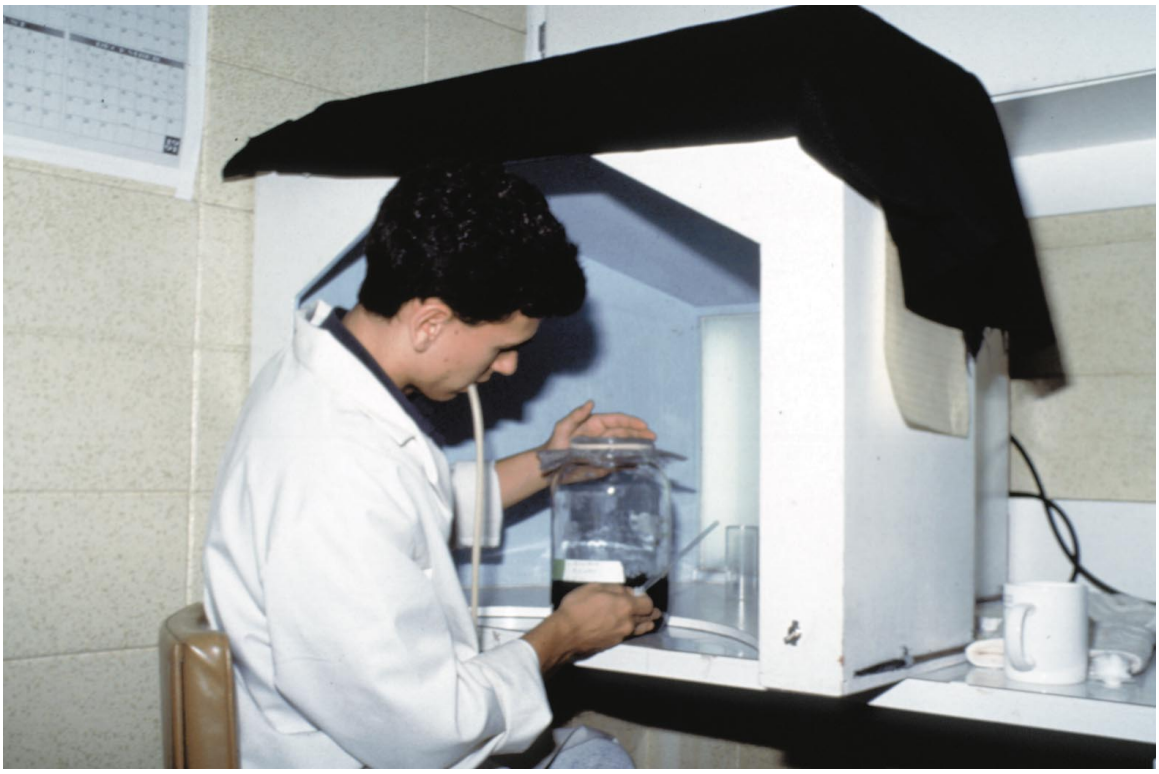

Figure 78. Lightbox used in quarantine to work with *Hydrellia* flies and other active insects, Jason Etchart

The following appendixes are edited travel logs of some surveys. Dr. Balciunas' travel logs were included in his annual Aquatic Plant Control Research Program presentations as Balciunas (1990, 1991).

Appendix A
Surveys 1 and 4 - Beijing, Inner Mongolia, Jiangsu, and Liaoning Provinces - Gary R. Buckingham - August-September 1990

Aug 27. Flight from Bangkok to Beijing.

Aug 28. Met with Dr. Ren Wang and Mr. Yuan Wang to plan itinerary and work schedule. Observed quarantine and insect rearing along with Ms. Jiang Hua.

Aug 29. Traveled to weekly sampling sites, San Jia Dian Reservoir and Qiao Zhuang, to collect Eurasian watermilfoil and hydrilla. *Phytobius* weevils present on milfoil and *Hydrellia* flies on hydrilla.

Aug 30. Examined plant material from previous day and collected E. watermilfoil at the Summer Palace lake.

Aug 31. Called Dr. Balciunas in Australia to discuss work plans and progress. Continued examining plant material.

Sept 1. Collected E. watermilfoil at Yuyuan Lake (August 1st Lake). *Phytobius* weevil adults and immatures common on the flowers. Hydrilla also collected but no *Hydrellia* flies observed on it.

Sept 2. Free day.

Sept 3. Processed cultures in the laboratory. Sent FAXs to J. Balciunas, C. Bennett, L. Anderson.

Sept 4. Processed cultures in the laboratory. Revised Bennett and Buckingham *Bagous affinis* paper. Ran black light at Qiao Zhuang in the evening with Ren Wang, Yuan Wang, and Jiang Hua and collected more hydrilla samples.

Sept 5. Dissected hydrilla from the Qiao Zhuang samples for *Hydrellia* larvae and midge damage.

Sept 6. Collected hydrilla at Yun Chao Jian River, Tongxian County on the outskirts of Beijing. Also collected several additional aquatic plant species. Collected milfoil and hydrilla at August 1st Lake.

Sept 7. Continued dissections of hydrilla from Qiao Zhuang and processing of other material.

Sept 8. Sorted through *Potamogeton* collected at various sites for *Hydrellia* and midges. Called Joe Balciunas in Australia to discuss a possible meeting with him outside of Australia.

Sept 9. Free day.

Sept 10. Moved from hotel, packed field supplies, processed insects, caught up on paper work, and flew to Shenyang in Liaoning Province. Met at the airport by Mr. Kong of the University foreign affairs office.

Sept 11. Met with Prof. Guang Qing Guan of the Shenyang Agricultural University, Botany, who accompanied us to the outskirts of Shenyang where we met officials of the local Plant Protection Station. They accompanied us to Lin Hu (Lin Lake) which was a small city lake close to the station. We collected milfoil which was flowering and hydrilla and after lunch we processed the samples at the station with help from some technical people, former students of Prof. Guan. *Hydrellia* flies abundant on hydrilla along with tip midge.

Sept 12. Prof. Guan accompanied us to another site, Hun He Bridge, where hydrilla was abundant and where Dr. Balciunas had collected a weevil on hydrilla but was unsure of the host plant. The weevil was found after a short search on *Monochoria*, an emergent relative of waterhyacinth, and was later reared from *Monochoria* plants collected at that time. The hydrilla tip midge and *Hydrellia* also common. In the afternoon I presented a seminar about biological control to 30-40 students, instructors, the Dean and the Department Head at the Biology Department.

Sept 13. Returned to Beijing. Examined plant material from trip and material left in the laboratory for emergence and rearing.

Sept 14. Continued examining plant material and prepared FAX messages for Dr. Balciunas and for the U.S. Packed for trip to Inner Mongolia and went to airport in the evening. Flight was canceled.

Sept 15. Flew to Hohhot Inner Mongolia after spending evening as a guest of the airlines, in an airport hotel with a Chinese roommate from Hohhot. Was met by Dr. Ren Wang and Mr. Ming Yan who had driven from Beijing. After checking in at the hotel we visited the Biology

Department of the University where we met Mr. Cao Rui and Mr. Yao Li, who will cooperate with us, and the Department Head. After lunch we went to a nearby lake, BaBai Lake, where we collected *Phytobius* weevils on Eurasian watermilfoil and collected plant samples. Mr. Cao Rui and Mr. Yao Li accompanied us.

Sept 16. Field trip to Ha-su Hai Lake to west of Hohhot. High winds prevented a boat trip on the lake to Balciunas' locations, but milfoil beds were found along shore at wading depth. *Phytobius* adults were still present but at much reduced levels from earlier in summer when Balciunas visited. At least 3 species of *Bagous* were collected on *Nymphoides peltata* leaves above the milfoil. All fed selectively on *Nymphoides* in containers carried to the laboratory. Fly larvae were observed in *Nymphoides* leaves and in stems of *Scirpus*.

Sept 17. Field trip to Dai Lake to southeast of Hohhot in a restricted area. Obtained police permit beforehand. Waded into milfoil beds along northwest shore but found only *Phytobius* and stem midge. *Phytobius* uncommon but flowers were also uncommon.

Sept 18. Returned to Beijing in AM. In PM examined plant material from Hohhot.

Sept 19. Because the car from Hohhot was delayed returning I did not start the short course. Instructed Prof. Guang-qing Guan, Yuan Wang, and Jiang Hua in photographic techniques, i.e., aquarium shots, bellows, extension tubes, while attempting to obtain photos for Dr. Balciunas' and my talks during autumn and winter. Processed insects.

Sept 20. Mr. Cao Rui and Mr. Yao Li from Hohhot arrived by auto. We collected hydrilla at San Jia Dian reservoir giving instructions in how to collect and distinguish *Hydrellia* adults in the field. In late afternoon they received instructions for processing material in the Berlese funnel.

Sept 22. Continued instructions in the laboratory about aquatic insects—presented characters for weevil differentiation, *Parapoynx* larvae, tip midge damage. Presented a lecture on biocontrol of aquatic weeds to the course participants. The course ended at noon because all workers were given the afternoon off to watch the opening ceremony of the Asian Games on TV. In the afternoon I packed and prepared *Hydrellia* colonies for quick packing on Sunday. Ms. Jiang Hua and Prof. Guan aided me.

Sept 23. Checked out of hotel and met with Dr. Ren Wang, Prof. Bao, and Prof. Qiu of the Biocontrol Lab, Dr. Michael Ma, Univ. of Maryland, and Dr. James Oliver, ESA President. Dr. Oliver was invited to advise on organization of the 1992 International Congress of Entomology. After a short discussion period we were hosted at a Peking Duck banquet with other dignitaries. In the afternoon Yuan Wang and I flew to Nanjing where we met Prof. Gun-lun Lin, Jiangsu Agricultural College, who had visited

my lab in Gainesville with Dr. Ren Wang. Prof. Lin drove us to Yangzhou. We were met at the hotel by Prof. Ziqiang Lu, Dean of Plant Protection and a *Trapa* researcher, who explained our itinerary.

Sept 24. Drove to Jin Hu (Jin Lake) with Prof. Lin and Prof. Lu where we met the County plant protection chiefs. All went to Jin Hu lake where we boarded a boat that took us to the middle of the lake. The lake is a wildlife refuge. Hydrilla was mixed with other plants, for example, *Myriophyllum spicatum*, *Potamogeton* spp., *Ceratophyllum*, *Nitella*(?), and was abundant along the shore of an island. This island had a two story building used as a bird observation tower for Chinese tourists, as it was explained to me. *Hydrellia* puparia were present in hydrilla. The main boat was too large to maneuver close to the milfoil beds along the shore of the lake so we were not able to sample milfoil flowers. That evening we were hosted by the Vice-President of the County in a banquet.

Sept 25. Surveyed Wu Jing Dang, a large lake near Xiang Hua City, with a large speedboat and accompanied by an entourage of local officials. Hydrilla common but plants were very clean. Only tip midge damage observed. It was common.

Sept 26. Flew to Guangzhou, Guangdong Prov.

Sept 27. Met with Joe Balciunas and Ren Wang to discuss progress and plans for next year.

Sept 28. Flew home via Hongkong.

Appendix B
Surveys 6 and Korea 1 - Xinjiang Province and Korea - Gary R. Buckingham - August-September 1991

Aug 10. Arrived in Seoul, S. Korea, in AM. Met at airport by Dr. Robert Pemberton, USDA/ARS Asian Parasite Laboratory.

Aug 11. Free day.

Aug 12. Visited the Asian Parasite Laboratory with Dr. Pemberton and then accompanied him east of Seoul along the Han River. Five sites had hydrilla and four of them had small amounts of Eurasian watermilfoil. Site 1 was a tranquil bay off the Han River north of Yongsari. We collected along a private driveway leading to the gate of a residence. Hydrilla was the dominant plant in shallow water up to about chest deep. The plants had relatively heavy load of epiphytes. Most were just below the surface. The hydrilla was in closely spaced patches rather than in a contiguous mat as in Florida. Some patches had almost all old stem tips missing due to midges with some regrowth. Other patches still had most tips. We found a small amount of *Hydrellia* damage at this site during laboratory examination. *Nymphoides* were scattered throughout the site and *Hydrilla* adults were collected from the leaves. The *Nymphoides* leaves were searched for *Bagous* but none were found. Small feeding holes in the leaves appeared to be made by *Galerucella* larvae that had destroyed a small-leafed *Trapa* and were climbing on every object in the water. If the holes were made by them, they were just test holes. No holes larger than about 1 mm2 were found. Pupae covered *Nymphoides* leaves, beer cans, sticks, etc. Many *Trapa* plants had only the floats left. Adults were common also. A narrow-leafed *Potamogeton* was scattered throughout the site (*P. maackianus*?) but very little mining by flies was observed in the leaves as was true for the few *P. perfoliatus* plants and *Vallisneria* plants. All had mining but little. Puparia found only in the stem of *P. perfoliatus* (probably from leaves). A few plants of *Myriophyllum spicatum* were

scattered through the site. No flowers. Relatively small amounts of *Lemna* and *Spirodela* were along shore and there was mining in *Spirodela* but we never examined the plants in the lab. *Ceratophyllum* present. A few plants of hydrilla from several sites had male or female flowers. Both sexes were not observed on the same stem. Very few flowers.

Site 2 was a small pond along the highway along the east bank of the Han River just north of Yongsari. No more than 10 small clumps (few stems) of hydrilla were along shore. Nothing found. A few scattered *Trapa* were present without *Galerucella*. Site 3 was an elongate lake along the highway back toward the town of Yongsari. Again hydrilla was in scattered patches along the shore. We collected on the east shore near houses and rice fields. A few scattered plants of *M. spicatum* were found. *Lemna-Spirodela* mined was present. *Hydrellia* were in hydrilla leaves. The hydrilla was relatively soft and lush with filamentous algae that easily washed off. The narrow-leafed *Potamogeton* was present. A fisherman was cast-netting here. Site 4 was a small pond along the highway east of the town of Yongsari along the other branch of the Han River. Hydrilla was along shore and some was stranded. More hydrilla compared to the size of pond than at other sites. An adjacent smaller pond was about half covered with hydrilla. A few *M. spicatum* plants found. *Najas marina* and probably *N. minor* present. The narrow-leafed *Potamogeton* was relatively more abundant than at other sites. *Vallisneria* present. The hydrilla from this site was not examined in the lab—ran out of time. Site 5 was north of Seoul in the Lake Chongpyong reservoir. A 1-2m band of hydrilla was along shore where the fishermen had not pulled it out. Many fishermen. There was a floating "fish farm"-holding nets in the lake- just out from shore. A few plants of *M. spicatum* were scattered among the hydrilla. Tip midges were abundant at this site. Many plants were found to be damaged during lab examination. *Hydrellia* damage was also observed. There was a small pond-mudhole just behind the beach that was covered with hydrilla and almost dry—mostly mud. This might be a good tuber insect site when it goes dry.

