AQUATIC PLANT CONTROL RESEARCH PROGRAM

TECHNICAL REPORT A-82-5

INSECTS AND OTHER MACROINVERTEBRATES ASSOCIATED WITH EURASIAN WATERMILFOIL IN THE UNITED STATES

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Fauna associated with Eurasian watermilfoil (*Myriophyllum spicatum* L.) were collected and identified from 71 collections in 11 states. Sixty-four insect taxa were identified, of which damselfly nymphs were most frequently encountered, being found in two thirds of the collections. Midge larvae, when present, were the predominant component of collections, both in number of individuals and number of species. Larvae of aquatic moths fed voraciously on Eurasian watermilfoil and produced the most severe damage of any group. Three
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species of caddisflies were found to be probable or possible feeders on Eurasian watermilfoil. An aphid and three weevil species were found to feed on emersed flower spikes, but their direct impacts were thought to be minimal. None of the insects identified in this study appeared to be promising candidates as biological agents for the control of Eurasian watermilfoil.

PREFACE

This report presents results of a biological control program being conducted for the Aquatic Plant Control Research Program (APCRP) by the U. S. Department of Agriculture (USDA), Agricultural Research Service, Aquatic Plant Management Laboratory (APML), Fort Lauderdale, Fla. The purpose of this program is to evaluate insects to determine their potential for use in aquatic plant control. This particular project in the overall program involved a survey of insects and other macroinvertebrates associated with Eurasian watermilfoil in the United States. Funds for this effort were provided by the Office, Chief of Engineers, under appropriation number 96X3122, Construction General, through the APCRP at the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss.

The principal investigator for the work and author of this report was Dr. Joseph K. Balciunas, University of Florida, on assignment to the APML. The author extends his appreciation to Ms. Donna Newman, Ms. Mary Cabot, and Mr. Ken Carraccia for their assistance in processing samples, to Dr. Dale Habeck for his help in the identification of insects, and to Dr. Ted Center for invaluable aid provided throughout the study.

The research was monitored at the WES by Dr. D. R. Sanders, Sr., and Mr. R. F. Theriot of the Wetland and Terrestrial Habitat Group (WTHG), Environmental Resources Division (ERD), Environmental Laboratory (EL). The study was conducted under the direct supervision of Dr. H. K. Smith, WTHG, and the general supervision of Dr. C. J. Kirby, Jr., Chief, ERD. Dr. John Harrison was Chief, EL. Manager of the APCRP at WES was Mr. J. L. Decell.

Commanders and Directors of WES during the study and preparation of this report were COL John L. Cannon, CE, COL Nelson P. Conover, CE, and COL Tilford C. Creel, CE. Technical Director was Mr. F. R. Brown.

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
feet	0.3048	metres
miles (U. S. statute)	1.609347	kilometres

INSECTS AND OTHER MACROINVERTEBRATES ASSOCIATED WITH EURASIAN WATERMILFOIL IN THE UNITED STATES

PART I: INTRODUCTION

Purpose and Scope

1. The purpose of this study was to compile a list of insects associated with Eurasian watermilfoil, *Myriophyllum spicatum* L., in the United States. Trophic roles of each species were noted and potentially damaging species were emphasized. Sequential quantitative sampling was conducted to provide an indication of seasonal fluctuations in the biomass of *M. spicatum* and the response of insect populations to those fluctuations.

Description

2. Eurasian watermilfoil (Figure 1) is a submersed macrophyte with long, narrow, branching shoots that grow to the surface and frequently form dense mats. While the plant roots in almost any substrate, it most commonly grows in silty muck. The leaves, up to 35 mm long, are simply pinnate and feathery with 14 to 24 pairs of segments per leaf. The leaves are usually arranged in whorls of four, spaced 1 cm or more apart on the stem. Lower leaves are continually sloughed off, giving stems growing in deeper water a naked appearance. Stem width doubles below the inflorescence. Flower spikes, 2.5 to 10 cm long when present, are erected above the water surface from the apical portion of the shoots. The base of the spike has pistillate flowers arranged in whorls of four, while the apical portion has whorls of staminate flowers that mature later, favoring cross-pollination. Bractlets are round or kidney-shaped and are broader than long; the floral bracts are longer than the fruits. There are four seeds in the schizocarp and each seed is four-angled and 2.5 to 3 mm in diameter. Flowering does not necessarily

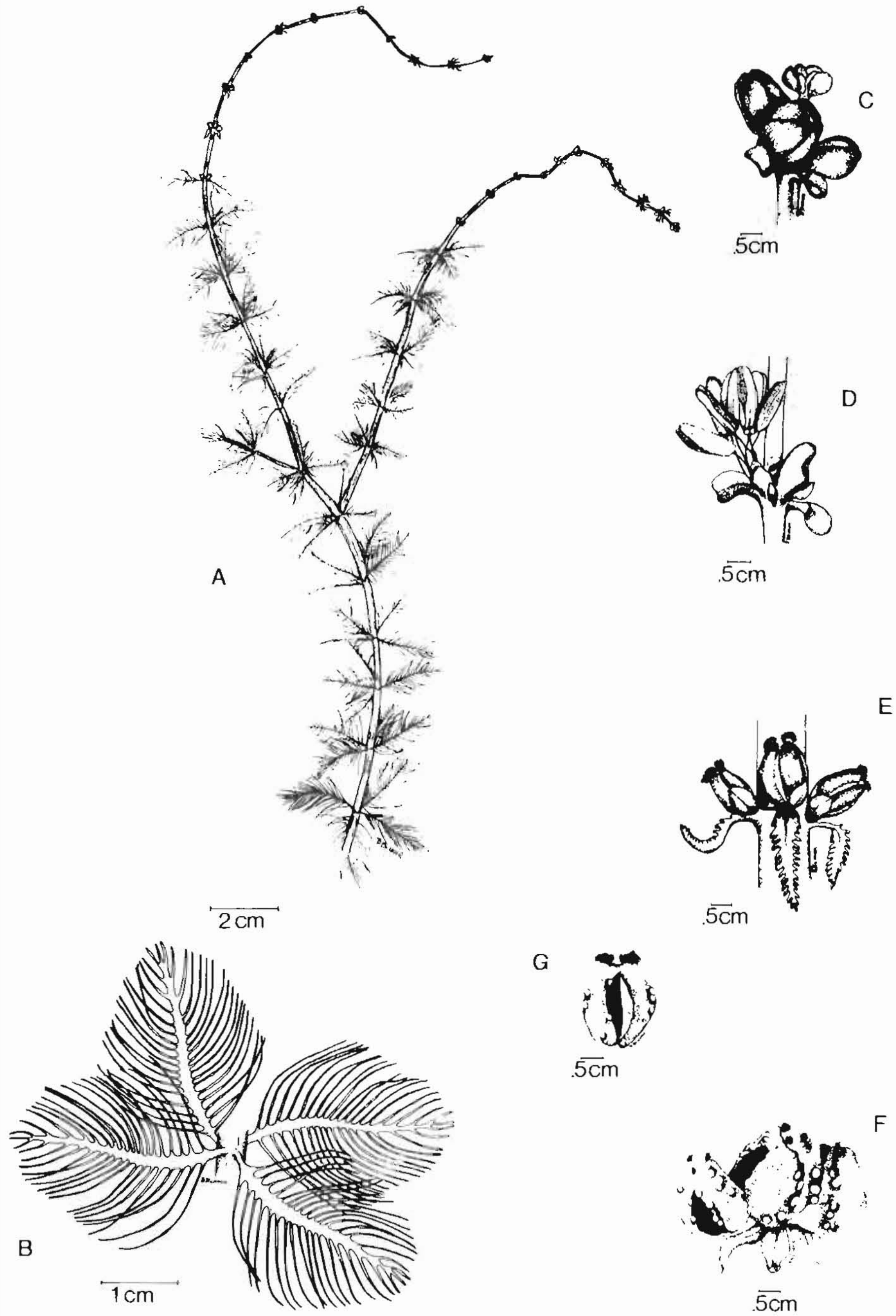

Figure 1. *Myriophyllum spicatum*. A: Apical portion of shoot showing flower spikes; B: Closeup of leaf whorl; C: Tip of flower spike with unopened male flowers; D: Male flower (opened); E: Female flowers; F: Maturing seeds; G: Mature seeds

occur in every infestation every year. In west-central Florida, flowering begins in late March or early April, soon after new shoots in shallow water reach the surface, and progresses outward along the edges of the *M. spicatum* mat. Some flowers are usually present in the mat throughout the season, and a secondary flowering peak begins in late summer and early fall. In Florida, some flowers are present until October and November; in more northerly latitudes, flowering may be restricted to late summer and early fall.

3. *Myriophyllum spicatum* is a member of the Haloragaceae (=Haloragidaceae) family and is placed in the order Onagrales. It grows in almost any aquatic situation, both fresh and brackish, in depths up to 10 m but is most common at 1 to 3 m. It most frequently becomes a problem in impoundments, both large reservoirs and small farm ponds, and in estuaries. While it is most common in cooler climates, it also thrives in the warmer waters of the southern United States.

Taxonomic Difficulties

4. In 1919 Fernald, noting differences between European and American specimens of *M. spicatum*, established a new species, *M. exalbescens*, for the American material (Fernald 1919). After that botanists usually called all specimens from America, American watermilfoil, *M. exalbescens* Fernald, or treated it as a variety or subspecies of Eurasian watermilfoil, i.e., *M. spicatum* var. *exalbescens*. Reed (1970) became the first to treat both as species occurring in North America. The two species are very similar in appearance (see Figure 2); they are usually separated on the basis of *M. exalbescens* having: (a) fewer pairs of divisions per leaf (less than 12); (b) bracts seldom exceeding the fruits in length; and (c) a stem which is not enlarged below the inflorescence. However, except for the last characteristic, there is a great deal of variability in these features. The number of leaf divisions in *M. spicatum*, for instance, can vary from 5 to 24, or the leaf may even lack divisions (Aiken et al. 1979). Positive identification of sterile specimens may depend on newly developed chromatographic

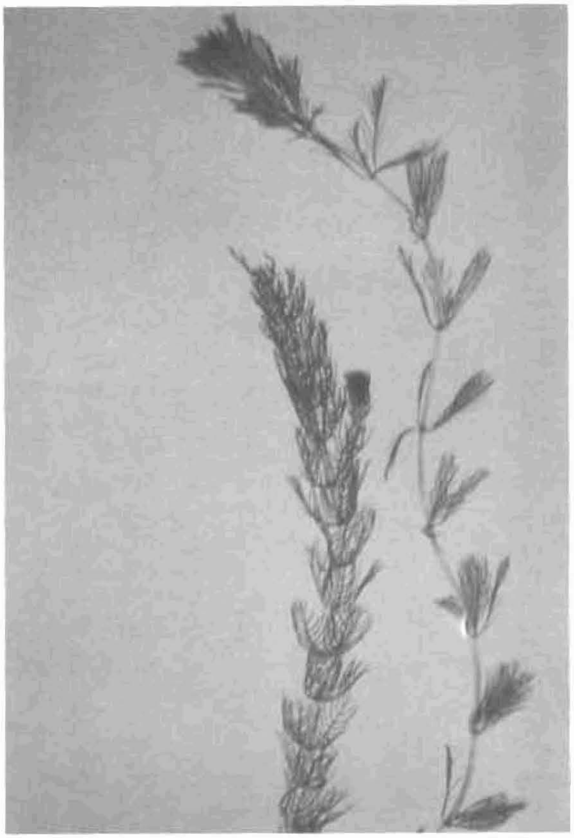

Figure 2. Comparison of floating strands of *M. exalbescens* (left) and *M. spicatum* (right) found growing 5 m apart in Seneca Lake, New York

techniques for separating these species (Ceska 1977). Another characteristic often used in the field for identifying *M. spicatum* is its frequently weedy nature. Since *M. exalbescens* seldom becomes weedy, large infestations are generally considered to be *M. spicatum*.

5. However, intergrades are not rare and, as mentioned earlier, some authorities consider *M. exalbescens* a subspecies of *M. spicatum* (Patten 1954a, 1954b; Amundsen 1977). This author tends to consider *M. exalbescens* a "good" species, having seen it growing side by side with "good" *M. spicatum* in Lake Ontario and New York's Finger Lakes.

Distribution

6. Eurasian watermilfoil, as its common name implies, is found throughout Europe and most of Asia. It also occurs in parts of Africa (Guillarmod 1977).

7. Eurasian watermilfoil was introduced in North America as early as 1848 (Gray 1848). However, Reed (1977) suspects this and other early references are actually *M. exalbescens*. He states that the first American record of *M. spicatum* authenticated by a herbarium specimen is Ward's 1881 record from the Potomac River. Reed (1970) shows the distribution of *M. exalbescens* (Figure 3) to be quite broad, while his map of the distribution of *M. spicatum* (Figure 4) shows it to be spotty. This author has collected *M. spicatum* from numerous locations (indicated by triangles in Figure 4) in the West and South which are shown by Reed to be uninfested. *Myriophyllum spicatum* is probably much more common, especially in the Southwest and Midwest, than Reed's distribution indicates.

Reproduction

8. While *M. spicatum* produces copious numbers of seeds, most of which are viable, seedlings are rarely observed by experimenters in the field (Patten 1954a, 1954b; Aiken et al. 1979; and Goldsby, personal communication). Spring regrowth usually initiates from rootstock buried in the hydrosoil or from dormant plant fragments. Any plant fragment containing a dormant lateral bud can develop into a new plant, and this is the chief mode for infesting new areas. This is aided by a propensity toward autofragmentation, especially by older plants that have already flowered, and which is followed by lush regrowth from the rootstalks. Turions or winter buds, while present in *M. exalbescens*, are usually considered absent in *M. spicatum* (Sculthorpe 1967; Aiken and McNeill 1980), but Patten (1954a, 1954b) reports occasional small turions in material from New Jersey.

Economic Importance

9. Smith (1971) reported that one plant, by repeated fragmentation, could produce 250 million plants. Shoots generally grow to the surface and, if numerous, form dense mats that crowd out native

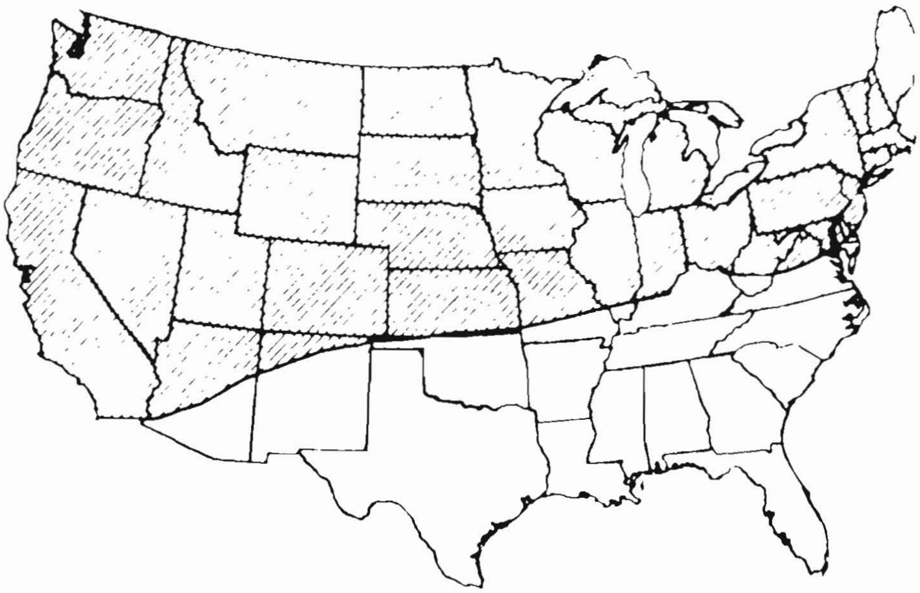

Figure 3. Map of U. S. distribution of *M. exalbescens* (from Reed 1970)