Aug 13. Accompanied Dr. Pemberton and Mr. Lee to Kanghwa Island, NW of Seoul. We stopped at about 4-5 sites and did not find hydrilla or milfoil. At a reservoir forming a marsh we found *Potamogeton crispus* scattered but no other plants. At another site we found a *Polygonum* on shore attacked by a *Galerucella* which was collected. One reservoir was almost soupy green from algal bloom.

Aug 14. We stayed in the lab all day examining plants. A few tip midge larvae were found and preserved. Extensive damage. A couple of *Hydrellia* puparia were found in hydrilla. Milfoil was clean except for some tip damage. The material we did not examine was placed in plastic refrigerator-type boxes (ca 10" deep), capped with opaque cap, and set outside in a screen enclosure behind the lab in deep shade. This material had broken down generally by Saturday (17th).

Aug 15. Dr. Pemberton and I drove to Uiam Reservoir near Ch'Unch'on City. Across from the city and a couple of miles from the dam we found hydrilla and milfoil along shore. Scattered patches with only hydrilla were more common. Milfoil was only multi-stemmed plants—no patches of plants. Almost completely covered with algae and silt—only the bright green tips were clean. Hydrilla was also covered but much less so. Hydrilla ranged from being stranded on mud to about waist deep water. The milfoil was in the waist deep to chest deep water. The narrow leafed *Potamogeton* was common. There was also a *P. illinoensis*-like *Potamogeton* scattered. *Vallisneria* scattered along shore. Tip damage from midges was high in hydrilla, 26 of 30 tips with 2 of 30 tips of milfoil damaged. Did not observe live midges nor dead ones on surface except for a few large midges. We examined another site a few miles away where the hydrilla was in a pond (small bay connected to reservoir) that was drying up and only a foot or so deep. The water was very hot. Some midge tip damage observed. Adult *Hydrellia* common on *Nymphoides* leaves and several vials were collected. The *Nymphoides* did not have noticeable mining. Some mining was observed in small floating leaves of a thread-leafed *Potamogeton* that was in flower. The floating leaves were only about 2-3 cms long and the flowers only had 3-4 whorls. The hydrilla had a lot of algal epiphytes.

Aug 16. We stayed overnight in Ch'Unch'on City. Drove to another Reservoir in the morning and looked along shore. The Reservoir was a deep, straight sided one with no plants seen near the parking lot and excursion boat dock. The reservoir was at the top of a valley, quite high above previous sites. *Potamogeton* probably *P. crispus* was present in Ch'Unch'on near a restaurant on the water along with a few algal encrusted strands of milfoil. No samples collected. Same was true at the bridge crossing the river as we left Ch'Unch"on City. Near and almost across the Han River from Sites 2 and 3 of Aug 12 we found hydrilla along the road and along the banks of a small bay off the river. *Hydrellia* was present in the leaves and there was some tip damage. Adult *Hydrellia* collected from *Nymphoides* leaves. *Trapa* present. Farmers were collecting large clams at this site. The hydrilla was quite lush and relatively clean. We returned to Site 3 of Aug 12 and collected additional hydrilla. Quite soft and lush. We also returned to Site 1 of Aug 12 and collected hydrilla. A *Nymphula*(?) larva was collected on *Nymphoides*.

Aug 17. Dr. Pemberton and I examined plants all day. Set *Hydrellia* puparia up on cotton in cups and larvae of flies, midges, *Parapoynx* on hydrilla in cups for rearing. Dr. Pemberton will send specimens later. *Hydrellia* were very rare—only found 2 or 3 per hour with little mining also. Most puparia were parasitized.

Aug 18. Packed and wrote journal in AM. In PM flew to Tokyo.

Aug 19. Flew to Beijing. Discussed itinerary and plans for research work with Dr. Ren Wang and Dr. Ping-Ping Chen.

Aug 20. Sampled *Myriophyllum spicatum* at Aug 1st Lake with Dr. Ping-Ping Chen. Collected additional plants of hydrilla, 3 species of *Potamogeton, Najas marina, Ceratophyllum,* and *Vallisneria* to examine for flies. Examined a lab colony of flies reared on hydrilla by Yuan Wang, F2 adults. Most were the "silver-faced" species, but at least one male appeared to be different—perhaps *bilobifera*-like, also with a silver face. A *bilobifera*-like male was found in a vial of "hydrilla" flies collected from the Tsing Hua University WuMing canal, July 13, 1991 and emerged from Berlese funnels. These were possibly the parents of the lab colony. Most of the field adults collected in Korea were *bilobifera*-like. A few males were like hydrilla flies but I did not pull genitalia. Sorted through hydrilla sample and saved damaged pieces for later dissection. Some *Hydrellia* damage and empty puparia, some blackened stems, some damaged tips. *Hydrellia* puparia found in midribs of *Potamogeton malaianus*, in stems of *P. crispus* and *Najas marina. Parapoynx* larvae or cocoons found on hydrilla, *P. malaianus, and P. crispus* but only a few individuals. The lake had *M. spicatum* topped out with flowers but offshore and too deep to reach with waders. Near shore it was underwater as was most of the hydrilla. All the plants covered with more algae than they were in 1990. Water quality much worse than in 1990 when the water was very clear—may be because of higher Aug temperatures. Hydrilla was the most common plant near shore with *P. crispus* also common but scattered. Many fishermen at the sampling site.

Aug 21. We examined the Aug 1st Lake material in the laboratory.

Aug 22. Dr. Ping-Ping Chen, Miss WeiZhen Liu and I visited sites at Tsing Hua University. The WuMing (no-name) Canal (named by Jiang Hua because she could find no name) site which is at a bridge next to a large monumental arch had dense patches of hydrilla along with patches of *Hydrocharis dubia* and *Potamogeton natans. P. crispus* had scattered plants. Ping Ping sampled from the bridge with the grappling hook-rake sampler. One side of the bridge where they had been sampling no longer had plants—perhaps had not regrown after the sampling. WeiZhen and I waded in the canal on the western (non-sampling) side of the bridge. Adult *Hydrellia* were common, mating and chasing on the floating leaves of *H. dubia and P. natans (P. natans* was keyed out in the Flora of Beijing which mentioned the Tsing Hua U. site but it differed from the key by usually having 1-3 seeds instead of 4 seeds. That character was supposed to be a *P. distinctus* character). Both *H. pakistanae and H.* n.sp "silver-face" were present in the samples as well as a few other species. The hydrilla was relatively heavily mined (compared with other sites). The leaves of *H. dubia* had numerous *Hydrellia* eggs in some sort of feeding scars on upper surface (probably midges) and the flower stalks of *P. natans* and the floating leaves of *P. natans* (feeding scars) also had numerous *Hydrellia* eggs. *Hydrellia* larvae and pupae found in *P. natans* (pupae in stem) but not in *H. dubia*. Midge larvae were found in channels and internally in leaves and stems of *H. dubia* and *P. natans. Hydrellia* adults were collected in the open flowers of *H. dubia* which had copious pollen

on the anthers. *Polygonum* along shore was almost completely defoliated by a galerucine chrysomelid which was not collected (prob. same as collected 1990) but which may have been same as one adult collected on *P.natans* flowers. A second site, a lotus pond called Biology Pond, had *M. spicatum* covered with periphyton, also hydrilla, and duckweeds attacked by *Tanysphyrus*.

Aug 23. We examined the material collected at Tsing Hua University. Mr. Wayne Molstad, Agricultural Officer, and Mr. Fred Crook, Agricultural Specialist on PDY, visited SABCL and toured the facilities. It was Mr. Molstad's first visit.

Aug 24. Continued examining the material collected at August 1st Lake and Tsing Hua University. In late afternoon Dr. Ren Wang, Dr. Ping-Ping Chen and I visited two sites at Sleeping Buddha Park west of Beijing. The first site, Cherry Blossom Valley, was a small dam at the head of a narrow valley. The water was green from algal bloom and had many swimmers. *Ceratophyllum* formed a small mat in the shallow end of the reservoir mixed with a small amount of hydrilla. Additional hydrilla was scattered along shore along with *Ceratophyllum* and *Potamogeton crispus*. Watercress was growing along a small stream flowing into the reservoir (25x50 m). Only a little *Hydrellia* damage was observed on the hydrilla. The second site was a lotus pond next to the restaurant in the park. A narrow fringe of hydrilla was scattered around the margin of the pond. *Potamogeton pusillus* was mixed with hydrilla in one area. *Vallisneria*, *Ceratophyllum*, and *Najas marina* were scattered. Lotus and *Nymphaea* grew in the center of the pond. *Monochoria vaginalis* grew in small scattered bunches. Damage and two puparia of *Hydrellia* were found in a small sample of hydrilla examined in the laboratory. Nothing found in *P. pusillus*.

Aug 25. Examined the material from Sleeping Buddha Park, checked out of the hotel, and packed field supplies for trip to Xinjiang Province. Flew at night to Urumqi (or Ulamuchi).

Aug 26. Shopped for shirts and sweaters for cold nights, met throughout the day with our host, Mr. Jung, who was having to obtain a travel permit for my journey overland to Altay. No plane seats were available. In the evening Prof. Ren Du Bing and a companion visited the hotel and ate with us.

Aug 27. Drove to Karamay on way to Altay. Trip was delayed in morning to confirm return flight which we were unsuccessful in doing.

Aug 28. Drove from Karamay to Altay. Stopped at a large, wind-swept lake, Fuhai Lake, but no plant fragments were found along the eastern shore except some type of reed stems. The south side of the lake appeared to have some calm marshy areas but we did not visit them. From there to Altay there were valleys with some small ponds and lakes but

could see no waterweeds at the surface. We stopped at one that had clumps of algae on the bottom and *Potamogeton pectinatus and Najas marina* scattered along one section of shore. Altay was in the foothills of desert-like mountains.

Aug 29. Drove from Altay to Burqin. Stopped at several small ponds and streams along the way but did not find milfoil. One marsh had pools with mats of *Utricularia*, possibly *vulgaris*. It had red tips and looked extremely similar to a milfoil from shore. The bladders were purple and the flowers yellow. The 111 km trip took about 4 hrs over a washboard gravel road across the desert and grasslands. Vegetation was lush near waterways but elsewhere there was little. At the western end of the bridge west of town over the Burqin River, we found *Myriophyllum verticillatum* in a small waist to chest deep pothole across the road from a small lake that had *Potamogeton perfoliatus* and *P. pusillus*? On both sides of the road, small streams flowing through the woodlands of poplar and birch (or some other white-barked) tree had *M. verticillatum*. Other plants observed were *Ranunculus, Ceratophyllum,* a strap-leafed *Sagittaria* with an emersed flower stalk, *Hippuris, Potamogeton sp., Alisma, Spirodela & Lemna*, and possibly *Elatine*. Also other unidentified species. We collected *Phytobius* adults and larvae, *Eubrychius or Eurhychiopsis* adults and larvae, a case-making caterpillar and small adults possibly of it, a webbing caterpillar, aphids, and a small yellow flea beetle (prob. contaminant) on *M. verticillatum*. We drove north a little (several km) west of the bridge to a small reservoir (Aayin-Mo-Ke village, Wei Hu) with clear deep water but only found *P. pectinatus, P. perfoliatus,* and milfoil-like *Utricularia* in the small area I could reach by a local inner tube boat. Another shallow lake on the way back to town at a bridge and causeway had no milfoil.

Aug 30. Drove from Burqin to Fuhai stopping at various waterways along the way. At one medium-sized lake there was a lot of yellow flowered *Nymphoides, P. perfoliatus,* possibly *P. natans or P. indistinctus* (very heavy seed set, prob. 4 per flower, completely seeds), *Butomus*, and various other plants. *Nymphoides* was very thick - one side of the lake was yellow from the flowers. At Fuhai we rented a large passenger boat to take us and local officials from Fuhai and Altay out onto Fuhai Lake. The lake had *Phragmites* beds like islands along shore and along the channel from the Karamay-Altay road. The lake was green from algae and had no surface plants. Several pieces of *P. pectinatus* and one piece of *P. perfoliatus* in very poor condition were collected with the rake-like dragline.

Aug 31. Checked the old river bed at Fuhai in the morning—only *Ceratophyllum*—and then drove to the site of the old Altay Fish Pond which was a site suggested by Ren Wang from information from his contact. The site was Ke Ke Su farm near Ba Li Ba Gai town. We found only a few small stems of *Myriophyllum verticillatum* in a small drainage ditch leading from the pond which is now a large commercial nursery of *Pragmites*. It was mostly dry along the margin but we did search small water holes

along a dike where the drainage ditch was exiting from. There was a milfoil-like *Utricularia, Lemna trisulca* (thick layer covering surface), some *Nymphoides* -yellow flowered- but no E. watermilfoil in the drainage ditch. The milfoil looked like *M. spicatum* underwater, but it had aerial leaves like *M. verticillatum*. The aerial leaves, however, were mostly on pieces growing on mud and could be a terrestrial form of *spicatum(*?) but doubtfully. We checked ditches and waterways along our journey without success. The yellow *Nymphoides* is common in this area as is *P. perfoliatus* which seemed weedy in many places. During a car breakdown stop between Ba Li Ba Gai town and the intersection of the road between Fuhai and Altay, I found a *Parapoynx*-like cocoon on *P. perfoliatus*. We drove to Altay for the evening.

Sept 1. We drove to Burqin from Altay and revisited the 29 Aug site at the N. side of the bridge over the Burqin River. Collected in the small stream north of the pothole where Ping Ping collected bugs and weevils. *Eubrychius* adults were sitting on or near the tips of submersed stems of milfoil. Cocoons were usually attached within l cm of a submersed tip. The stem was usually curved slightly at the attachment and the stem was shrunken and black at the attachment. The brown cocoon was like that of *Phytobius* but was about 2/3 or more exposed instead of buried like that of *Phytobius*. Collected 54 adult *Eubrychius* and ca 10+ cocoons. Two larvae were found on submersed tips. Surprisingly little damage and larvae for the number of adults. Saw no *Phytobius* adults or damage on the exposed flower stalks. Observed milfoil stalks at the pothole with Ping Ping but saw no more *Phytobius*. Most stalks were lying down from Ping-Ping's previous collecting of bugs with the wire screen. Collected a few cocoons of *Phytobius* and one adult moth like those collected previously. Leaves of *Sparganium* were mined by a yellow caterpillar one of which had been found in a milfoil bag collected previously. If they are the same, it will be a contaminant of the milfoil bag. We found a large infestation of *M. verticillatum* in a small river or stream below the road from Burqin to Altay about 1 km E. of town, near a deep, concrete channel that the road crosses. The stream was about 50-75% covered with weed. All emersed stems had been eaten and were bare. There were no green leaflets on them. *Phytobius* cocoons were common even on the emersed stalks— multiple cocoons. The damage to the flower stalks was truly impressive, but it is not conclusive that it was all caused by *Phytobius*. Possibly a caterpillar also? Drove to Karamay in the afternoon.

Sept 2. Drove from Karamay to Urumqi (Ulamuchi) where we had difficulty getting a hotel room but finally found one.