Figure 4. Map of U. S. distribution of *M. spicatum* (from Reed 1970). Triangles indicate *M. spicatum* (collection sites in areas shown uninfested by Reed)

vegetation. These mats can severely restrict the use of bodies of water, especially recreational use by sportsmen. Although Eurasian watermilfoil has been in this country for a long time, it became a problem only around the 1930's. It was first collected in the vicinity of Chesapeake Bay in 1902 (Nichols and Mori 1971), became a minor problem there in the early 1930's, then declined to a low level. In the late 1950's, it once again became a problem, and, by 1959, 20,000 hectares (50,000 acres) of Chesapeake Bay had been infested (Steenis 1968). By 1960, this had increased to 40,000 hectares (100,000 acres), and, by 1962, the infested area totaled almost 80,000 hectares (200,000 acres) (Steenis 1968). At Currituck Sound in North Carolina, 40 heavily infested hectares (100 acres) in 1965 had, by the end of 1968, become 3,200 heavily infested hectares (8,000 acres) with an additional 26,800 hectares (67,000 acres) in the initial stages of establishment (Crowell and Steenis 1968).

Chemical Control Measures

10. Managers of aquatic systems that have become infested with Eurasian watermilfoil usually use herbicides to achieve some control. Newroth (1974) gives an exhaustive review of the literature on the herbicidal control of aquatic plants and indicates that 2,4-D (2,4-dichlorophenoxy acetic acid), diquat, paraquat, and endothall are effective in controlling Eurasian watermilfoil. *Myriophyllum spicatum* is very susceptible to 2,4-D (Smith 1971, Aiken et al. 1979), making 2,4-D the usually preferred herbicide.

Other Control Measures

11. Mechanical harvesting of Eurasian watermilfoil has been tried at a variety of locations with mixed results. Some claim that the extent and degree of infestation are increased because of fragmentation caused by harvesting operations (Newroth 1974). However, harvesting appears to have been effective in Wisconsin (Nichols and Cottam 1972, Nichols 1972).

12. Water level manipulations can also be used to control this noxious weed. Goldsby (1977) indicates that drawdowns as brief as 3 weeks can achieve substantial control in Tennessee Valley Authority (TVA) reservoirs. Hirst and Bank (1971) found that raising the water level by 15 ft* will kill *Myriophyllum* in shallow water.

13. Other manipulative measures, such as dredging and use of plastic film, while occasionally effective, are too costly for widespread application (Newroth 1974).

14. Several pathogens have been reported to affect *M. spicatum*. Lake Venice disease, characterized by a light-brown coating on the leaves that increases in thickness, eventually kills the plant. This pathogen was discovered in Maryland in 1962, but the causative agent was not found (Elser 1969). Northeast disease, first observed in 1964, is characterized by rigidity of leaves and stems, broken leaf divisions, and reduced leaf size (Elser 1969). The pathogen causing this disease was not identified either and laboratory transmission was unsuccessful (Bayley 1970).

15. The white amur, *Ctenopharyngodon idella* Val., eats *M. spicatum*, and the release of this fish appears to have controlled *M. spicatum* in Deerpoint Reservoir in northwest Florida (Kobylinksi et al. 1980). However, the fish prefers other aquatic macrophytes, and 4 years elapsed before an impact on *M. spicatum* density was noted.

Foreign Searches for Possible Biological Control Agents

16. Most of the control measures discussed thus far are costly and their effects are short-lived and require frequent retreatment. Since the mid-1960's there has been an interest in finding and establishing insect species or other organisms which, through their feeding or other activities, would reduce *M. spicatum* infestations. An ideal biological control agent, while difficult and expensive to discover,

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* A table of factors for converting U. S. customary units of measurement to metric (SI) is presented on page 7.

evaluate, and establish, would, once it becomes established, maintain and disperse itself with little additional effort and expense. It should result in new, lower levels of the pest, although complete eradication is neither expected nor hoped for.

17. Table 1 presents a chronological list of the efforts to find biological control agents on Eurasian watermilfoil. Of 25 species of insects discovered feeding on *M. spicatum* in Europe (Spencer 1974; Spencer and Lekic 1974), 3 appeared most promising: the aquatic pyralid moths *Acentria nivea* (Olivier) and *Parapoynx stratiotata* L., and the weevil *Litodactylus leucogaster* (Marshan). *Acentria nivea* was already present in the United States. Populations of *A. nivea* were tested in the laboratory by Batra (1977) and Buckingham (1979), who found that it had a relatively wide host range and that its developmental time probably precluded it from reaching population densities that would cause significant damage.

18. It was later learned that *L. leucogaster* also had been collected in the United States, but had been known as *Phytobius griseomicans* until its synonymization by Dieckmann (1972). Buckingham (1979) evaluated populations of *L. leucogaster* originally collected in California. He found it relatively specific to *M. spicatum*, but its damage was confined to the flowers and seeds. Since reproduction from seed is considered of minor importance in the United States, this weevil's impact as a biological control agent probably would be negligible.

19. Habeck (1979), after field studies of *Parapoynx stratiotata* near Rome, Italy, concluded that its feeding range is too broad to consider it for introduction into the United States. However, he noted that the literature indicates this species is more specific in other parts of Europe.

20. Other foreign workers, while not directly looking for enemies of *M. spicatum*, have incidentally reported on organisms feeding on this widespread plant. Gaevskaya (1969), in his exhaustive summary of world literature dealing with animals feeding on aquatic macrophytes, lists many organisms, including snails, crustaceans, and birds, along with a variety of insects, that feed on *M. spicatum* and other milfoils.

However, it is usually difficult to determine from his brief accounts of other experimenters' works whether the organisms, especially the insects, are feeding on dead plant tissue, on algae and other epiphytes attached to the plants, or on the actual living plant tissue. This researcher believes that organisms feeding on living plant tissue are much less common than Gaevskaya's lists would indicate.

21. Bownik (1970), Soszka (1975), and Urban (1975) studied the organisms associated with four species of aquatic plants in Polish lakes; all found that various species of Chironomidae (midge) larvae were the most common insects on *M. spicatum* and that *M. spicatum* usually had the least fauna of the four submersed macrophytes studied. Urban (1975) noted that insect mining activity, primarily that of the Chironomidae, caused only 0.3 percent loss of biomass in *M. spicatum.*

Domestic Insects

22. The fauna associated with *M. spicatum* in the United States is very poorly known. This researcher is aware of only a single published work dealing specifically with the subject. Menzie (1980) recently published the results of his studies of fauna associated with *M. spicatum* in the lower Hudson River. He found that Chironomidae larvae were the dominant organisms associated with the plant, and, of these, *Cricotopus sylvestris* was dominant. Kobylinski et al. (1980) noted the macroinvertebrates affected by the use of white amur to control *M. spicatum.*

23. One probable reason for the paucity of records of organisms associated with *M. spicatum* is the very localized distribution this species had until the mid-1950's. There are a few records of insects associated with *M. exalbescens*, which is considered more widespread. McGaha (1952) mentions that in Michigan seven species of insects, primarily caddisfly (Trichoptera) and midge (Diptera:Chironomidae) larvae, obtained at least a portion of their nutritive requirements from *M. exalbescens*. Scheiring and Foote (1973), in studying shore flies (Diptera: Ephydridae) of Ohio, noted some species were common in aquatic vegetation, which included *M. exalbescens*.

24. Since the insects associated with *M. spicatum* in the United States are poorly known, it is possible there are species present that could aid in controlling this pest. A thorough knowledge of the domestic insect fauna associated with *M. spicatum* is necessary if foreign studies to locate a biological control agent are to be effective. Had the presence of *A. nivea* and *L. leucogaster* been known in the United States, the emphasis of foreign studies, especially of these insects, probably would have been shifted.