Sept 3. Free day. Drove to Heavenly Lake accompanied by local plant protection personnel. Scattered plants of a *Carduus nutans*-like plant were near the restaurant at the lake. Rust was on the leaves and heavy on a dead flower stalk. Went to the airport in mid-afternoon but our tickets had been canceled and we were unable to board.

Sept 4-6. Waited in Urumqi (Ulamuchi) for our plane home.

Sept 7. In AM visited the herbarium at Xinjiang University but I was unable to see the plants. Ping-Ping was able to see them and she made notes about the specimen locations and characters. In PM flew to Beijing.

Sept 8. Worked in AM at SABCL and free day in PM.

Sept 9. Ren Wang, Ping Ping Chen and I collected hydrilla at Tsing Hua University in the canal which was almost dry (15 cm+ of water) and which had been cleaned of most hydrilla. Most of the *Hydrocharis* was also gone. Collected damaged *Spirodela* at the Biology Pond and adult flies and parasites on it. No weevil adults observed. *Marsilea* appeared to have fly mines. Collected hydrilla at Qiao Zhuang pond of last year. Extensive flowering. Also collected a narrow-leafed *Potamogeton, Najas minor*, and one plant of *Vallisneria*. The pond had been cleaned late Sept of 1990 and had not regrown through July. It was about 50% covered. In PM we collected hydrilla and other plants at Aug 1st Lake. Mostly milfoil, *Vallisneria, and P. malaianus*. Small amount of hydrilla and various *Potamogeton*. Milfoil beginning to flower close to shore. Jiang Hua examined the flowers but did not notice *Phytobius*.

Sept 10. Examined the plants from the 9 Sept collections.

Sept 11. Continued examining plants.

Sept 12. Examined plants in AM. Free in PM.

Sept 13. Departed for Tokyo and home.

Appendix C
Survey 8 - Heilongjiang and Liaoning Provinces - Gary R. Buckingham - June-July 1992

June 29. Arrived Beijing at 9:30 PM. Took taxi to the Friendship Hotel.

June 30. Met with Jiang Hua and Mr. Fan at SABCL in AM. In PM started an inventory of lab equipment. Late PM attended the General Assembly meeting of the IOBC at the International Congress of Entomology site.

July 1. Continued inventory of lab equipment, sorted through plant specimens throwing away the damaged ones, started separating insect specimens taxonomically. In PM Dr. Soper and other ARS scientists visited the lab and we met as a group with Biocontrol Lab leaders to discuss the Coop. Projects and future directions.

July 2. Jiang Hua, her husband and I went by taxi to August 1st Lake. Hydrilla common but most plants less than 1' tall, none at surface. *M. spicatum* was most common plant; most plants just under the surface but some floating; algae covered stems with old flowers. *P. malaianus* was common with much of it at the surface, *P. maackianus* was scattered throughout and still underwater as was *P. crispus* which was least abundant *Potamogeton*. Two *Najas* present, *N. marina and N. oguraensis. Vallisneria* was uncommon. *Potamogeton pusillus* was found in a sample during lab exam. In PM I attended the IOBC council meeting at the Congress site.

July 3. In AM Jiang Hua, her husband, and I collected plants at the canal at Memorial Arch, Tsing Hua University. Water was only a few inches deep so hydrilla exposed throughout canal. Few other plants. *Hydrocharis dubia* was present but only a few plants, *Potamogeton natans* had a small population with floating leaves, *Nymphoides* had a small patch, scattered along canal were *P. maackianus and P. pectinatus*. We collected fly adults off the floating leaves . In PM went to IOBC council meeting at

Congress site. Also collected in AM at Sleeping Buddha Park's lotus pond before going to Tsing Hua. Water very low. *Potamogeton pusillus* dominant with hydrilla next. *Zanichellia* present.

July 4. Spent all day and evening at the lab sorting through plant material from the previous days collections.

July 5. Spent all day at the lab processing plant material from August 1st Lake.

July 6. Jiang Hua, Mr. Zhiqun Chen, Bob Pemberton and I collected hydrilla and *Potamogeton,* either *pectinatus or pusillus,* at Qiao Zhuang pond. The hydrilla was near the surface along the margin of the pond with the *Potamogeton* interspersed or growing in deeper water. Hydrilla was heavy with *P.* prob. *natans* in an irrigation channel leading out of the pond. We then stopped at a small man-made pond near some fish ponds along the road bordering the river or canal at the junction with a road to Dao Xiang Lake. Hydrilla and *Najas oguraensis* were in patches in the pond. At Dao Xiang Lake Bob found two small patches of *Trapa* and hydrilla was scattered along shore. Some *P. malaianus, Ceratophyllum, Najas* and others also along shore. A lotus pond beside the lake was full of yellow flowering *Nymphoides* and *Spirodela* along with the lotus. We then drove over the hills to San Jia Dian Reservoir. The water level was very low with several feet of the lake bottom exposed. Hydrilla and milfoil were quite dense along shore with *P. perfoliatus, P. malaianus* scattered throughout.

July 7. Examined plant material from all the collections and prepared for the trip. Had to throw out many of the samples especially from the 6th which had gotten too hot. A few samples of hydrilla were placed in the refrigerator.

July 8. Bob Pemberton, Mr. Nanping Han, CAAS, Div. International Coop., and I flew to Harbin in early AM. We were met at the airport by Mr. Ting-Ju Fu, Plant Protection Institute of Heilongjiang, Chinese Academy of Agr Sciences, who took us to the Swan Hotel. After lunch Prof. Te-bao Chen, a weed scientist, came to discuss our agenda. Mr. Zhiqun Chen, the new SABCL employee, who had taken the overnight (22 hrs) train from Beijing, came to the hotel in late afternoon. We tried to purchase pans and wire screen for sun drying plants in early evening but the stores had already closed.

July 9. Mr. Han, Mr. Chen, Bob and I with a driver from the Institute drove to the Er-Zhuang-Chang (Second Brick Factory) area to look for the Da-Pao site of J. K. Balciunas' 1991 *Bagous* larval collection. We found a small drainage pond at almost 2 km from the factory. It was the right length but only a third as wide as the note card from 1991 indicated. It had a garbage dump at one end as Balciunas had indicated. The water was muddy brown with no submersed plants visible. A small pond adja-

cent to it on the side away from the road had many submersed and emersed plants but no hydrilla or milfoil. Floating leaves of *Alisma* were heavily mined by weevil larvae, only a few aerial leaves were mined. We asked bystanders if they knew where Da-Pao pond was or if they knew of another pond but they were only aware of the local fish ponds. We checked fish ponds along the road but found no submersed plants. We then went to the Harbin Fisheries Institute which was nearby. This was also a Balciunas 1991 site. The ponds had a lot of yellow flowered *Nymphoides* but no visible hydrilla. The furthermost pond with a pumphouse, called Niu Jiao Pond, had some *Trapa* and a little hydrilla as Balciunas had found. A grassland prairie to the SE(?) of the pond and lower in altitude had small scattered potholes with heavy hydrilla infestation. *Ceratophyllum* and *Potamogeton pusillus* or *cristatus* were also heavy with *Lemna-Spirodela* mix on top. We sampled 20 hydrilla stems from throughout 2 potholes and collected extra of it and *Potamogeton*. At Niu Jiao Pond we also collected 20 hydrilla stems. *Tanysphyrus major* adults found beneath leaf sheaths of *Monochoria*. We went to the Plant Protection Institute in the PM where we met Prof. Tie-bao Chen, Associate Professor, who was our host. We set up the microscope in his lab and briefly went through samples. I also took insect photos for Bob. Bob left some larvae in petri dishes for rearing.

July 10. We left for Qiqihar in AM by a rental "range rover" type vehicle. We were accompanied by Prof. Chen and Ms. Chio Ye Xu, the Director of the Qiqihar Protection Institute. About noon we arrived at the Wo-Li-Tun area where we stopped at Shi-er-li-pao marsh but not at the same site searched by Balciunas. Mr. Chen and I waded into mats of *M. spicatum*. *Phytobius* weevils were present and a teneral *Bagous* adult was found in a lower stem. Larvae were found in later examination. Plants were flowering. The site was at a small bridge where fishermen had set up nets along the road going from the Harbin road left towards a refinery or similar structure. We arrived at the hotel in Tai Kang at lunch time. After lunch Bob went with the group to look unsuccessfully for a *Trapa* site. I processed some of the material looking for additional *Bagous* larvae. At the hotel we met the local Plant Protection personnel.

July 11. We headed for Qiqihar via a slightly southwestern route going through the autonomous Mongolian Durbod County region. We passed a few waterways along the route but our hosts insisted there was no time to stop. Late AM we came to a small fishing lake in the middle of nowhere called Long Hu Pao. It was extensively covered with *Trapa* and *Potamogeton maackianus*?. A floating-emersed leaf *Polygonum amphibium* ? was scattered throughout the *Trapa* and in scattered patches. The *Polygonum* was heavily eaten by a galerucine chrysomelid which was not on nearby *Trapa* when the two were scattered in open water. The *Trapa* was heavily attacked on the mats where almost all floating *Polygonum* leaves had been destroyed. *Hydrellia* adults were collected from the *Trapa* and *Polygonum* leaves. Midges were recovered from sun-dried *P. maackianus*? Took field photos of the *Galerucella* for Bob. We had late lunch at Jiang

Wan Township, a frontier town which was founded in the 1950's or 1960's. We drove to Qiqihar after lunch arriving at dinnertime.

July 12. Departed for Harbin after getting gas. Stopped briefly at two sites in a marsh along the road at Long An Qiao about 30-45 minutes from Qiqihar. *Myriophyllum verticillatum* was present at the first site at a small bridge. A couple of *Phytobius* adults were collected on it along with *Galerucella*-like adults. Donaciine adults were found in the net after sweeping flower stalks of milfoil. Believe they were collected on underwater plants- *Nymphoides*, strap-leaf *Sagittaria*, *Potamogeton* - because I did not see them on the surface leaves. Later in the lab I found a heavy infestation of caddisfly cases on the *M. verticillatum* leaflets, but all had died rom the long period spent out of water. We arrived in Harbin at dinnertime.

July 13. With the driver of July 9 we returned to the Er Zhuang Chang factory area and remeasured the distance to the waterway of July 9. It was less than a 1/10 of a kilometer different from the 2 km mentioned by Balciunas. We decided it was Da Pao and continued along the Ha Shuang road stopping to ask directions to other waterways. We turned north at the town of Jian Guo Village and found a low prairie below the roadway with scattered fish ponds and potholes, at Milestone 3. *M. verticillatum*, hydrilla, *Utricularia, Hippuris, P. pusillus, Sagittaria, Monochoria, Trapa* were present. No *Phytobius* were collected on *M. verticillatum* but one *Eubrychius* adult was collected swimming in the water after the underwater stems were agitated. A *Bagous* was common on the flower stalks of yellow flowered *Utricularia* and Diptera puparia were exerted from stems of *Hippuris* at the juncture of green tissue and brown dried tissue. Weevil adults were present on *Monochoria* leaves especially floating leaves. Others were common on a large arrowhead-leafed *Sagittaria*. A couple of weevils (Phytobiines) were found on *Polygonum* along the shore of two fish ponds at the 90 degree curve in the road about milestone 2. *Trapa* was present in some ponds and hydrilla also. No weevil adults or larvae were recovered from hydrilla but many leaves had feeding holes similar to those of *Bagous hydrillae* or possibly *Hydrellia* damage after the damaged tissue has dropped away. No *Hydrellia* larvae were found however. In late PM returned to the Institute to pick up Pemberton's insects.

July 14. Mr. Han, Mr. Chen and I departed for Shenyang by train in AM while Bob went to the field before a PM air departure to Beijing. The train took all day arriving after 7 PM. We were met at the train station by a lady from the International Exchange Section of the Foreign Affair's Office, Shenyang Agricultural University, who took us to the hotel.

July 15. Prof. Guan and Mr. Khong from the International Exchange Section, Foreign Affair's Office, Shenyang Agricultural University, met us at the University's biocontrol of weeds office. We also met Mr. Yin Rui who works with Prof. Guan on the ragweed and aquatic weeds project. We discussed our collecting plans with them and observed their herbarium cabi-

nets and two large aquaria. They had collected hydrilla and milfoil shortly before our visit but had found nothing. They had 6 metal Berlese funnels. We then went south from the University to the first Hun He Qiao (bridge) where we collected in gravel pits along the river on the NE side of the bridge (the bridge near Dong Ling Lu). Hydrilla was scattered in patches with milfoil patches less common. *Potamogeton* was also scattered. Milfoil flowers were not present but a few *Phytobius* weevils came to the surface when the plants were disturbed underwater. Hydrilla was collected along with a little of the other plants. We then went to the second bridge where we collected at the SE corner—the location of Sept 12, 1990. The small pond where *Tanysphyrus major* had been collected in 1990 was dry but an old gravel pit still had a couple of feet of water. It was vegetated along shore and in the water- like a natural lake. Hydrilla formed patches as did *Potamogeton pusillus, P. crispus*; some milfoil present as was *Trapa, Monochoria, Sagittaria* (large arrowhead). Collected samples. After lunch we drove ca l km south of the bridges where we collected *Trapa pseudoincisa* (det Prof. Guan) in a drainage pond along the highway. The plants were heavily attacked by *Galerucella*. We then continued another km or less when we turned east to another gravel pit complex. This was called Wang Jia Pao. Hydrilla and milfoil were present but *Trapa pseudoincisa* was the dominant plant in patches along shore. Most water surface was open. Collected *Galerucella* on *Trapa* and midges in petioles. Drove back towards the second bridge on a small road past the gravel company. Checked a small stream, fast flowing, beside the gravel pit operation. *Trapa pseudoincisa* was attacked by *Galerucella*. Returned to the hotel for the evening.

July 16. Drove with Prof. Guan, Mr. Yin Rui, and Mr. Khong to the Plant Protection Station, Su Jiatun District, where I had visited in 1990. Our host was Mr. Chang Qing Dong, Senior Agronomist, Vice-Chief and an assistant Ms. Jie Chen, Agronomist Master from the Total Plant Hospital where they ID plant diseases. We visited the nearby park lake, Lin Hu, along with an entourage of other officials. Hydrilla was common in areas along shore with *Potamogeton cristatus* and *P. malaianus*. In AM we collected hydrilla on the side of the bridge with the smallest amount of water. No milfoil and only 1 *Trapa* were found. The *Trapa* had typical weevil feeding on the petioles—relatively large feeding scars—i.e., *Bagous*-like but no weevils were found. *Hydrellia* damage and a pupa were found in hydrilla which was shown to the entourage. After lunch we returned to Lin Hu and collected a sample of hydrilla from the opposite portion of the lake. We also collected *Trapa* there and in the smaller lotus pond across the small road. Milfoil was not flowering and there was little of it. *Galerucella* was present on *Trapa*. We then collected at a small farm drainage pond, , near the city. The pond had *Trapa* with *Galerucella* and a *Polygonum* on shore with a different galerucine. A small amount of hydrilla was present along the shore of the pond. We returned to Su Jiatun District office to drop off Mr. Dong and Ms. Chen and to pick up hydrilla we had left to sun dry during the PM. *Hydrellia* were found in the samples.