PART II: METHODS AND MATERIALS

Sampling Areas

25. Since Eurasian watermilfoil is widespread throughout North America, sampling areas were selected on the basis of one or more of the following criteria: (a) presence of large infestations of Eurasian watermilfoil in the area; (b) availability of reservoir managers, cooperating scientists, or other personnel to guide researchers to exact locations of infestations; (c) indications from the literature and/or from other scientists of the presence in the locality of insect species that might be stressing Eurasian watermilfoil; and (d) anticipated costs in time and finances to sample in the area.

Sample Collection

26. At each collecting area, a sample of Eurasian watermilfoil, approximately 2 to 4 kg wet weight, was obtained with a rake or by hand from a dense portion of the mat, usually reached from a boat or an airboat. At sparsely infested areas, movement from one clump of milfoil to another was necessary to obtain sufficient plant material. Most of the Florida collections were made with a specially constructed sampler that removed a 0.125-m^2 portion of mat and associated fauna down to a depth of 4 m (Figure 5). The sampler is basically an aluminum box, open on both ends, with sharpened stainless steel blades on the bottom edges and a mesh bag over the top. A trap door with a screen bottom is closed by means of ropes once the sampler reaches the bottom. Five quantitative samples are usually taken to estimate the variability of both insect and *M. spicatum* biomass.

27. Each Eurasian watermilfoil sample taken was placed in a plastic bag marked with an identifying collection number. Initially, the plant samples were immediately searched in the field for insects. However, by the end of 1978, samples were searched in the laboratory to

Figure 5. Quantitative sampler for submersed aquatic vegetation and associated fauna

allow more time for field sampling and because microscopic examination was more thorough.

28. Environmental data recorded in the field notebook, under the corresponding collection number, included: water depth, mat depth (if below the surface), water temperature, salinity, conductivity, and water transparency. The depth of the water and mat were measured with a lead-line marked in 0.1-m intervals. Water temperature, salinity, and conductivity were measured with a Yellow Springs Instrument Company Model 33 portable water quality meter. Water transparency was measured using a 20-cm Secchi disk attached to a line marked in 0.1-m intervals. Secchi disk transparency readings were difficult to obtain and of limited value since most sites were too shallow for disappearance of the disk.

29. Bagged samples of Eurasian watermilfoil were placed on ice as soon as possible and shipped air-freight to the laboratory in Fort Lauderdale, Fla., where they were frozen. As time permitted, samples

were thawed and a technician inspected each piece of plant material under a dissecting microscope, removed any fauna, and placed it in 80 percent isopropyl alcohol in vials marked with the collection number. Twenty-five randomly chosen strands of milfoil from each sample were rated for the amount of apparent feeding damage. Leaves and stems on each of the 25 strands were rated on a scale of 1 to 4, with 1 being no damage and 4 being severe damage. It was frequently difficult to interpret whether damage, especially severe damage, was due to feeding or to environmental factors such as low temperature, wave action, or other factors (e.g. toxins or herbicides). Hence, the damage ratings probably overestimated the amount of insect feeding damage.

30. The plants were sorted by species (if species other than *M. spicatum* were present); all the fauna was removed; and the wet weight of each plant species was recorded. Several plant specimens from each collection were pressed and mounted on herbarium sheets to serve as voucher specimens. The plant samples were then dried to a constant weight and their dry weights recorded.

31. Insects were sorted into groups and identified. The work of Merritt and Cummins (1978) was useful in identifying aquatic insects, especially the immature stages, to family level. Many families of insects could be identified to generic level using Pennak (1978) and Usinger (1956). Wiggins and MacKay (1977) was excellent for identifying the genera of caddisfly larvae (Trichoptera). Simpson and Bode (1980), Mason (1973), and Beck (1977) were useful in identifying midge (Chironomidae) larvae to genus. Dragonfly (Odonata:Anisoptera) larvae, when large enough, usually could be identified to species level using Needham and Westfall (1954). This reference was the only one that had keys to all the U. S. species of this major group of aquatic insects. Species level determinations for other groups were very difficult. Regional, localized treatments for some taxa were helpful. Among the most noteworthy of these were: Berner (1950) for Florida mayflies (Ephemeroptera), Bobb (1974) for Virginia Hemiptera, Walker (1953) for the Canadian damselflies (Odonata), and Young (1954) for Florida beetles (Coleoptera). If not covered by these works, the insect could usually be

identified only to genus. Dr. Dale Habeck, University of Florida, identified the aquatic moth (Lepidoptera) larvae.

32. All data, including species counts, gathered from July 1978 through July 1980 were entered into a computer for statistical analyses. Data from the quantitative collections were graphed to show seasonal variation in plant biomass and faunal populations.

33. Determination of whether an insect species was damaging Eurasian watermilfoil was based primarily on literature records, which were especially useful in excluding groups. This was supplemented by personal observation of actual feeding and by correlations between the density of a particular species and the damage to Eurasian watermilfoil.

Site Descriptions

34. Table 2 provides the exact locations and dates for all Eurasian watermilfoil collections. General comments about the collection sites in each state are provided below. Figure 6 shows a typical infestation.

Alabama

35. Five sites were visited in the backwaters and main body of Guntersville Reservoir. This shallow impoundment is the most seriously infested of all of the TVA system of reservoirs (T. Goldsby, personal communication).

California

36. A collection was taken from points along the shoreline of Pilarcitos Reservoir, near San Francisco. This is where the weevil *L. leucogaster* was collected and sent to Dr. Gary Buckingham, who studied its biology and potential as a biological control agent on *M. spicatum*. A sample was also taken from the South Alamo Canal in Imperial County, approximately 10 miles north of the Mexican border.

Florida

37. Eurasian watermilfoil is not widespread in Florida. However, there are many thousands of acres infected with *M. spicatum* along the Homosassa River and Crystal River estuaries. Crystal River was sampled

Figure 6. Typical *M. spicatum* infestation, St. Lawrence Lake near Robert Moses State Park, New York, collection site 78503

on a monthly basis and 18 collections were made there. *Myriophyllum spicatum* is also present in widely dispersed clumps at Salt Springs Run, where two collections were made.

Georgia

38. Lake Seminole, which is at the junction of the borders of Florida, Georgia, and Alabama, has many thousands of acres infested with *M. spicatum*, primarily in Georgia, where two collections of Eurasian watermilfoil and associated insects were made.

Louisiana

39. Three collections were made at Toledo Bend Reservoir, a recent impoundment of the Sabine River. The reservoir, with its 1250 miles of shoreline, much of which is fringed with *M. spicatum*, is one of the major Eurasian watermilfoil infestations in the United States. False River Lake, in central Louisiana, where *M. spicatum* grows in widely scattered clumps intermixed with other aquatic vegetation, was also sampled.

New York

40. Several days were spent collecting at St. Lawrence Lake in northern New York's Robert Moses State Park (Figure 6). Some of the large patches of *M. spicatum* in this area had previously been found to harbor relatively dense populations of the aquatic moth *A. nivea*, which has been considered for use as a biological control agent on *M. spicatum*. Three of the Finger Lakes in western New York were also sampled. The infestation at Cayuga Lake was quite severe, especially at the north end, while the infestations at Seneca Lake and Owasco Lake were not as bad. An infested bay of Lake Ontario and a stream feeding into the lake were also sampled.

Oklahoma

41. Samples were taken from the Illinois River, a generally shallow, cool stream stocked with trout, and from Robert S. Kerr Reservoir, probably Oklahoma's best-known Eurasian watermilfoil infestation.

Tennessee

42. Three TVA reservoirs (Nickajack, Chicamauga, and Ft. Loudon) were sampled. The milfoil infestations in these reservoirs were much smaller than that at TVA's Guntersville Reservoir in Alabama. Infestations along the Tennessee and Clinch Rivers were also sampled, as were several ponds near these rivers.