July 17. The day was overcast and later rain terminated the collecting. We collected from a drainage canal along the highway in the prison/ reformatory area. Convicts were observed working in crews in the fields. We were accompanied by another man who replaced Mr. Khong as the Intern. Affairs representative and by local plant protection people. At the first stop both hydrilla and *Trapa* were abundant. The hydrilla had regrowth with small leaves, almost African-hydrilla like. Lower leaves appeared to be normal size. Tips were very compact. Later *Hydrellia* were found in the leaves. Donaciine larvae were found on the roots and lower stems of almost all plants. They were white with greenish tinge, attached to the plants, and usually more than one on each plant. Plants were mostly collected in a few inches to a foot of water in sand-fine gravel soil. No adults could be found. I had not seen hydrilla that looked like this before. A short distance along the road, hydrilla in the same canal was lush and green and no larvae were found. At a third site along the road in the same canal the unusual hydrilla was present again along with the donaciine larvae.

July 18. Examined material at the hotel and prepared for trip home. Left for Beijing late in the PM.

July 19. Held discussions with Ren Wang and started examination of the plants collected in Shenyang and Harbin areas.

July 20. Continued examining plants from Shenyang-Harbin.

July 21. Discussions with Chris Bennett, who had arrived last night. Sampled August 1st Lake in the PM. Hydrilla more common at the surface than earlier, all plants had grown larger, more algae.

July 22. Examined plant material from Aug 1st Lake.

July 23. Sampled at Tsing Hua University, Qiao Zhuang, and Sleeping Buddha Park. The University canal had much lower water level but still lots of hydrilla. The biology pond had some hydrilla and milfoil but much less than last year. Qiao Zhuang had a lot of hydrilla and considerable amounts of *Potamogeton*. Water level had greatly declined at Sleeping Buddha.

July 24. Visited Prof. Chi Kun Wang at Beijing Agric University to pick up antlions for Lionel Stange. Examined plant material in PM.

July 25. Examined plant material in AM. Free afternoon.

July 26. Packed. Met with Ren Wang. Examined plant material.

July 27. Met with Chris and Mr. Chen about plans for work after I leave. Examined plant material. Departed Beijing in PM for Tokyo.

July 28. Train to Misawa in northern Japan (Honshu)

July 29. Took city bus to the swimming area at Lake Ogawara and then walked to the reservoir at Odauchi-Numa Lake—the lake appeared to be on property of the US military base. The lake was below a hill on which there was a monument to a local born author. *Galerucella* beetle damage heavy on *Brasenia*, few beetles, no *Trapa* found. *Lythrum* had galerucines and *Apion*-like weevils. Two adult phytobiines collected on *Myriophyllum verticillatum*. Neither hydrilla nor *M. spicatum* found although Prof. Y. Kadono, Kobe, said the latter should be here

July 30. Train from Misawa to Niigata. Took a local train from Niigata to Toyosaka City and then a taxi to Kushima-gata lake. The lake is a protected wildlife preserve mostly filled with cattails or reeds. Found hydrilla only in some demonstration ponds planted with the protected plant *Eurale*. Most hydrilla had been pulled out onto shore. Inside the piles it was still green. No insects on it. Flea beetles on *Ludwigia*. Walked back to train station.

Aug. l. Train from Niigata to Akatsuka stop, then walked to Akatsuka and Sa-gata lake. *Trapa* completely damaged by *Galerucella*. I found neither hydrilla nor milfoil which was supposed to be there.

Aug. 2. Train from Niigata to Kobe.

Aug 3 - 5. Surveyed near Kobe with Prof. Y. Kadono, a botanist at Kobe University and a hydrilla expert, and Bob Pemberton. Found both *Myriophyllum spicatum* and hydrilla, although milfoil was not common. Caddisflies found on leaves of *M. spicatum*. Cases conical like those from China. *Hydrellia* leafminers and tip midges found in hydrilla.

Aug 6. Visited Prof. Kadono's lab and prepared for trip home.

Aug 7. Flew to San Francisco.

Appendix D
Survey 1 - Beijing - Chris A. Bennett - July-August 1992

20-VII. Arrived in Beijing 20:00 after spending the night in San Francisco due to cancellation of the flight to Japan. Wang Ren and Gary Buckingham met me at the airport and took me to the Friendship hotel.

21-VII. Met Gary at 8:00 AM, and we went to SABCL. After meeting the people and touring the laboratory, we processed plants from various locations around Beijing. In the P.M., we went to August 1st Lake and collected several species of plants.

22-VII. Checked *M. spicatum, Potamogeton crispus*, and two species of *Potamogeton* for *Hydrellia.*

23-VII. Continued working on samples from August 1st Lake until 9:00 AM and then went to the field. First went to Tsing (Hsing) Hua University to a drainage canal. The canal had very low water and was extremely muddy. *Hydrilla, Potamogeton natans, Potamogeton crispus* and *Hydrocharis* sp. were present here. We collected adults of *Hydrellia pakistanae and Hydrellia* n.sp. on floating leaves of *Potamogeton natans* and *Hydrocharis* with vials. Day was cloudy, so flies were not so numerous. Total collection was 17 females and 9 males. We sampled *Hydrilla* and *P. crispus* by collecting 20 stems of each. General collections of both plants were also made. We then went to a small pond behind the biology building on campus and collected *Myriophyllum spicatum*. We then went outside Beijing past the Summer Palace to Sleeping Buddha Park to a small ornamental pond filled with hydrilla, *Potamogeton pusillus,* and *Hydrocharis*. We couldn't wade, just collected from the sides with a rake on a rope. After lunch, we drove to Qiao Zhuang pond and collected a sample of twenty hydrilla stems plus general collection of hydrilla and *Potamogeton cristatus*. Zhiqun Chen also collected a sample of large leaf *Potamogeton* in the stream that fed the pond. We returned to SABCL and finished processing plants from August 1st Lake. *Hydrellia* adults were set up on hydrilla in a large bell jar for oviposition. Later went shopping at local department stores for plastic pans.

24-VII. Continued to process samples. In samples collected at Tsing Hua University, *Hydrellia* larvae were dissected from *P.natans* and *P. crispus* but not hydrilla.

25-VII. Continued to work on samples collected on Thursday. *Hydrellia* pupae were dissected from P. *pusillus* collected at Sleeping Buddha park. Pupae were also found on *Hydrilla* and *Potamogeton cristatus* collected at Qiao Zhuang pond. Set up samples in pans for sun drying. P.M. was free.

26-VII. Free day.

27-VII. Spent morning with Jiang Hua, Zhiqun, Weizhen (Jane) Liu and Gary discussing field work schedule for next two weeks. We will go to August 1st Lake every Monday, and the other sites on Thursday. I stayed at the lab and checked the insects, while everyone else took Gary to the airport. Flies collected at the canal at Tsing Hua University were still alive, but the plant material was smelly. Borrowed ten small jars and transferred material into five of them. Checked *Bagous*, feeding present on *M.spicatum*, but no eggs.

28-VII. No sun all day and cooler temperatures, so we put samples that we had started to sun dry in Berlese funnels to finish drying. Some flies emerging from other plants mostly, *H. bilobifera*-like but one possible *H*. sp. "silverface" from *P. crispus*. Changed all *Phytobius* containers. Finished processing Sleeping Buddha samples in PM. Met Mr. Fang, talked to him about taking trip to Harbin, but I am not cleared by the Ministry of Agriculture, so Mr. Chen will try to go to Harbin to collect more milfoil insects before I leave.

29-VII. In AM checked and fed insects. Checked a 100 gram subsample of the large leaf *Potamogeton* from Qiao Zhuang and dried the rest in the Berlese funnel. At 2:00 took taxi to Chinese National Museum with Zhiqun and Jane and saw Chinese insect exhibit which was mostly butterflies.

30-VII. Went to Sleeping Buddha Park and collected hydrilla and *Potamogeton pusillus*. Then to Qiao Zhuang to sample and collect. Zhiqun collected 20 stems of hydrilla while I collected stems of *P. pusillus* and *Najas major* which was mixed in with the hydrilla. Also made general collections of hydrilla, for sun drying to obtain fly larvae for colonies. Then went to San Jia Dian which is a large river but shallow along the banks. We sampled hydrilla, *Potamogeton crispus*, large leaf *Potamogeton, Myriophyllum spicatum, Hydrocharis sp.*, and *Ceratophyllum*. Zhiqun collected flies from floating leaves of *Hydrocharis*. Most flies were neither *H.* "silverface" nor *H. pakistanae*. Returned to lab and set up Qiao Zhuang material in pans outside to dry since hot and sunny. Separated flies. Met Dr. Ping Ping Chen.

31-VII. In AM started processing 100 gram sample from Qiao Zhuang and found a few larvae and pupae. Also started looking at hydrilla tips from San Jia Dian for midges. I looked at 25 or so and found no midges but many damaged tips. In PM continued processing Qiao Zhuang hydrilla samples which were saved to feed fly colonies at a later date.

1-VIII. Spent all day in the lab checking insects and processing samples from Qiao Zhuang and San Jia Dian.

2-VIII. Changed and fed milfoil weevils. Found a *Bagous* larva in one stem. Separated *P. pusillus* from hydrilla collected at Sleeping Buddha for the funnels. Checked *P. malaianus* from San Jia Dian.

3-VIII. Overcast, rain started 11:00 AM and continued most of the day. Checked insects first thing. A few flies that were out Sunday PM—disappeared. Ants got in 1 small cup and ate the pupae and flies. About 10:30, a car and driver were available and we went to August 1st Lake. We collected samples of hydrilla*, Myriophyllum, Potamogeton crispus, Potamogeton malaianus, Potamogeton maackianus, and Najas marina.* We also found a few stems of *P. perfoliatus* Only found 6 or 7 stems of *P.crispus.* Collecting was difficult because water was high, stirred up and plants broken off because of all the rain. Returned to lab about 12:15 and started working on the samples. We finished *Potamogeton malaianus, P. maackianus, and Najas marina.* Checked Gary's donaciines, which were dead. I also found 5 female *H.* "silverface" emerged from hydrilla from Qiao Zhuang. Placed these with other females, but still no males.

4-VIII. Checked insects first, but not much emergence. Started working on August 1st Lake samples again. We checked *Hydrilla verticillata* first. Zhiqun found 8 pupae on one stem, and I found 2, population seems to be picking up. Also checked *P. crispus* and the few strands of *P.perfoliatus* we found floating. Also checked *P. pusillus* collected at Sleeping Buddha on July 30th, and only found three empty puparia. I put the rest of the sample in the funnels as starting to rot. Wang Ren came in and we discussed Zhiqun trying to go to Harbin before I leave. He will also try to borrow a box to put herbarium samples in with some camphor to protect plants from ants. After lunch checked 20 tips of hydrilla collected at August 1st Lake for midges. Many *Hydrellia* adults emerged from Qiao Zhuang mostly females, but a few males. I think most of the males are *H. pakistanae.* All placed together anyway. Wang Yuan, formerly with our SABCL project, came in and we talked awhile.

5-VIII. Checked 3 midges from Qiao Zhuang in tennis ball container with mesh. Started checking 100 gram subsample of hydrilla from San Jia Dian. After lunch checked *Bagous* on *Myriophyllum* and changed the plant material. No larvae or eggs but didn't dissect every stem. Adults have not fed on flowers. They were mating when I opened the box. Went to White Peacock store and Lufthansa Shopping Center. Returned to the

lab and took care of the flies; more flies were out, still very few males and think females are *H.* "silverface" —males *H. pakistanae*.

6-VIII. We first went to Qiao Zhuang and collected samples of hydrilla and *Potamogeton* plus samples of hydrilla tips for midges. Then collected bags of hydrilla material to take back for drying in funnel to collect fly larvae. Then went to San Jia Dian to collect *P. crispus, P. malaianus, Myriophyllum spicatum, Najas marina,* and *Hydrocharis.* Zhiqun collected flies from the floating leaves of *Hydrocharis*. Not as many flies as last week, and most were not our flies. Put bags of material into funnels for drying.

7-VIII. Free day.

8-VIII. Started checking samples from Qiao Zhuang and San Jia Dian. Worked all day on samples and finished all of them.

9-VIII. Checked *Bagous* and found two eggs and 11 larvae plus one new *Bagous* adult. Wrapped milfoil stems with larvae in newspaper and placed in plastic bag. Checked funnels, got a lot of *Hydrellia* larvae out of Qiao Zhuang hydrilla. Checked jars on window sill, pupae in *P. crispus* from Tsing Hua University placed in cup. Checked cups. Then checked Qiao Zhuang hydrilla tips for midges. Found two. Checked flies.

10-VIII. Went to August 1st Lake. We collected hydrilla, *Myriophyllum,* three species of *Potamogeton, Najas minor* and *Vallisneria*. *P. crispus* is scarce right now. Water is low again, lots of plants floating.

11-VIII. Finished samples. Checked midge samples and found damage but no insects. Started going through samples, vials and cups preparing things to go home.

12-VIII. Prepared insects for trip home. Wrote detailed instructions for Zhiqun and talked to him for a couple of hours about work to do after I'm gone. He will go to Harbin on Monday and collect hydrilla and look for weevils. Filled up vials with alcohol and cleaned up lab.

13-VIII. Returned home.

Appendix E
Survey 10 - Heilongjiang and Liaoning Provinces - Chris A. Bennett - July-August 1993

22-VII. Arrived Beijing at 22:00. Zhiqun Chen met the plane and took me to the Friendship Hotel.

23-VII. Talked with Zhiqun in AM about details of my visit. We will have to work in quarantine, since they are repairing the heat in the laboratory. After lunch, we decided to go to San Jia Dian. Stopped at new site Han Jia Chun where Zhiqun had collected *Hydrellia* the day before. At San Jia Dian, we collected flies from duckweed and floating leaves of *Hydrocharis dubia* with the hand vacuums. Flies were present but not in large numbers, but weather was overcast, cool and windy. *Myriophyllum spicatum,* hydrilla, and *Potamogeton* sp. were also present. Zhiqun collected a bag of hydrilla for checking for midge damage. Started home and fan belt broke. The driver bought a new one from a local auto store and fixed the car in about 10 minutes.

24-VII. Checked flies collected yesterday. Males are green eyed and gold faced, females have silver faces. We collected 7-10 female *H. pakistanae* and 3 *Hydrellia* sp. Placed females and males in a jar with hydrilla for oviposition. After lunch, Zhiqun and I planted 3 jars of hydrilla tips in the greenhouse. Packed suitcase and cooler for trip to Shenyang and Harbin. Spent rest of day checking hydrilla from San Jia Dian for midges and midge damage. No midges but numerous *Hydrellia* larvae. Will try and sample on return from Harbin and Shenyang.

25-VII. Free day.

26-VII. Zhiqun picked me up at the Friendship Hotel about 7:40 to go to airport to catch plane to Harbin. Met at the airport by Mr. Ting-Ju Fu, Office Director of the Plant Protection Institute of Heilongjiang, Academy of Agricultural Sciences. They took us to the Swan Hotel. After checking

in, we went to lunch and then to a department store to buy a small lamp for use with the microscope.

27-VII Mr. Fu introduced us to Mr. Yang, Director of the Weed Division of the Plant Protection Institute who went with us to the field along with Mr. Fu. We went to the area near the fish ponds and the brick factory where Gary collected damaged hydrilla last year. There were many ponds along the way but none had any plants in them. We passed one large pond on the left that had *Nymphaea*? in bloom. But we didn't stop. We finally reached a pond— Chang Lin Lake or Lin Gai Guest House (Mr. Yang's description). The pond had no visible hydrilla. There was *Hydrocharis dubia, Polygonum* and *Utricularia* in bloom. *Typha* was also present around the pond. A second smaller pond which Zhiqun said was covered with hydrilla last year in August had no visible surface hydrilla, just the above mentioned plants. Zhiqun was able to find a small bag of hydrilla. The plants were very thin stemmed, but had no insect damage. We walked over to look at a marsh-like area surrounded by *Typha*. There were no plants except for *Utricularia.* This area may have just recently flooded as a lot of the plants in the water were terrestrial. Mr. Yang said the summer had been cooler and wetter than normal. Returned to Harbin for lunch. Mr. Yang will go with us to Shi-er-li-pao along with the Institute driver and car. We returned to the hotel and processed plants in the room the rest of the PM. Found elongate white eggs inserted into the stems of the hydrilla. Found one *Galerucella* adult and one *Donacia* on *Trapa*.

28-VII. Mr. Yang and the driver met us at Swan Hotel about 8:30. After dropping Mr. Fu at the train station we headed for Wo-Li-Tun arriving about 12:00. We briefly stopped at the area where Zhiqun and Gary collected the *Bagous* on milfoil. Zhiqun said there is considerably less milfoil and *Typha* has moved in. There was one patch of *M. spicatum* in flower across the marsh. We hope to return this PM and hire the boat to reach the plants. As we drove along the road I noticed more areas that look like *M. spicatum* in flower. We were not able to find rooms in Wo-Li-Tun so we went to Daqing to stay. Checked into Daqing Hotel and ate lunch. It was raining after lunch, so we canceled our plans for collecting. Rest of PM free.

29-VII. Returned to Shi-er-li-pao marsh where Gary and Zhiqun had previously collected. Water too deep to get to milfoil areas with waders, but fisherman who lived there took us out to the areas where we wanted to go. We first checked a small 5x5' patch of *M. spicatum* in bloom and *Utricularia* sp. Some of the milfoil here had larger bracts and probably is *M.verticillatum*. The stems of milfoil were water logged and very small. We collected adults of *Phytobius sp.* and found more damage on these stems. We collected *Phytobius* adults on both *M. verticillatum* and *M. spicatum*. Pond surrounded by *Typha* which is thick in areas where milfoil was last year. The fisherman took us through *Typha* to another patch of milfoil in flower. Zhiqun found two black and elongate weevils in a stem here. The plants here were also water logged with small stems. Water was too deep

to get to roots. We took the fisherman back and Zhiqun poled the boat back to first area. We checked stems by holding them up to the light looking for transparent areas. We found no insects here even though we found some holes in several stems especially toward roots. We poled out to the area on the other side of *Typha*. We looked through the stems and found two *Bagous* pupae. We decided to collect plants and then move to another site. We stopped at 3 patches of *M. spicatum* about 50 feet away through the *Typha*. These plants had large robust stems that were not water logged. In these stems we found *Bagous* pupae and larvae. We collected until 12:00. We returned to the hotel. After lunch we returned to the room and processed plants until 5:30. After dinner, we continued working until 9:30. Results of general collecting of *M. spicatum* for *Bagous:* 12 stems collected at the shore line had 2 adults, 2 larvae and 1 pupa. 95 stems collected in 2-3 feet of water, had 1 adult, 5 larvae and 5 pupae. 48 stems collected in 5-7 feet of water, had 1 larva, 1 pupa. Results of a sample of 25 flower stalks for *Phytobius*: 17/25 stalks damaged, 9 cocoons, 2 adults, no *Phytobius* larvae, but 2 *Bagous* larvae.

30-VII. Checked out of hotel and headed for Shi-er-li-pao. Low on gas but two stations in town had no gas or the wrong gas. Went past bridge to another site 1 km down the road, where *M. spicatum* covered a larger area and expanded into canal. It was shallow enough that we could wade. Milfoil covered the whole area. Again mixed populations of *M. spicatum* and *M. verticillatum*. *Typha* was present in shallower water along with an unidentified grass. *Utricularia* sp. was also present and in flower. We started from shore counting the number of stems and insects we found to get an idea of population. We found that the greatest number of insects were found on plants that were about waist deep. Usually *Bagous* pupae or larvae were found on the lower portion of the plant on the whitish part of the stem. We also found some *Bagous* pupae on the stem at the flower stalk. *Phytobius* was also present but not as abundant as at the other site. A sample of 20 stalks and stems was taken and processed later. 9/20 stalks were damaged, 0 adults, 2 larvae and 1 cocoon were found. While pulling up plants, we found donaciine larvae on the roots. A single crown had as many as 10-12 larvae. Donaciine larvae do not seem to damage the roots but do feed on the stems and crowns. Pieces eaten out of stem. Plants do not show any signs of stress from larvae. The larvae ranged in size from small to large. We finally found a cocoon, brownish red on the roots. We collected plants for processing later. It was getting late and the driver was anxious to find gas. We had to go to two different towns before we found gas. We arrived back at Harbin about 4:00 p.m.

Second Shi-er-li-pao site ***Bagous sp.***									
Zhiqun	**# Stems**	**# Adults**	**# Larva**	**# Pupa**	**Chris**	**# Stem**	**# Adults**	**# Larvae**	**# Pupa**
Shore	4	2	1	1	Shore	9	0	1	0
2-3 ft	45	1	2	1	2-3 ft	50	0	0	2
5 ft	23	0	1	0	5 ft	25	0	0	1

31-VII. We headed for the Harbin Fisheries Institute in AM. We walked down to the small ponds that Zhiqun and Gary had collected at in 1992. The area was completely dry. We looked through this area for water, but everything was dry and had been for awhile. Found a small pond with water but no aquatic plants. We then returned to Nu Jiao Pond which had a fair amount of *Hydrilla, Ceratophyllum, Potamogeton crispus, P. pusillus* or *cristatus. Trapa and Euryale ferox* were also present. We collected hydrilla, *P. crispus* and *P. pusillus?*. Zhiqun collected *Donacia* adults on the *Euryale ferox* (spines). Adults were bluish in color. The pond was muddy and very hard to work in. Roots were checked. *Alisma orientale* was present but no insects were found. We collected weevils on *Monochoria* under the leaf sheath. Returned to Harbin, ate lunch and returned to the hotel. Started processing milfoil collected at Shi-er-li-pao second site. First bag contained 70 stems from which we found 4 *Bagous* larvae and 4 pupae. Second bag was stems collected closer to shore and may have been too short as we only found two larvae (in a stem close to a flower stalk) in 113 stems.

1-VIII. Started working on hydrilla collected at Nu Jiao Pond. Decided to try and find some screens to dry hydrilla with lights. Took a taxi to department store and bought a screen and another light bulb. After lunch, we spent the afternoon processing the rest of the plants collected at Nu Jiao Pond. We only found a few elongate white eggs and several midge larvae on the hydrilla. A few leaves of *P. crispus* had holes in them, but no insects, maybe snails.

2-VIII. Finished processing *P. crispus* from Fisheries Institute pond, also checked some hydrilla from the Fisheries pond. Neither had damage or insects. Checked *P. pectinatus* from Shi-er-li-pao with microscope. After lunch, we packed the luggage, and spent the rest of the afternoon downtown. After dinner, we found 11 *Hydrellia* sp. pupae in hydrilla collected at the Fisheries pond. We had earlier dried two pans of hydrilla collected at the same site with the light in the room and found nothing.

3-VIII. Flew to Shenyang and met at airport by Associate Professor Liu Changjiang who took us to the Rose Hotel. After lunch, spent the afternoon in the room checking the insects. *Bagous* adults emerging. Checked *P. pusillus or cristatus* from Fisheries Institute and found 2 *Hydrellia* larvae and eggs.

4-VIII. Professor Guan Guang-qing and Mr. Yin Rui from Shenyang Agricultural University, Botany, arrived in AM. We discussed our plans for collecting in Shenyang and then left for Younth Lake, Su Jiatun District. The lake had hydrilla and *Potamogeton malaianus* around the bank and expanding 5-10' out. The lake is terribly dirty with floating garbage and an algae bloom was starting. We collected two samples of 20 stems of hydrilla. We returned to the hotel to pick up the rubber boat. We ate lunch and went to the Hun He Qiao (Bridge) area where Zhiqun had earlier found a donaciine pupa on milfoil. Shenyang had 10 days of heavy rains and the river was flooded. The milfoil was gone and we were unable to sample because the river was swollen and flowing extremely fast. We returned to the hotel and spent the rest of the PM processing plants.

5-VIII. Professor Guan and Mr. Yin Rui picked us up at hotel and we headed to Ma Shan Jia. We then went to the site which is a drainage canal along the road. Hydrilla, *Typha, Trapa, Ceratophyllum, Hydrocharis dubia* were present. The water was about waist deep. The hydrilla was green and had very small stems but did not look like hydrilla found here in 1992. We checked along the canal pulling up hydrilla and looking for donaciine larvae. A bag of tips was collected for checking for midges later. *Hydrellia* sp. adults were flying and landing on the floating leaves of *Hydrocharis dubia*. Zhiqun swept the plants along the ditch but collected only two moths, and one lady beetle. One *Donacia* adult landed on Zhiqun's back but he moved and the beetle flew before I could catch it. We finally found 3 small greenish donaciine larvae on the lower portion of a small stem of hydrilla and one on the root in hydrilla that was in about a foot of water. Since it was getting late and our host had prepared lunch for us, we collected 5 bags of hydrilla stems and roots for checking at Beijing. After lunch, we returned to Shenyang. Professor Guan dropped us and Mr. Yin off at the hotel. We put up the plants and then went to North Temple. Packed that evening for the return trip to Beijing.

6-VIII. Arrived Beijing airport in AM. No SABCL driver available so we took a taxi to the Friendship Hotel. After lunch, returned to the lab and took care of the insects and started processing the Shenyang hydrilla. Talked to Gary by phone. I am to bring back *Phytobius, Bagous* and the donaciine pupa. We placed the 3 donaciine larvae from Ma Shan Jia on the hydrilla in one of the jars in the greenhouse. Zhiqun is to return to Harbin probably the end of August or 1st of September. Richard McDonald arrived from N. C.

7-VIII. Spent day processing plants from Ma Shan Jia. No insects found in 3 bags of hydrilla.

8-VIII. Checked insects. Found 9 new *Bagous* adults from Shi-er-li-pao milfoil. No midges or damage found on hydrilla stems collected at Ma Shan Jia. Stems just red. Checked samples taken at lake in Shenyang. First sample had many stems with *Hydrellia* damage. Found 5 fly pupae

and 2 midge larvae. Second sample found 4 pupae and 8 larvae of the fly, 1 midge larva and 1 damaged tip.

9-VIII. We first went to the drainage canal at Tsing Hua University. Hydrilla was present but covered with algae and mud. *Hydrocharis dubia* was also present. We didn't try to get down to the canal since hydrilla did not look good and the creek was too muddy. We then went to August 1st Lake. Milfoil, *Potamogeton malaianus* and *P. maackianus* were the dominant plants. *Najas, Vallisneria* and hydrilla were also present but not as abundant as others. We collected milfoil, very thin stems and no flowers, hydrilla and the two *Potamogeton*. We then collected flies landing on the styrofoam floats and on white plastic bags. Collected 2 *Hydrellia* "silverface" females and other *Hydrellia sp*. Returned to the lab and Zhiqun and I went to lunch with Mr Fan, Richard McDonald, and Mr. Chen. Weizhen's sister visited us after lunch. Zhiqun and I started checking the hydrilla from August 1st Lake. We found many midge larvae, 1 pupa and 1 adult. We decided to put some stems with larvae in tunnels in a jar to see if we could get some midge adults. No *Hydrellia* found but some damage. Hydrilla coverage was less than last year, maybe the midge.

10-VIII. Left lab in AM for Han Jia Chun, a new site that Willey Durden and Zhiqun found in June (Survey 9) when Qiao Zhuang was dry. The site is a drainage canal full of hydrilla, *Ceratophyllum* and a little bit of *Potamogeton crispus*. We collected two bags of hydrilla. The plants are very lush, soft and bright green. They are very clean but fragment easily. We then went to San Jia Dian and started collecting flies from floating leaves of *Hydrocharis dubia*. There were not many flies, but parasites were very abundant, about 3-4 parasites/fly. We collected for about 45 minutes and then returned to the lab. In PM, Zhiqun checked *Potamogeton* from August 1st Lake. He found 1 *Hydrellia* sp. pupa on *P. malaianus*, along with midge larvae in tunnels in the stem in *P. malaianus* which he will try to rear. I checked flies in quarantine. I found only 11 *H. pakistanae* females and some of these had sunken abdomens. Also collected *H.* "silverface" and other *Hydrellia* species. Also collected some flies probably not *Hydrellia*.

11-VIII. We checked hydrilla from Han Jia Chun in the AM. We found 2 *Hydrellia* larvae and 1 midge larva in association with a damaged tip. We found 4 tips damaged probably by midges. Tunnels through the tip or the tip missing. Returned to find Jack DeLoach and Dr. Lu had returned from their saltcedar survey. They had found over 1000 chrysomelid beetles. Pulled *H. pakistanae* adults emerging from the hydrilla material we set up before we went to Harbin.

12-VIII. Mr. Fan will get permits to export insects today. We checked and packed insects for trip home. Cleaned up quarantine.

13-VIII. Departed for home.

Appendix F
Survey 13 - Heilongjiang Province - Gary R. Buckingham - August 1994

Aug 6. Arrived in Beijing in evening. Zhiqun Chen and Dr. Lu Qing-Guang met the plane and took me to the Friendship Hotel. Briefly discussed our plans.

Aug 7. Met Zhiqun and Dr. Lu at SABCL in PM. Zhiqun separated out 20 female l0 male *Neochetina bruchi* from the shipment that I carried from Ted Center via Gainesville and placed them on 5 waterhyacinth plants in two cages in the quarantine. I took photos. The remainder of the weevils were left in a cooler. Dr. Lu was supposed to feed the remainder some leaves on the 8th. They had very few waterhyacinth plants, ca 20. Zhiqun and I packed for the trip and printed out the file of instructions for melaleuca work by James Okine that I had typed on the plane. FAX'd it to him.