Texas

43. Infestations in a spring run and a lake within the city limits of Austin were sampled. Infestations in the spring-fed San Marcos River, about 50 miles south of Austin, and at Lake Conroe about 60 miles north of Houston, were also sampled, as were several locations on the Texas side of Toledo Bend Reservoir.

Washington

44. Infestations along the north and south shore of Lake Washington's Union Bay in Seattle were sampled. *Myriophyllum spicatum* has become a problem in the state of Washington only in the last few years.

Wisconsin

45. Several areas within the city limits of Madison on and near

Lake Wingra and Lake Mendota were sampled. The infestation at Lake Wingra is longstanding and well documented, primarily by researchers from the nearby University of Wisconsin. During 1979, the infestation was at a low level compared to previous years. *Myriophyllum spicatum*, well interspersed among eelgrass, *Vallisneria* sp., and pondweeds, *Potamogeton* spp., was also collected from the large but very shallow Buffalo Lake about 50 miles north of Madison.

PART III: RESULTS

46. The locations and dates for all 69 Eurasian watermilfoil collections are listed in Appendix A, which also lists the collection method and the number of samples comprising each collection. Three collections of *M. exalbescens* are included in Appendix A for comparison.

47. Appendix B presents data describing the collection site parameters and those delineating the floral sample. Water depth, mat depth, temperature, salinity, conductivity, Secchi disk transparency, and the wet and dry weights of each aquatic plant species in the sample are listed. Most earlier samples are missing part or all of these data since test protocol had not been established. Other missing data are due to lack of measuring instruments when originals were being repaired or replaced. Also included in this table are average damage ratings for both leaves and stems for top, middle, and lower portions (six different ratings per collection) of 10 randomly chosen plant specimens from each collection.

Annotated List Explanations

48. All insect species collected are listed in the following pages. Information about the relationship of each group to aquatic plants is noted. The total number of specimens of each species is given. Collection numbers where each species was collected are listed and the patterns of distribution noted. The number of specimens from Crystal River is noted separately. Since 20 collections came from there, any species abundant at Crystal River would tend to exaggerate that species' commonness on a national scale. The orders of insects are arranged in evolutionary order, the more primitive insect orders first and the more highly evolved orders last, following the pattern of Merritt and Cummins (1978). Within the orders, the families are arranged alphabetically as are the genera and species found in each family. The species are numbered and an asterisk (*) appears if that particular species is thought to feed on *M. spicatum*. An asterisk followed by a

question mark (*?) precedes species considered possible feeders.

49. Appendix C presents the data from the quantitative samples at Crystal River.

Annotated List of Insects Collected on *Myriophyllum Spicatum*

Ephemeroptera (Mayflies)

Although not numerous, the nymphs of mayflies were fairly frequently encountered, with 248 specimens found in 18 of the 46 non-Florida collections and 10 of the 23 Florida collections. Mayfly nymphs are usually considered opportunistic omnivores (Edmunds et al. 1976), although some consider them primarily herbivorous (Pennak 1978). Detritus, diatoms, and other algae are the preferred plant material (Edmunds et al. 1976), although Pemberton (1980) noted an African species feeding on the leaves of *Hydrilla*. Five specimens were too deteriorated for identification.

Family BAETIDAE

1. *Callibaetis* spp. - 14 specimens in 7 collections from Georgia, Louisiana, New York, Oklahoma, and Tennessee (collections 78503, 78514, 78517, 78518, 78519, 79541, and 79552). The nymphs of this genus are known to be associated with aquatic macrophytes, especially in lentic habitats (Edmunds and Cummins 1978). The nymphs are herbivorous, feeding on algae and diatoms found on the plants (Edmunds et al. 1976). Approximately 24 species are known from the United States; only the specimens from Florida were identified to species level. Kobylinski et al. (1980) reported *Callibaetis* on *M. spicatum* in northern Florida.

2. *Callibaetis floridanus* Banks (Figure 7) - 76 specimens in 10 collections from Crystal River, Florida (collections 78508, 78510, 79525, 79526, 79548, 79559, 79560, 80501, 80506, and 80507). Berner (1950) recorded this species from a *Myriophyllum*-infested lake in Florida. This species ". . .

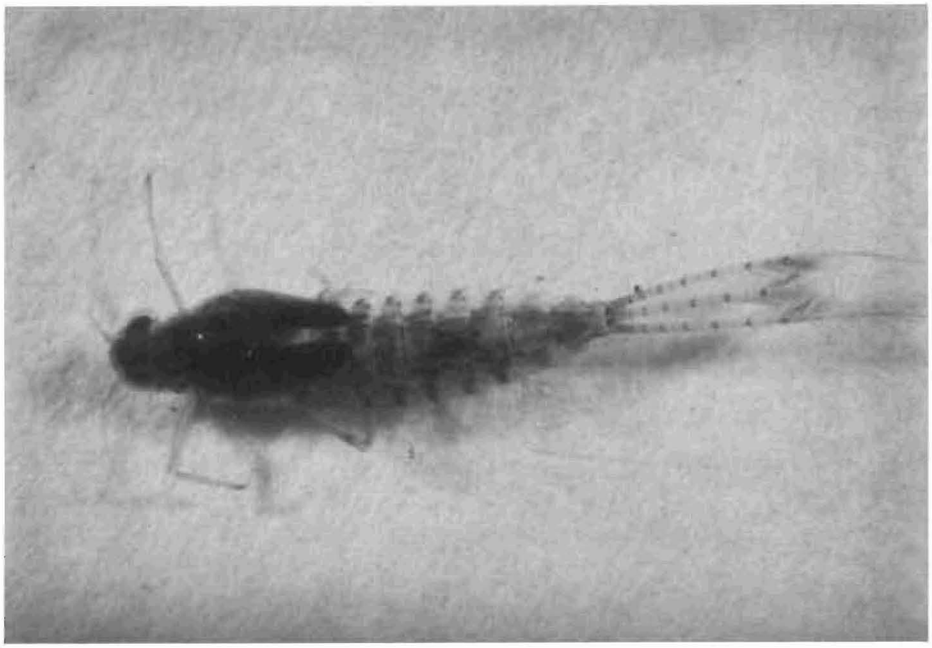

Figure 7. *Callibaetis floridanus* (Banks) nymph (Ephemeroptera:Baetidae)

is the only mayfly in North American which is known to inhabit brackish water" (Berner 1950, p 198).

Family CAENIDAE

3. *Caenis* spp. - 114 specimens in 12 collections from Alabama, Georgia, New York, Tennessee, Texas, and Wisconsin (collections 78501, 78508.3, 79530, 79533, 79535, 79536, 79539, 79540, 79541, 79544, 79545, and 79556). Members of this genus were widely distributed and occasionally fairly abundant (0.18 specimens/g dry weight at collection 79539 in Alabama). This genus contains 13 U. S. species, but species level determination could be made only for Florida material. Kobylinski et al. (1980) reported *Caenis* on *M. spicatum*.

4. *Caenis diminuta* Walker (Figure 8) - 39 specimens in 10 collections, all from Crystal River, Florida (collections 79521,

79525, 79548, 79560, 80501, 80502, 80503, 80505, 80506, and 80507). These nymphs were frequently collected at Crystal River, although their numbers were usually low, well under the maximum of 21 nymphs/m^2 found in the July 1980 collections. Nymphs are known to prefer submersed vegetation and they feed on plant material, including the epidermis of macrophytes (Berner 1950). There is no indication that they damage living *M. spicatum*.

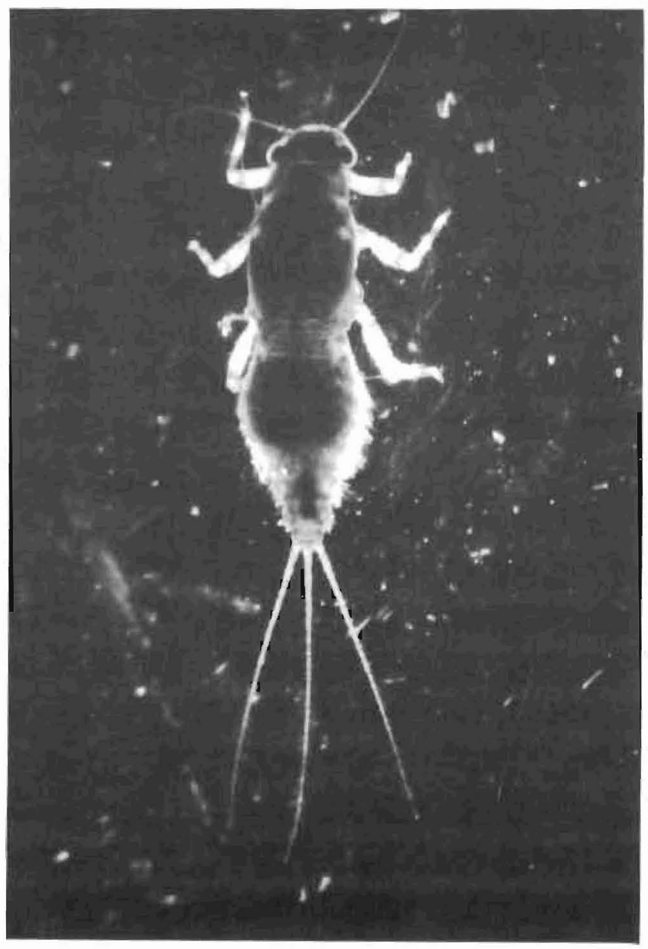

Figure 8. *Caenis diminuta* (Walker) nymph
(Ephemeroptera:Caenidae)

Odonata (Dragonflies and Damselflies)

Suborder Anisoptera (Dragonflies)

Only 26 dragonfly nymphs were collected during this study. Most dragonfly nymphs live on or in bottom sediments and it appears that few use *M. spicatum* as a base for their activities. All dragonflies, both adults and immatures, are predacious. They have little impact on the growth of aquatic macrophytes, except indirectly by preying on other organisms such as midge or moth larvae that might damage aquatic plants.

Family CORDULIDAE

5. *Tetragoneuria* sp. - a single specimen from Texas (collection 78520).

Family LIBELLULIDAE

6. *Erythemis simplicicollis* Say (Figure 9) - 24 specimens in 5 collections from Alabama, Louisiana, Tennessee, and Texas (collections 78518, 79535, 79539, 79543, and 79555). This species appears to be the dragonfly most often invading *M. spicatum*. It is one of the more abundant Anisoptera species in waterhyacinth roots (Balciunas 1977).

7. Unindentified libelludid species - 1 specimen from Tennessee (collection 79544). This single specimen, while not an *Erythemis*, was too small to be accurately identified even to genus.

Suborder Zygoptera (Damselflies)

Unlike the Anisoptera, damselfly nymphs are frequently associated with aquatic vegetation and have adapted well to *M. spicatum* mats. Almost 400 specimens were collected from 10 states. Like dragonflies, damselflies are predacious and do not feed on plant material. Many

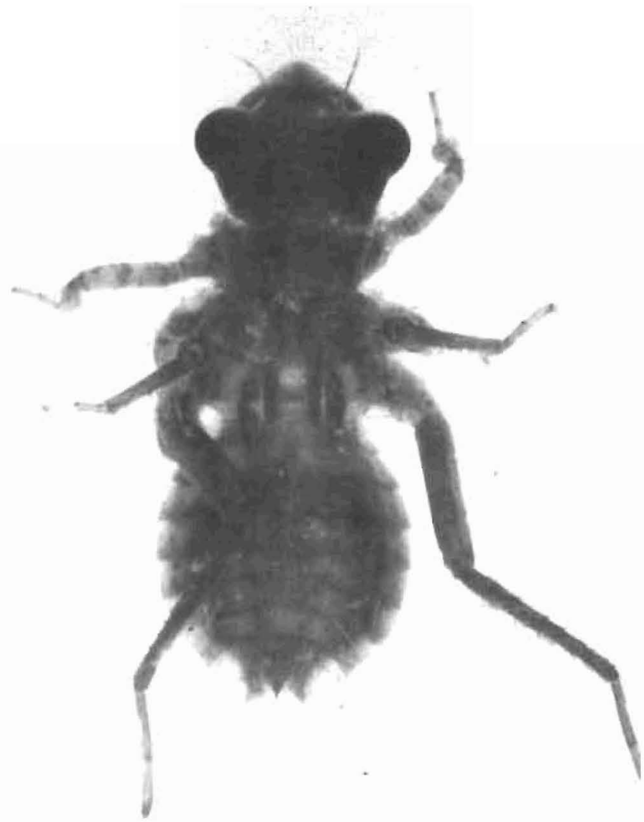

Figure 9. *Erythemis simplicicollis* Say
nymph (Odonata:Libellulidae)

species, however, oviposit on or in plants, both above and below the water surface, and their oviposition sites may serve as entry points for pathogens. Like other generalized predators, damselfly nymphs may reduce population levels of prey organisms, some of which might cause injury to *M. spicatum*.

Family COENAGRIONIDAE

Nymphs of this family were second in abundance only to midge (Chironomidae) larvae. However, they were more frequent (i.e., found in more collections) than any other group, appearing in over two thirds of the collections. In the keys, generic and species level identifications are based on characteristics of the caudal gills or lamellae, and less than 20 percent of the current specimens still had their gills intact. Of the damselflies collected, 92 were too badly damaged or too small for identification even to genus level.

8. *Argia* sp. - 1 specimen from Louisiana (collection 78315).

9. *Enallagma* spp. (Figure 10) - 166 specimens from Alabama, California, Florida, Louisiana, New York, Oklahoma, Tennessee, Texas, and Wisconsin (collections 78504, 78505, 78510, 78515, 78517, 78518, 78520, 79522, 79524, 79526, 79527, 79529, 79530, 79533, 79535, 79539, 79544, 79545, 79546, 79548, 79549, 79552, 79553, 79555, 79559, 79560, 80501, 80502, 80503, 80506, and 80507). A widely distributed group, *Enallagma* spp. were found in 40 percent of the collections. The nymphs of the 34 U. S. species of *Enallagma* are very poorly known and are difficult to distinquish. Probably 6 to 10 different species are present in the above collections. Members of this genus were collected on *M. spicatum* both by Menzie (1980) and Kobylinski et al. (1980).

Figure 10. *Enallagma* sp. nymph (Odonata:Coenagrionidae)

10. *Ischnura* spp. - 110 specimens from Alabama, California, Florida, Louisiana, New York, Oklahoma, Tennessee, Texas, and Wisconsin (collections 78502, 78503, 78505, 78508, 78511, 78515, 78517, 78519, 79524, 79525, 79526, 79530, 79532, 79535, 79536, 79539, 79540, 79545, 79548, 79549, 79553, 79555, 79556, 79557, 79559, 79560, 80501, 80503, 80506, and 80507). The nymphs of *Ischnura* were also frequently encountered and were frequently found along with *Enallagma* spp. nymphs. Probably at least 2 or 3 of the 7 known U. S. species of *Ischnura* are present in the above collections.

Homoptera (Aphids)

Family APHIDAE

Aphids and other Homoptera are not considered truly aquatic since they have no obligatory life stage in or on the water. However, aphids frequently are found on the flower spikes of *M. spicatum*. Although they feed on the plant sap, it is doubtful that they cause serious damage at the densities usually observed. However, their feeding punctures may serve as entrance points for plant pathogens.

*11. Prob. *Rhopalosiphum nymphaeae* (L.) - 11 specimens in 3 collections from Alabama, Florida, and Wisconsin (collections 78510, 79537, and 79539). This species, sometimes known as the plum aphid, has a very wide host range and a cosmopolitan distribution. Gaevskaya (1969) lists 22 species of aquatic plants, mostly from Europe and Russia, on which this species has been found. The low abundance of the aphid in this survey is due to the infrequency of flowers at collecting sites and the fragility of the insect. It appears to burst or deform upon freezing and, even when present, was very hard to detect in the samples due to its superficial resemblance to flower parts of *M. spicatum*.