Aug 8. Flight to Harbin in AM. Met at the airport by Mr. Ting-Ju Fu and Mr. Ya Zhou Wang, Plant Protection Institute, who had met us in 1992. We ate and went to the hotel. Discussed our trip plans. I prepared a FAX for Geri Barber about the SCA amendment and sent it in the evening.

Aug 9. Met the new director and the vice director at the Plant Protection Institute in AM. After the formalities, Zhiqun, Mr. Wang, and I went to the 1992 site, 2.9 km N of Jian Guo Village, at km. marker 3, on a road off Ha Shuang Road west of Er Zhuang Chang brick factory. A garbage dump has begun to fill in the wetlands, but we were still able to collect in the drainage canal, 5-6' wide, north of the road. I had collected in it in 1992. We were unable to find *Myriophyllum verticillatum* in the canal. I was looking for *Eubrychius* which I collected (1 specimen) in 1992. Hydrilla was abundant in the canal but no donaciine larvae were found on the roots. We pulled numerous plants and used a shovel in a few spots. A broad leafed *Potamogeton* was at one spot but found nothing; *P. pusillus*? was in one spot—took a sample. *Alisma orientale* was all along the canal

and was attacked by the *Bagous* (?) larvae, even the emersed leaves-serpentine mines, adults were found on the leaves, one larva in the petiole. A small arrowhead *Sagittaria* had similar adults and scattered larval mines. Adults were collected on the leaves—feeding usually heaviest on the leaf tip—dried, curled. Appeared to be a different weevil than that on *Alisma*, but the feeding and damage distribution looked like spillover from *Alisma*. *Monochoria* was heavily attacked by *Tanysphyrus major*—petals also eaten, mating pairs. There were two flowers of a pretty, white water lily—very small, 1-2". Greenish Collembola were inside an open flower that had the petal tips eaten. Damage might not have been by them—might have been Lep damage in the bud which would explain why so many petals were eaten. *Polygonum* was heavily eaten by *Galerucella*—mostly adults, but larvae also seen. Small yellowish species. A few *Nymphula*-like Lep larvae were found in plastic bags with *Lemna* and hydrilla. Did not notice moths on the water. One km to the W at kmstone 2, there was a drainage pond to the north of the road that had *Myriophyllum verticillatum* in an open area among cattails. The larger open area was too deep to wade. The *M. verticillatum* was regrowing from shoots lying on the surface. Most shoots were only 3-5 cm tall. The water was up to midchest and completely covered with a submersed plant surface layer—milfoil and *Ceratophyllum*. At arms length beneath the surface, the water was at most 11 degrees C. The mercury warmed quickly as I pulled the thermometer out. Air was warm, at least in 80's F, maybe in 90's. *Phytobius* adults were on the shoots. One collected on every 3 or 4 shoots. A few yellow larvae were feeding in the apical buds. Adult feeding was present—leaflets eaten; blackened areas—hardened latex?—where adults had fed. Swept underwater for *Eubrychius* but found none. Plants were covered with algae and underwater leaflets old—would not have been good for *Eubrychius*. It appeared that the shoots might have been damaged earlier with regrowth from the damaged areas. A large arrowhead *Sagittaria* prob. *sagittifolia* had weevil larvae in the heads and pupae in the flower shoots. Flowers and stems were placed separately in plastic bags for emergence. A small *Nymphaea* was completely riddled with weevil feeding holes. Collected some adults on the leaves and held a sample of crowns and petioles in a plastic bag for emergence. *Spirodela* had weevil feeding holes. Collected a bag full. Returned to the hotel and processed the samples in the afternoon.

Aug 10. Drove to Qiqihar past Shi-er-li-pao. Windy, could see some milfoil but not much. Waves probably covering it. At km marker 802 on Daqing-Qiqihar road, there was milfoil heavy on both sides of road. Wetlands below a reservoir. Did not stop. Rainy and windy. The Plant Protection Institute did not know we were coming. We stayed at the Crane Hotel which was remodeling except our floor which was not very comfortable.

Aug 11. Drove to Long An Qiao via the road to Daqing and then backtracking. *Myriophyllum verticillatum* was common on both sides of the road but especially to the north. Much of the area was too deep to wade but we were able to at several spots. The area is a large wetland with a

slow north to south flow through bridges. *Phragmites*, cattail, and various grasses are the dominant plants. Other plants are found in numerous open areas. Along each side of the road is a deeper area, probably a canal, with shallow water further out. Horses and cows wading further out did not have water above their stomachs. We found *M. spicatum* at only two sites north of the road and mixed with *M. verticillatum*. There were essentially no bracts on the *M. spicatum* flowers. The *M. spicatum* had almost no damage on the flower stalks. A sample from the large bridge of 9 buds had no damage but 1 *Eubrychius*? adult and 1 *Phytobius* adult were found in the bag they were held in —this is suspect, the adults might have been contamination from an earlier *M. verticillatum* sample. A sample of *M. spicatum* from the north side of the road west of a small bridge had 11 stalks in flower-0 damage, 10 with seeds-1 damaged, and 4 with buds-9 damaged. A second sample of flower stalks at the same site had 8 flowering-0, 31 with buds-2 damaged (1 with *Phytobius*? larva); 5 roots collected-0. A sample of *M. verticillatum* had 24 stalks with buds-8 with minor feeding (1 cocoon on flower stalk), 1 with Lep cocoon. Another sample had 6 apical buds (underwater)-0 damage, 5 roots-0 damage. A large leafed *Potamogeton* was common, one sample of 20 flower stalks from the small bridge had 0 damage. At the site with *M. spicatum*, north side of road and west of bridge, we collected 20 *Potamogeton* plants-1 flower stalk had damage that might have been disease rather than insect feeding; the stalk was excavated but black epidermis was still present over some of the blackened tissue; 2 leaves had fly larvae (*Hydrellia*?). The site at the small bridge had changed dramatically since 1992. A large volume of water was now flowing through so that there was a large open, plant free area in front of it. Plants were only found to the side along the banks on the East & West. We found a few plants of *M. verticillatum* mixed among the grass, no *Potamogeton*. I swept underwater with the net looking for *Macroplea* adults but found none. This site was rich in plant species in 1992 with the main channel only a few feet wide. This year the yellow flowering *Nymphoides peltata* was common all along the road. The leaves were heavily eaten by *Donacia* or weevils. We found hydrilla just to the northwest of the main bridge; it also appeared to be in the main channel on the north side. Large, dense mat at the surface; we collected a small sample—1 bag from near shore. Male, female flowers, but it is apparently dioecious. Dense female flowers noticeable from shore. No damage found in the sample. One weevil found in the bag, but looks like *Tanysphyrus major*. Also one Lep cocoon on hydrilla. *Phytobius* cocoons were found on *M. verticillatum* as well as a galerucine larva—black and an adult—tan. The galerucine might be from *Polygonum* although the larva fed and grew on *M. verticillatum* in a vial. *Caldesia renformis* was found at one site—Lep larvae collected from the leaves. Spent from about 10:30-11 AM until 3 PM walking along the road and collecting here.

Aug 12. Drove to Daqing stopping near a reservoir at Qi Lin Dao Chun. First stop was near km marker (stone) 810. A small patch of *M. spicatum* was in the canal on S side of road but the water was too deep to reach it. Donaciinae adults were common on cattails- feeding, mating, but we

found no larvae on the 5-6 plant roots we pulled. The reservoir was at about the 806 to 802 km markers. *M. spicatum* appeared to be abundant in the canals along the road but it was too deep to get to it. Just to the west of the bridge at the reservoir spillway on the south side of highway, we were able to wade in a shallow area (along a dirt road going from the highway into the marsh) that had *M. spicatum* mixed with *M. verticillatum*. *M. spicatum* was less abundant. The shallow canal was almost covered with milfoil stems. A few *Phytobius* adults and larvae were collected on *M. verticillatum*. Damage was observed on *M. verticillatum* flowers but not on *M. spicatum* flowers. The small white flowered *Nymphaea* was heavily eaten by *Donacia* adults, a few of which we collected. Two crowns were pulled and a donaciine larva was found on one. The crowns were taken. Donaciine larvae were found on the roots of *M. spicatum* and *M. verticillatum* but more commonly on *M. spicatum*. Three donaciine cocoons were found on several roots of *M. spicatum*. Samples taken. In the reservoir behind a restaurant at the spillway was a fringe of hydrilla. Also a lot of hydrilla had apparently floated in—not rooted. Some milfoil was mixed with it. Some leaves looked to be mined by flies. Adult flies were collected from a plastic bag and from *Nymphoides* leaf. Lep larvae and/or cocoons were found on both hydrilla and milfoil. A bag of hydrilla was collected. At least one donaciine larva was found on a lower stem near the crown.

Aug 13. Shi-er-li-pao, the 1992 site on the road along the eastern margin had filled in with cattails and the water flowing under the small bridge was both higher and stronger. No milfoil seen. About 1/2 - 1 km to the south, about half way between the small and large bridges, *Myriophyllum verticillatum* fringed the cattails. Too deep to wade so we used inner tubes. We attached a 2" wide strap, used to keep my luggage closed, across a tube and then straddled and sat on the strap. Uncomfortable but effective. Some *M. verticillatum* had very small bracts and we initially thought it was *M. spicatum*, but the bracts were pectinate. Apparently only *M. verticillatum* was present. Collected a few *Phytobius* adults and cocoons. Donaciine larvae were found on the roots. *Bagous* larvae, pupae, and adults were present in the stems, most of which were no longer rooted and were floating. Many appeared waterlogged and the *Bagous* might be dead. Collected a bag of stems and examined them outside near the car wash at the Daqing Hotel. One *Eubrychius* was found. I examined 91 stems; 11 with *Bagous* immatures, 5 with *Phytobius* cocoons. 3 pupae, 3 larvae of *Bagous* were in extra uncounted stems. Zhiqun examined 80 plants and had 14 *Bagous* immatures, but his counts were not exact because he included the extra stem results in his *Bagous* count but not in his stem count. His 14 *Bagous* thus came from 80 stems plus extra stems.

Aug 14. Drove to the road along SW side of Shi-er-li-pao. At a bridge to west of the intersection of the two roads along the marsh, at edge of Wo-Li-Tun city, we rented (20 yuan/hr) a wooden pole boat. The owner would not pole for us. Poled out, with extreme difficulty in the swift current, to a cattail island and collected from *Myriophyllum verticillatum* that

had floated and collected along the north side of the island. Strong wind but sunny. Zhiqun waded in the water and collected 20 *M. verticillatum* roots. 13 had donaciine larvae attached and 2 empty cocoons. We found other cocoons on roots floating in the flotsam. One had a mature pupa/adult inside and it looked like *Macroplea*. Water depth was about waist deep. *Eubrychius*, or like, was crawling out of the water and resting on stems, lvs., etc. It was gray-brown and smaller than *Phytobius*. About 9 *Bagous* were also found out of the water. This activity occurred around 12-1 PM with full sunlight. Fewer adults were seen about 130 PM when shadows had covered the small area I was searching, but by then I had collected many weevils and thus might have reduced the population. I tried to watch what they did after climbing from the water, but I gave up watching them just sit there drying off. A narrow leafed *Potamogeton* was present beneath the flotsam. I examined several handfuls of the *Potamogeton* in a plastic pan but saw no larvae, pupae, or adults. None were found on milfoil either. Perhaps the weevils were riding the flotsam to shore for winter diapause. Yellow flowering *Utricularia* was abundant in this area of the marsh as well as in all other areas. *M. verticillatum* was beneath the surface throughout the open areas at this site. Aerial leaves were present on the plants but submersed indicating the water was lower earlier but had risen, probably within a few weeks. A few *Bagous* were found in the stems. Zhiqun collected a large bag of *M. verticillatum* stems at Site 1 after lunch for later examination at the hotel. We examined stems for 2 hrs at the hotel and collected more *Bagous* immatures.

Aug 15. Returned to the Qi Lin Dao Chun Reservoir area on the way to Qiqihar at km marker 802, near the first small spillway coming from Daqing. *Myriophyllum spicatum* was dense in open areas among cattails and grasses. *M. spicatum* was dominant but *Myriophyllum verticillatum* was scattered. *Potamogeton lucens* was in heavy mats at areas throughout. Small flowered white *Nymphaea* was common. *Caldesia reneformis* leaves were scattered among the *Potamogeton lucens* but no flowers seen. Hydrilla formed a dense mat throughout, both mixed with milfoil and in monoculture. Hydrilla was in flower. Male plants appeared to be in monostands and those plants appeared to have smaller leaves than did female plants. Fly-*Hydrellia*- puparia were collected although damage was very light. Adult flies collected from *Nymphaea* and *Caldesia* floating leaves with the battery aspirator. Pulled their roots in shallow water but no donaciine seen. The lower stems of the large leafed *Potamogeton lucens* had donaciine cocoons attached. One had cocoons of two greatly differing sizes. *Hydrellia* damage was heavy in the leaves; puparia were collected from the stems, did not examine leaves. Examined 20 *P. lucens* plants for *Phytobius* and *Bagous*. None found nor damage. One donaciine cocoon on lower stem. Extra flowers appeared to be eaten by *Phytobius* but could not be sure—might have been a Lep or other herbivore. Zhiqun and I each sampled 25 plants of *M. spicatum*, 25 of *M. verticillatum*, for later examination. Sampled them in pairs, 1 of each species, close together. *Phytobius* cocoons were found on both species but few and mostly on *M. spicatum*. Only one *Phytobius* adult was found and that

one was on my arm while I was examining plants in the plastic dish pan. It was a unicolorous brown or grayish—unlike the usual mottled color. Might be something else. Almost no damage on the flowers of either species although old stalks with seeds were damaged. Apparently the population peaked and the adults moved on, perhaps for winter diapause. A couple *Bagous* adults collected from plants and a few immatures in the stems. The leaves of milfoil, especially *M. spicatum,* covered with calcium and algae—extremely lime encrusted. Hydrilla was relatively soft, although some algae. This site, ca 15 m x 40 m of open water was almost completely covered by milfoil flowers except for the small *Potamogeton* patches. Water was 24C at my arm depth (ca. 38"), 30C at the surface. We then returned to the spillway of Aug 12 near the restaurant and collected in the reservoir. Donaciine larvae and cocoons were found on roots of hydrilla but also on lower stems and roots of *Potamogeton perfoliatus*—extremely heavy with cocoons—*Nymphoides*, *Myriophyllum spicatum,* and an unknown grass or sedge. Vacuumed flies from *Nymphoides* leaves. Collected a few Lep cocoons from hydrilla. Mr. Wang collected moths on shore. Most of the hydrilla and scattered *M. spicatum* was not rooted and had washed to shore, but there were many rooted plants also. The "soil" was composed entirely of pieces of aquatic plants. Actual soil must have been several inches lower. We found the donaciine larvae attached to roots and stems in this plant material layer. Large plant mats could be seen out on the reservoir, but we don't know which species—a fisherman said all the plants were out there. Returned to Daqing.

Aug 16. Drove to Harbin. Raining in Harbin.

Aug 17. Examined plant material, fed insects, completed field cards.

Aug 18. Continued examining plant material in AM. In PM free.

Aug 19. Drove northwest of Harbin on road to Suei Hua City. Tried to reach Nihe (DaFang Shen- the local name) reservoir but road conditions prevented it—too muddy. Examined *M. spicatum* in a lake-wetland along the road at Chang Fa (78 km from Songhua River). A few *Phytobius* cocoons collected and a little damage but very little. Could not find *Bagous* damage. Collected buds and flowers for food for our weevils. *Trapa* abundant and might be managed by farmers. *Ceratophyllum* heavy. Examined *M. verticillatum* in a drainage channel along the road (50 km N of Songhua Bridge past Xu Bao Village, Suei Hua City Road) at km marker 50. West side of road had plants heavily damaged by *Phytobius*—many had multiple cocoons but east side had almost no damage—fewer plants on east side. *Eubrychius* adults, cocoons, and larvae also present. A few adult *Phytobius* collected but few seen. Lep larvae were heavy on plants but might be from the *Lemna trisulca* mat which surrounded the plants. The cone-shaped caddisflies were common on the leaves. Leaflets were heavily eaten by something. A few *Bagous* larvae were found in the stems. *Polygonum amphibium* blooming. *Potamogeton*

pectinatus was present, but I did not have time to examine it. Checked a few *Potamogeton perfoliatus* for cocoons, but found none.

Aug 20. Drove to Shi-er-li-pao and collected *Bagous* infested stems at the Site 1, along the road from the expressway to Wo-Li-Tun. Zhiqun and I each collected 50 stems, mostly floating but some rooted. A large *M. verticillatum* patch was across the canal from where we had collected near shore. Using the inner tubes we crossed the canal and could wade on that side. The flowers were almost all damaged by *Phytobius* adults; many were completely eaten, but we found only one adult. Larvae and cocoons also absent except for a couple of cocoons found while collecting *Bagous*. We examined the stems at the site, often while holding them in the water, which made it easier to see pupae and large larvae. We collected damaged stems but we should have broken off the portions with mature individuals. We had to re-examine all of them again in the hotel because they were rotting and drying. Examining stems in the field was faster and more efficient than examining them later. Examined a few stems, 10-20, of *Utricularia* but saw no damage. A little *Potamogeton pectinatus* was present but most other plants were *Utricularia. M. verticillatum* was very dense. The trip out to Shi-er-li-pao from the Swan Hotel, Harbin, took about 2 hrs. We held the stems (all defoliated by us in the field) in a cloth bag and spread them out overnight on a sheet in my hotel room. I covered them with dry towels when I went to sleep. Placed them the next day in a cloth bag (rice bag) but that evening and the next day we excised larvae and pupae because the stems were collapsing. At least 60 immatures were excised in small stem sections. We probably saw many more when we examined them in the field, but we couldn't see them in the hotel. We carried all the stems to Beijing in the cloth bag.

Aug 21. Free day. Went to Sun Island. Milfoil observed in some ornamental ponds.

Aug 22. Prepared insects for the trip—changed paper and plants, excised more *Bagous* immatures, and packed in AM. Flight to Beijing in PM.

Aug 23. Examined plant material and fed insects.

Aug 24. Examined plant material and fed insects; prepared computer inventory of the lab.

Aug 25. In AM changed and fed insects; free in PM.

Aug 26. Field trip to the *Hydrocharis Bagous ?* weevil site found by Willey Durden and Zhiqun and to San Jia Dian Reservoir in AM, to August 1st Lake in PM. Examined a sample—one plastic bag, rodent size—of hydrilla for the *Bagous* from *Hydrocharis*. None found although they were present on *Hydrocharis*. No milfoil flowers present at San Jia Dian or August 1st Lake. Passed Qiao Zhuang site which was dry. Water level at San Jia Dian was actually high, as it was at August 1st Lake. The

tube boat was used by Zhiqun at San Jia Dian. Collected adult flies with a battery aspirator at the first two sites.

Aug 27. Final change of insects and taking of specimens. Packed alcohol specimens. Prepared permits. Met with Dr. Lu about our program and biocontrol in general

Aug 28. Counted and packed insects for trip. Went to lunch with Zhiqun and Liu, his friend.

Aug 29. Departed for home.

Appendix G
Survey 15 - Heilongjiang and Liaoning Provinces - Chris A. Bennett - June-July 1995

16-VI. Arrived Beijing about 9:00 PM and met at airport by Dr. Lu Qing-Guang and Zhiqun Chen. Checked into Friendship Hotel and briefly discussed plans.

17-VI. Free day.

18-VI. Free day.

19-VI. Met in AM with Zhiqun, Dr. Lu Qing-Guang and Mr. Jiangqing Ding from Institute of Biological Control, CAAS. Mr. Ding will go with me to Harbin since Zhiqun is still not able to work and travel because of health problems. After lunch Zhiqun, Mr. Ding and I packed the equipment for trip to Harbin.

20-VI. Landed in Harbin in AM. Met by Mr. Wang from Institute of Plant Protection. Went to lunch and then hotel. Rested until 3:00 when we went to the Song Hua Jiang (River) in town. This is a recreation area where people rent boats or take boat rides. We rode down the river for awhile but did not see any aquatic plants.

21-VI. Went to the Plant Protection Institute and met the director, Wei Jun Xu. We then went upstairs to a conference room and discussed biological control with the director, Mr. Wang, Professor Fengchun Han and Mr. Young who I had met in 1993. Professor Han arranged to show us some aquatic plants after lunch. We drove east of the Harbin Train Station to a small village Chen Mong Tun to a place Minzhu Xiang, Talping District, Harbin. This was a small pond on the left hand side of the road. The pond was covered with *Lemna* and algae. Underneath the *Lemna* and algae, most of the pond was covered with *Potamogeton cristatus* in flower. The floating leaves had feeding holes. A blue flea beetle was found in among the sample. Close to shore was some very small, soft and

fragile hydrilla. Collected a bag of hydrilla and *Potamogeton. Typha, Phragmites, Scirpus* and *Ceratophyllum* were also present. Hydrilla was also present in a nearby drainage canal with *Potamogeton pusillus* the most dominant plant. The *Hydrilla* was processed at the hotel later. Some of the leaves had damage similar to damage Gary found in 1992 on hydrilla in Harbin.

22-VI. Left for Daqing city. Mr. Ding thought that the sites on the Suei Hua City road are on the way to Daqing city. The driver didn't tell him otherwise. We stopped first at the 50 km marker 1993 site, a drainage canal along both sites of the road. No milfoil on the right hand side of the road even though more water. Plants on the right were *Potamogeton pusillus, Potamogeton maackianus,* and *Ceratophyllum. Polygonum amphibium and Myriophyllum verticillatum* were in the canal on the left. Leaves of *P. amphibium* were heavily damaged but no insects found. The flowers of *M. verticillatum* were attacked, but no insects noticed in the field. Bag of *M. verticillatum* collected. Sampled later: found 32 *Phytobius* adults (short snout); 3 *Eubrychius* adults; 2 *Phytobius* cocoons, 3 larvae; 7 empty *Eubrychius* cocoons, l dead *Eubrychius* cocoon; 3 dead *Eubrychius* adults and 4 cocoons of *Eubrychius*. Most of *M. verticillatum* flowers slightly damaged by adult feeding. *Hippuris vulgaris* growing among *Scirpus, Typha and Phragmites*. Two fly larvae and a pupa were found in tunnels in the stem *of H. vulgaris*. Several *Synclita*-like cocoons were found on *Hippuris*. Returned to Harbin and then on to Daqing City.

23-VI. Windy and overcast day. Drove to Shi-er-li-pao. Stopped at 1st 1993 site but no milfoil. *Typha* has filled in and *Utricularia* in flower was only floating plant noticed. Drove along road and then over bridge to edge of Wo-Li-Tun. Turned on road to right which has a pipeline running along road. Found place where Gary and Zhiqun rented boat last year but too windy and rainy to rent boat. Drove back to eastern margin of the marsh to examine plants we noticed as we drove by the first time. Stopped near bridge heading away from Wo-li-tun. Plants were mainly *Potamogeton pusillus* and *Ceratophyllum,* but no milfoil seen. Finally returned to the hotel. Too rainy, windy and cold to collect. Processed in PM the plants collected yesterday.

24-VI. Went to 1994 site on pipeline road. Rented a boat for 30 Yuan/ hour, this included owner. We poled around the marsh but found only *Utricularia* in flower (yellow) as the dominant submerged plant. Some flower stalks looked attacked, and were collected to be checked later. *Typha* and *Phragmites* also present along with some *Ceratophyllum.* I found one small piece of *M. verticillatum* in flower caught in the algae. Owner finally took us to area where Gary and Zhiqun had been last year. In among the cattails, and *Phragmites,* we found *M. verticillatum* (aerial portion of the plant only) in flower. We collected some from the boat and then Mr. Ding and I got out of the boat. I collected a sample of 25 stems and we made general collections. The first stem I checked had two *Phytobius* larvae. Flowers showed damage. The plants were growing on a mat

of *Utricularia* on top of *Phragmites* and cattails. I pulled up the *Phragmites* and *Typha,* but found no donaciine larvae. I swept underwater using the swimming pool net and did not find any adults. We poled around the marsh for 2 1/2 hours and then returned to the fisherman's hut. We returned to the hotel and processed the plants. We found 16 *Bagous* adults, 51 mixed *Phytobius*, majority short snout, but a few long snout. Will separate at SABCL since microscope hard to use. 40 cocoons of *Phytobius* sp. Cocoons were brown and round but not in stem; up on leaves. Many small to large *Phytobius* larvae were collected. Sample of 25 plants: 19 were damaged and found 3 *Phytobius* larvae, 4 cocoons on the leaves, and 2 adults.

25-VI. Drove to Qi Qi Har stopping at km marker 802 Qi Lin Dao Chun by a bridge next to Red Dam (the first bridge and dam coming from Daqing). Hydrilla was the dominant plant. *Typha* and grasses lined the bank of the river; we collected on the Daqing side. I found 2 pieces of milfoil among the hydrilla. *Potamogeton lucens* was in flower and scattered among the hydrilla, and in larger beds in middle of small river. I used the float tube to check plants in water which was too deep to use the waders. Could not go into middle of river because current from spillway and the wind was too strong. Float tube works ok and is almost comfortable. Fisherman came over to talk to us and told us there were more plants further down river and offered to pole us around for 30 yuan/hour. We poled down the river to several dense *M. spicatum* beds. The plant was in flower but no damage or insects were seen. We collected several bags. *M. verticillatum* was also present in flower scattered among the *M. spicatum*. No weevils or damage was seen on the *M.verticillatum*. Further down the river *Potamogeton pusillus* was thick and in flower. *Polygonum amphibium* was also present. *Ranunculus* in flower was scattered throughout a grass-like submerged plant (reminded me of thin leaf *Sagittaria* but seemed to have floating leaves mixed in). *Nymphaea* was also present with a small amount of feeding (small holes in leaves), *Donacia* adult were common sitting on *Nymphaeae* leaves, floating leaves of plant I didn't know, l small *Trapa* plant and me, adults were brown and blue in color. Pulled up plants, but found only l donaciine larva later in a bag of milfoil. Took samples of *Potamogeton lucens, P. pusillus* and *Hydrilla*. Further down river *Hydrilla* was very thick and had formed thick mats, heaviest I have seen in China. Female flowers were plentiful, only a few male noted. Continued on to Qi Q Har and after lunch checked into the Crane Hotel. Spent the afternoon processing plants.

26-VI Drove from Qi Har to Daqing City stopping at km marker 810. The canal on the south side the of road had *M. spicatum* in patches along the whole canal. Water was deep so we used the float tubes. *Potamogeton lucens* also present in flower in canal along with a small amount of *Potamogeton pusillus* also in flower. At first glance, most of *M. spicatum* did not look damaged and we saw no beetles. We moved throughout the canal. Mr. Ding went to the west corner of the canal where the water was shallower. He found damage and many small to large larvae of *Phytobius*.

I moved to a patch closer to shore and found a few *Phytobius* adults. After moving again, I collected 25 *Phytobius* adults. They were coming out of the water on the stems. If I found one, I found several. They were clumped on the stems. Some of the milfoil and *P. lucens* had black areas on stems and flower stalks, but was not insect damage—maybe disease. Some *Potamogeton lucens* flowers were also black. Milfoil samples produced: Chris' sample: 43 stems, 4 had damage to flower buds, 1 had small amount of damage, and 1 had *Phytobius* eggs, and 1 damaged flower bud had 1 *Bagous* adult; Mr. Ding's sample: 33 stems, 12 damaged, 6 had *Phytobius* adult damage on buds plus larvae, the larvae were mostly on the tip. One with 2 larvae; 1 with 1 larva + 1 cocoon, 25 adults found. Returned to Daqing Hotel and spent PM resting, processing samples, and taking care of insects.

27-VI Returned to Shir-er-li-pao to boat rental place and rented the boat and owner to pole for us for 30Y/hour. We paddled around the marsh and found two large patches of *M. verticillatum*. These plants looked like the normal *M. verticillatum* underwater portion, aerial portion and flowers. We immediately found numerous *Phytobius* adults, 1 *Bagous* adult and *Eubrychius* adults. We found one large patch and Mr. Ding and I got out and waded. Almost every bud or flower had some damage, mostly adult feeding on the bracts and flower stalks, adults were numerous. I pulled up many plants and found some medium to large donaciine larvae on the roots. No cocoons were found, but several adults were found either underwater or on the flowers. We continued searching further, but didn't find any more large mats, just a plant here and there. The last place we stopped, I noticed *Phytobius* cocoons on the underwater portion of *M. verticillatum*. The aerial portion and flower were missing, whether they were eaten or broken off, I could not tell. I pulled about ten stems and found a cocoon on every stem. Returned to the hotel and after lunch took care of insects and started processing.

28-VI Drove to Harbin. After lunch worked in room processing plants. a sample of *Hydrilla* taken from 810 km marker had a few holes on the leaves but no *insects*. *Hydrellia* was not found either. *Potamogeton pusillus* from this same site had no damage. *Potamogeton* from km 802 had feeding on leaves but suspect caterpillars, 1 Lep adult in bag, white body with dark markings on white wings with long thin legs.

29-VI Headed for 1992 site, 2.9 km N of Jian Guo Village, at km marker 3. After an hour of driving around and asking people, we found the site. The garbage dump has almost completely filled in the site except for a few small ponds surrounded by *Typha*. Two of the small ponds were covered with plants, after walking down the steep bank we found it was mostly *P. pusillus*. a small amount of soft thin leafed *Hydrilla* was around the edge of the ponds. We collected as much as possible that could be reached from shore, the pond was too deep and the bottom too soft to wade. We had left the float tube at the hotel. Returned to city and after lunch checked *Hydrilla*. Found 2 stems with holes eaten in the leaves,

however no fly damage. Packed up insects and equipment for the trip to Beijing.