Hemiptera (True Bugs)

The aquatic Hemiptera, most of which are predacious, were poorly represented in the *M. spicatum* collections.

Family BELOSTOMATIDAE

12. Unidentified - 2 specimens from Texas (collection 80510). These specimens were too tiny for further identification. Belostomatids are predacious.

Family CORIXIDAE (Water Boatmen)

13. *Trichocorixa* sp. (Figure 11) - 6 specimens in 3 collections from Florida and New York (collections 78503, 79525, and 79560). Most water boatmen are omniverous or herbivorous, feeding on particulate organic material. Members of this genus, however, are primarily carnivorous (Cummins and Polhemus 1978).

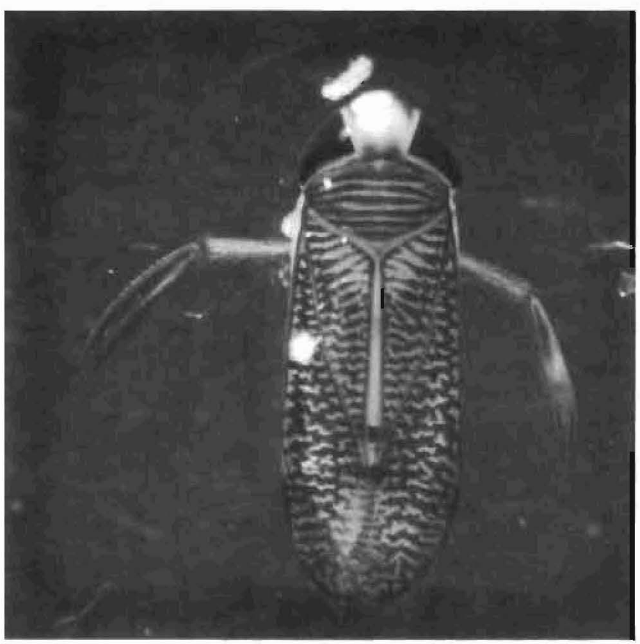

Figure 11. *Trichocorixa* sp. (Hemiptera:Corixidae)

Family MESOVELIIDAE (Water Treaders)

14. *Mesovelia* sp. - 6 specimens in 4 collections from Florida and New York (collections 78503, 78510, 79526, and 79529). *Mesovelia* are frequently associated with aquatic plants. Members of this genus are carnivorous.

Family HEBRIDAE (Velvet Water Bugs)

15. *Merragata* sp. - 2 specimens from Tennessee (collection 79541). Members of this genus and family are carnivorous.

Family PLEIDAE (Pygmy Backswimmers)

16. *Neoplea* sp. - 1 specimen from Wisconsin (collection 79531). Pygmy backswimmers frequent dense aquatic vegetation where they prey upon smaller organisms, especially microcrustacea (Cummins and Polhemus 1978).

Tricloptera (Caddisflies)

Caddisfly larvae were well represented in the Eurasian watermilfoil collections. Some 285 specimens, representing at least 9 species, were found in almost half (N=35) of the collections. Only the midge (Chironomidae) larvae and damselfly (Zygoptera) nymphs were more numerous. Caddisfly larvae are usually omnivorous and most of the plant material consumed is detritus. Relatively few species feed directly on aquatic macrophytes.

Family HYDROPTILIDAE

This family is frequently referred to as micro-caddisflies because of their small size, usually under 6 mm. This small size makes them easy to overlook and hard to identify. There are at least 175 species in 14 genera north of Mexico, and most of these feed on filamentous algae or diatoms (Wiggins and MacKay 1977). Members of this family are unusual in that only the final (fifth) larval instars build the cases that are so characteristic of caddisfly larvae.

17. *Agraylea* prob. *multipunctata* Curtis - 51 specimens from 3 collections in New York (collections 78505, 78509.1, and 78509.2). Larvae of this species (Figure 12) are usually found ". . . in beds of submerged aquatic plants where they feed on the cellular contents of filamentous algae." (Wiggins and MacKay 1977, p 126).

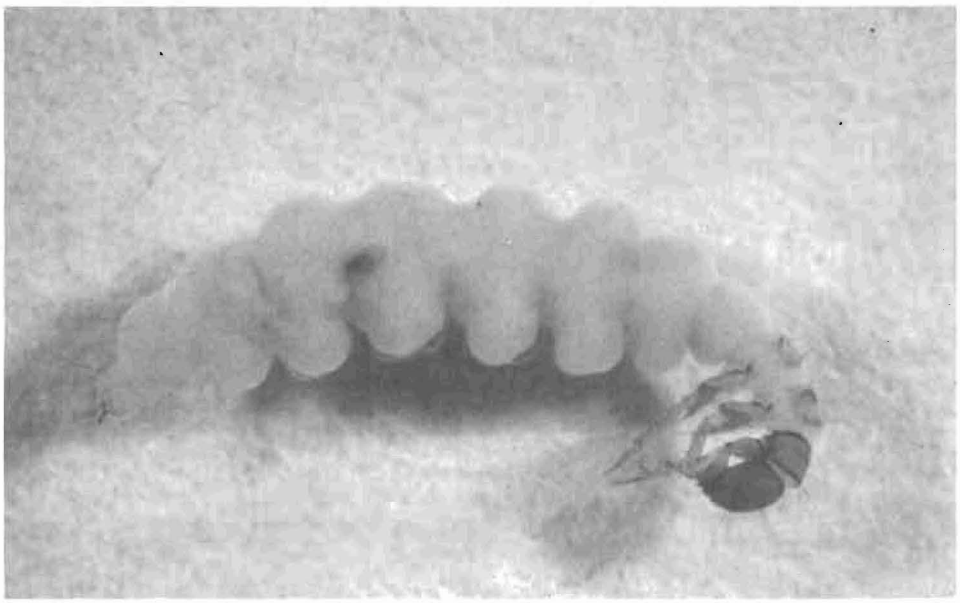

Figure 12. *Agraylea* prob. *multipunctata* Curtis larva (Tricoptera:Hydroptilidae)

18. *Agraylea* prob. *saltesa* Ross - 7 specimens from 3 collections in California and Washington (collections 78512, 78514, and 78515). This is the western member of this genus; the larvae probably have feeding habits similar to *A. multipunctata*.

19. *Hydroptila* sp. - 1 specimen from Crystal River (collection 80506). There are some 60 species of *Hydroptila* known from North America. The larvae feed on cellular contents of filamentous algae.

20. *Orthotrichia* spp. - 140 specimens in 11 collections from Crystal River, and an additional 11 collections from Alabama,

Georgia, Louisiana, New York, and Texas (collections 78502, 78504, 78510, 78517, 79521, 79526, 79527, 79529, 79535, 79536, 79537, 79538, 79554, 79556, 79559, 79578, 80501, 80502, 80503, 80505, 80506, 80507). The tiny larvae of this genus (Figure 13), usually less than 3.5 mm long, were the most frequently collected and abundant caddisfly larvae on Eurasian watermilfoil. Since these larvae were found in a variety of locations in almost one third of the collections, probably several of North America's 6 species are represented. The larvae live among submersed plants in lentic waters and feed primarily on filamentous algae (Wiggins and MacKay 1977).