30-VI Returned to Beijing. Met at airport by Zhiqun. We first went to the Friendship Hotel and then to the lab. Zhiqun helped unpack and fed all the insects.

1-VII Free day.

2-VII Free day.

3-VII Zhiqun and I went to San Jia Dian. *Hydrilla* covers 90% of the reservoir. *Potamogeton crispus, P. perfoliatus, P. melanus and M. spicatum* are present but scattered throughout the mat of hydrilla. We first collected flies from the floating leaves of *Hydrocharis dubia*. Flies were plentiful, but most were not *Hydrellia pakistanae or Hydrellia sarahae* or even *Hydrellia*. Parasites were also present in fairly large numbers on the *N. dubia* leaves. We collected flies for about an hour, and then sampled *Hydrilla,* all the *Potamogeton,* and milfoil, 25 of each. Returned to the lab. Discussed permits for Chinese government, Driver Chen will go tomorrow morning to get them. Separated flies using Nikon microscope in lab. Set up flies in large jar.

4-VII Received fax from Gary to bring flies home. Got specimens ready for Driver Chen to take to Ministry of Agriculture to get Chinese permits. Processed plants from San Jia Dian. In sample of 25 *Hydrilla* stems only one *Hydrellia* larva and no damage, however heavy midge damage. Almost every stem has at least one damaged tip. Stems have many lateral tips, and much regrowth from old tips. Found only one midge larva dead in tunnel in tip. Zhiqun thinks the people will pull the hydrilla out later. At 3:00 went to biology pond at Tsing (Hsing) Hua University. Last year, Zhiqun, Judy and Willey collected a small amount of milfoil here. We found no milfoil. The pond is covered with lotus and *Ceratophyllum*. On the back side, near the stepping stoned in the water, we collected a small amount of *Hydrilla.* Returned to the laboratory and finished checking the *Hydrilla.* Briefly checked the insects.

5-VII Finished checking samples from San Jia Dian and Tsing Hua (Biology Pond). Changed all insects.

6-VII Went over the inventory list of the lab. Checked out GSP. Packed up the insects for the trip home.

7-VII Departed for home.

Appendix H
Surveys 16 and 17
South People's Republic of China
Zhiqun Chen
August–October 1995

Aug. 21. MON. Arrived in Kunming, Yunnan Prov., at 3:30 PM.

Aug. 22. TUE. 8:00 am went to Dali Erhai Lake, 400 km west to Kunming by bus, arrived at 8:30pm

Aug. 23. WED. Collected at Erhai Lake and around. It's a big lake, the water is clear and deep. Only few milfoil growing in the lake, sampled plants, no insects were found, just some midge damage and big red midge larvae in the stem. Collected three small ponds around the lake, only found *Ceratophyllum* (*demersum*-like) in the water, but nothing feeding on it.

Aug. 24. THU. Back to Kunming by bus.

Aug. 25. FRI. Took bus to Cengjiang county, Fuxianhu lake about two hr. drive south to Kunming . Deep water without any plants, the deepest area is about 150m.

Aug. 26-31. SAT-THU. Investigated water hyacinth in Kunming area.

Sept. 1. FRI. Flight to Guiyang, Guizhou Prov., in the evening. Met Mr. Fan at the airport.

Sept. 2. SAT. Drove to Longli county, Sanyuan town 70km Southeast to Guiyang city. The road was very bad. Stopped at a pond about 50km from Guiyang .There were *Potamogeton crispus, Myriophyllum spicatum, Ceratophyllum* and other grasses growing in the pond. Sampled 30 milfoil stems, three of the tips were damaged by insects, but did not look like weevil damage, no insects were seen . Only few midge damage and midge

larvae were in the stems, few holes in the *P. crispus* without insects were also found . *Ceratophyllum* were very clear. Arrived at Sanyuan town at 5 PM.

Sept. 3. SUN. There was a rice field near by Mr. Fan's friend's home and an irrigation canal goes through the rice field (N 26. 52, E 107.12**)** . The water in the canal was about 1 m deep and 3 m wide. Six species of aquatic plants. *Myriophyllum sp, Hydrilla verticillata, Potamogeton malaianus, Ceratophyllum* (*demersum*-like), *Najas sp., Ottelia acuminata* and some grasses growing in the canal. Hydrilla and *P. malaianus* were the major plants. *P. malaianus* leaves were damaged by fly larvae *(Hydrellia ?)* heavily. Larvae tunneled in the leaves, also five fly pupae were collected, got two adults and two parasites in three days. The fly adults were bigger than which were collected on hydrilla before. No insect damage was found in the leaves and stems of hydrilla, only some leaves were eaten by maybe snails, but the *Donacia (Macroplea?)* cocoon on the roots and lower part of stems were very common, also three larvae were found on the plants. Collected 35 cocoons, most of them were dark color, there were 18 adults emerged at noon. Kept the adults live in a plastic box with hydrilla plants and water to bring back to Beijing. Reared in the Lab on hydrilla which was planted in the greenhouse before I left for the trip. Examined all the plant materials, but no egg and larvae were seen till Sept. 16. Mr. Fan also collected one *Donacia* adult on the grass in the field. *M. verticillatum* did not look like healthy, few midge damage and larvae in the stems, but no other insects damage were seen. Pulled the roots out in shallow area, no *Donacia* larvae were found. This site is in the mountain and a little far away from the city. It began to rain at 1:30 PM, could not continue to examine in the field. Returned to Guiyang by train in PM . Stayed at Gui zhou Agricultural University.

Sept. 4. MON. Collected in Huaxi river, near by Guizhou Agricultural University, in Huaxi distract 15km southwest to Guiyang city. The river goes though Huaxi park and the environment was more natural . Near the town the river was deep, just few hydrilla and *Vallisneria* floating on the surface of the water, 400 m up, *Vallisneria spiralis* and *Ceratophyllum (demersum*-like) were dense in the water, some hydrilla and milfoil were mixed among the plants. Went up 500 m far . There was an open area, near Huaxi Hotel**.** **(**N26.43, E106.65). Hydrilla *verticillata* was dense, *Vallisneria*, very few *M. spicatum* and *Ottelia acuminata* mixed in the plants. Examined plants, did not find insects damage in hydrilla stems and leaves. But a few *Donacia* larvae were on roots and lower part of stems, all the plants with larvae on were thinner, and the leaves were smaller than that without *Donacia* larvae, no *Donacia* cocoon was collected in this site. There were only few *M. spicatum* in the water (5 plants). Pulled the roots out of water, 14 *Donacia* larvae were found on one milfoil plant's roots and a total of 16 larvae were collected on milfoil. *Vallisneria* was the second major plant there, did not see any insect damage on it, nothing on other plants either. Collected in Nanminghe river in the afternoon, north to the town, about 3 km. Alligator weed and *Ceratophyllum*

were very common there, few hydrilla could be seen among the plants, but it was clear, no insect feeding.

Sept. 5. TUE. Flight to Chengdu, Sichuan Prov., with Mr. Fan arrived at 7:30pm.

Sept. 6. WED. Drove to Longquanhu lake, 30 km east to Chengdu city, it looked like a reservoir; but no plants growing in the water, some alligatorweed growing on the bank feeding by beetle. Drove to Dujiangyan in the afternoon, it's a big river, 60 km north to Chengdu, but the bottom was filled with stones. None of plants in the river.

Sept.7. THUR. Examined several small ponds near the city in south area, only Alligatorweed and grasses were seen. Alligatorweeds were damaged by beetle which was released in Chongding in the end of 1980's.

Sept. 8. FRI. Flight to Beijing in PM.

Sept. 20. WED. Flight to Nanning, Guangxi Zhuanzi Zizhiqu Prov., from Beijing, arrived at 2:00 PM.

Sept. 21. THU. Drove to Dawangtan reservoir, 33 km south to Nanning city . On the bottom of east dam of the reservoir, there were two small ponds (N. 22.58, E. 108.32)**.** One was very small, about 10 m2, some big stones which people used to build the dam were on the bottom, hydrilla, *Vallisneria* and alligatorweed growing in the pond. Two fly adults *(Hydrellia)* were collected on the surface of the water, examined hydrilla plants, fly damage were found, but not much, pulled the plants out, no insect feeding on roots and stems, alligatorweed was damaged lightly by some insect too. Another pond was a little bigger, waterhyacinth, alligatorweed and *Vallisneria* growing in it. 2:00 PM drove to Lingshui, it's also a natural swimming pool, *Vallisneria* and *Ceratophyllum* growing very well, but no insect was seen. Checked two ponds on the way back, but none of hydrilla, milfoil and *Trapa* were seen, Returned to the hotel at 6:00 PM.

Sept. 22. FRI. Drove to Xijing reservoir, 150 km east to Nanning city, but the road was too bad to go, had to return from Liancheng, about 80km from Nanning. At 32 km stone mark, 11 km from Pumiao sugar factory, there was a pond beside the road, hydrilla was dense in the pond, several species of Gramineae plants and one *Ottelia acuminata* mixed in. Hydrilla plant was thick and very easy to break, fly damage was found in the leaves but very few, no insect was collected. Took a bag back to examine, one small cocoon was found on the tip of Hydrilla. Returned to Nanning at 1:45 PM . On 3:15 PM, walked to Nanhu park in the city. It is a big lake and several small ponds around it on the map. But the people were using as fish ponds.

Sept. 23. SAT. Collected in Laohulin reservoir, 15 km north to Nanning. But it was also as a fish pond. Examined samples collected from the field and completed field cards in the afternoon.

Sept. 24. SUN. Flight to Guangzhou, Guangdong Prov., arrived at 11:30 am. Met Prof. Zhicheng Liu, Prof. Jianfeng Liu and Mr. Donsong Li in Plant Protection Institute, Guangdong Academy of Agricultural Sciences. I was told Dr. Wang Ren and Dr. Balciunas have visited Guangzhou, found nothing, because of more development of industry in this area.

Sept. 25. MON. Prof. Jianfeng Liu drove me to Xianchun town, Zhencheng city by motel cycle, 50 km east to Guangzhou, checked two branches of Zhujiang river and two small canals in the rice field, waterhyacinth and alligatorweed were everywhere, but there was not milfoil and hydrilla growing.

Sept. 26. TUE. Mr. Dunsong Li drove me to Huangpodong reservoir, near Guangzhou city. None of plants growing in the water, Raining at 10:45 am.

Sept. 27. WED. Raining all day.

Sept . 28. THUR. Flight to Fuzhou, Fujian Prov. Met Prof. Zengquan Wu in Biocontrol Institute, Fujian Agricultural University on 2:00 PM. At 3:00 PM, went to Putian city, 110 km south to Fuzhou by bus, arrived at 7:45 PM, stayed at Xinghua Hotel

Sept 29-30. FRI-SAT. Raining, examined one reservoir and one pond near the city when the rain stopped for a while, but both of the water bodies were covered completely by water hyacinth.

Oct. 1. SUN. Returned to Fuzhou by bus at 1:30 PM. Drove to 10 km southeast and 8 km west to the University, checked one river, one pond and Jingxi canal (west), but no hydrilla, milfoil and *Trapa* were seen.

Oct. 2. MON. Collected in August First Reservoir, about 18 km to the University, it's a small reservoir in the Forest Park, the water came from a small canal, 300 m from the reservoir in the canal, under a small bridge, hydrilla was growing, about 2 m2 . Examined the plants, found only three leaves were damaged by fly larvae, but no cocoon and larvae were seen, collected two bags back. Drove to Denyun reservoir in PM, the situation was same, but about 500 m far, there was a Golf Club (XingDongYang Golf Club), and a small canal goes though the club, 500 m in the club, there was a pond which was the wider part of the canal. *Potamogeton crispus* growing in the deep area. In the shallow area, in the middle of waterhyacinth, was an open water about 5 m2, hydrilla was dense, only one stem leaves were damaged by fly larvae, but no larvae or adults were found . It was raining at 3:30 PM. Brought two bags back.

Oct. 3. TUE. Examined the samples at Prof. Wu's Lab.

Oct. 4. WED. Drove to Minghou, Ganzhe town, 18 km west to the University, Guanyuan Village, there was a irrigation canal (Guanyuanxi canal), hydrilla, waterhyacinth and alligatorweed growing in the canal, hydrilla plants were healthy, no insect damage on it, only some of the leaves were eaten by snails. Drove 26km far to the west to Wenxi, another canal in PM, no plants in.

Oct. 5. THUR. Raining. Flight to Wenzhou, Zhejiang Prov., met Mr. Jianguo Li, my schoolmate at the airport.

Oct.6. FRI. Examined three ponds around the city, almost all the waterhyacinth and alligatorweed. At 7:00 PM went to Hangzhou by bus, arrived at 2:00 PM next day (Oct. 7)

Oct. 8. SUN. Collected in Deqing, Sanqiao town 60 km north to Hangzhou, there was a river just near by Sanqiao railway station, hydrilla, *M. spicatum, Ceratophyllum, Najas, Vallisneria* and alligatorweed in the river. Examined the plants, only found *M. spicatum* stems were damaged lightly by midge larvae and alligatorweed were damaged by somebody. Dried some of hydrilla plants on a big white paper, some small snails were only seen. There was another river located 3 km south to the station, but the situation was same. People planted *Trapa* in almost every pond. Examined Trapa in a pond 5 km east to Sanqiao town, the beetle (adult, larva, pupa) collected in Shenyang in 1992 was very common and damaged heavily on the plant, 5 Lep. larvae, one moth and two species of leafhopper were also collected on the plants. Lep. larvae cut the leaves and hide inside.

Oct. 9. MON. Collected in Fuyang 35 km southwest to Hangzhou, Fuchunjiang is a big river in the county, rice field was along the river, few single hydrilla plants in the rice field, but nothing attacked it .

Oct. 10-15. TUE- SUN. On vacation at home.

Oct. 12. THUR. Collected in Erdu village 140 km north to Hangzhou, 15 km from my home. One pond beside the road was seen from the tram on the way home. Hydrilla, *Vallisneria* and *Ceratophyllum* growing well in the pond and no one damaged them.

Oct. 16. MON. Returned to Hangzhou.

Oct. 17. TUE. Flight to Beijing.

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13. ABSTRACT ***(Maximum 200 words)***

Many of the most important aquatic nuisance plants are immigrants that arrived in the United States without their respective natural enemies. These include, among others, alligatorweed, waterhyacinth, waterlettuce, water chestnut, hydrilla, and Eurasian watermilfoil. The first two species have been controlled at many sites and reduced throughout much of their range by insects imported from their native homes and released into the environment. This method of control is called classical biological control.

The objectives of this study were (a) to identify and visit diverse regions of P. R. China, Japan, and Korea that had hydrilla and Eurasian watermilfoil, (b) to collect herbivorous insects on the target species and on related species, (c) to note the life cycles and types of damage for the insects, (d) to carry living specimens of promising species to the Gainesville, FL, quarantine facility, and (e) to establish colonies of the insects in quarantine for companion biology and host range studies.

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