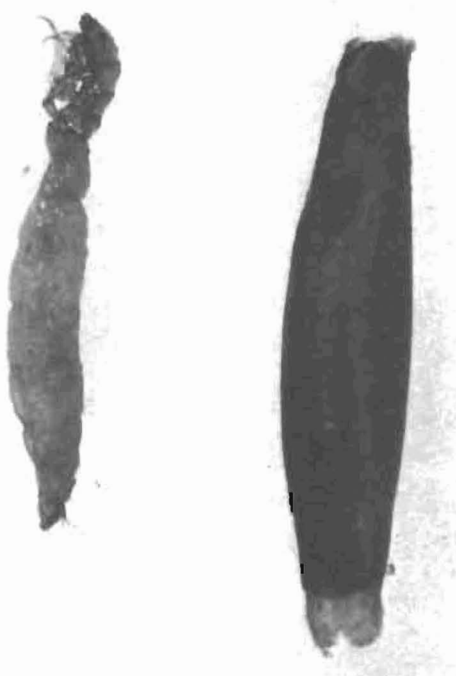

Figure 13. *Orthotrichia* sp. larva and case (Tricoptera:Hydroptilidae)

21. *Oxytheria* sp. - 2 species from Texas (collection 79522). The ecological requirements and feeding habits of *Oxytheria* larvae are similar to those of *Orthotrichia*. This genus has

also been found on *M. spicatum* in North Florida (Kobylinski et al. 1980).

Family LEPTOCERIDAE

Approximately 100 species in 7 genera are known from this family in North America. Found in warmer, permanent waters, most larvae are omnivorous, but one genus is predatory and several genera have members that feed on aquatic macrophytes.

*?22. *Leptocerus americanus* (Banks) (Figure 14) - 35 specimens from 4 collections in Wisconsin (collections 79530, 79531, 79532, and 79534). The larvae of *L. americanus* swim actively, carrying their case, among the aquatic plants among which they are found. Their primary food appears to be fine particulate matter. McGaha (1952) reports this species feeding on 3 species of submersed plants; therefore, this caddisfly should be considered as possibly feeding on *M. spicatum*.

*?23. *Oecetis* sp. similar to *cinerascens* - 47 specimens, mostly from Alabama and Wisconsin, with an additional specimen from both Florida and Texas (collections 79526, 79531, 79532,

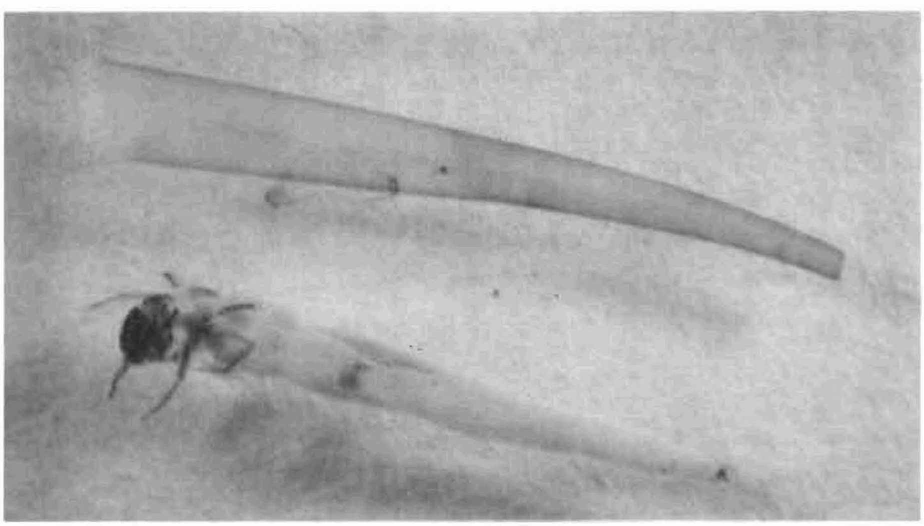

Figure 14. *Leptocerus americanus* (Banks) larva and case (Tricoptera:Leptoceridae)

79534, 79535, 79537, 79539, and 79553). The larvae of *Oecetis* (Figure 15) are bottom-dwellers and, unlike most caddisflies, are predatory, although a Japanese species has been reported to feed on rice plants (Wiggins and MacKay 1977). This species was reported by McGaha (1952) to feed on *M. heterophyllum* and thus should be considered a possible feeder on *M. spicatum*.

24. *Oecetis* sp. - 1 larva from Texas (collection 79556). Only a single larva of what appears to be *Oecetis*, but differing greatly from the previous species, was collected.

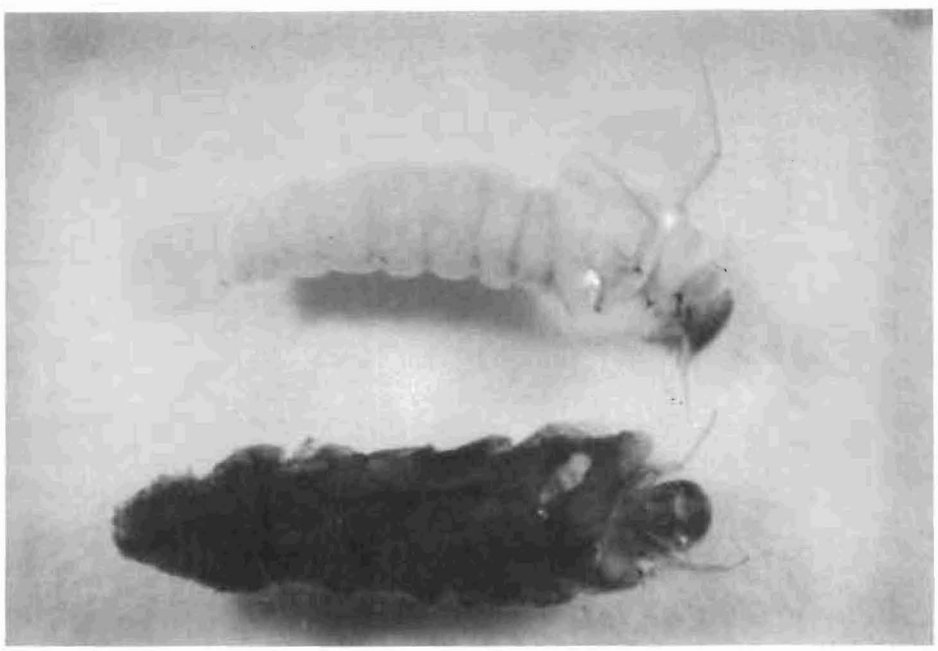

Figure 15. *Oecetis* sp. similar to *cinerascens* larva and case (Tricoptera:Leptoceridae)

Family PHRYGANEIDAE

There are 27 species in 10 genera in this family in North America, and most are considered omnivorous although some are largely predacious (Wiggins and MacKay 1977).

*25. *Fabria* sp. prob. *inornata* (Banks) - a single larva from New York (collection 78505). This species lives in dense, submersed aquatic vegetation and is important and fairly unique in that it not only uses pieces of aquatic plants for building its case, but also feeds on vascular aquatic plants (Wiggins and MacKay 1977).

Lepidoptera (Moths and Butterflies)

Although butterflies and moths are not usually aquatic, several families of Lepidoptera have larvae that are truly aquatic. Since almost all Lepidoptera species are herbivorous, the specimens collected were of considerable interest.

Family PYRALIDAE (Snout Moths)

The relatively few aquatic members of this large family are extremely important aquatic herbivores. The larvae, of which 118 were collected, live in the water, are voracious feeders, and cause considerable damage to the aquatic plants on which they feed. They probably do more noticeable damage to submerged aquatic plants than any other insect group. Most of the aquatic Pyralidae are members of the subfamily Nymphulinae. Of the five genera of aquatic pyralids collected during this survey, all but *Acentria* are members of this subfamily.

26. *Acentria nivea* (Olivier) (Figure 16) - 106 specimens in 9 collections from New York and 2 specimens from Wisconsin (collections 78503, 78504, 78506, 78508.1, 78508.3, 78504.1, 78509.1, 78509.2, 78516, and 79534). This species, which appears to be the most abundant Lepidoptera on *M. spicatum*, especially in the northern United States, became of considerable interest when researchers in eastern Europe discovered it on *M. spicatum* and noted its potential for controlling this pest (Lekic and Mihajlovic 1970). A subsequent search of the records showed this species as having been recorded in Canada in 1927 (Sheppard 1945), although its preferred host was thought to be *Ceratophyllum demersum* (Judd 1950). This species, unlike the other moths collected, is a member of

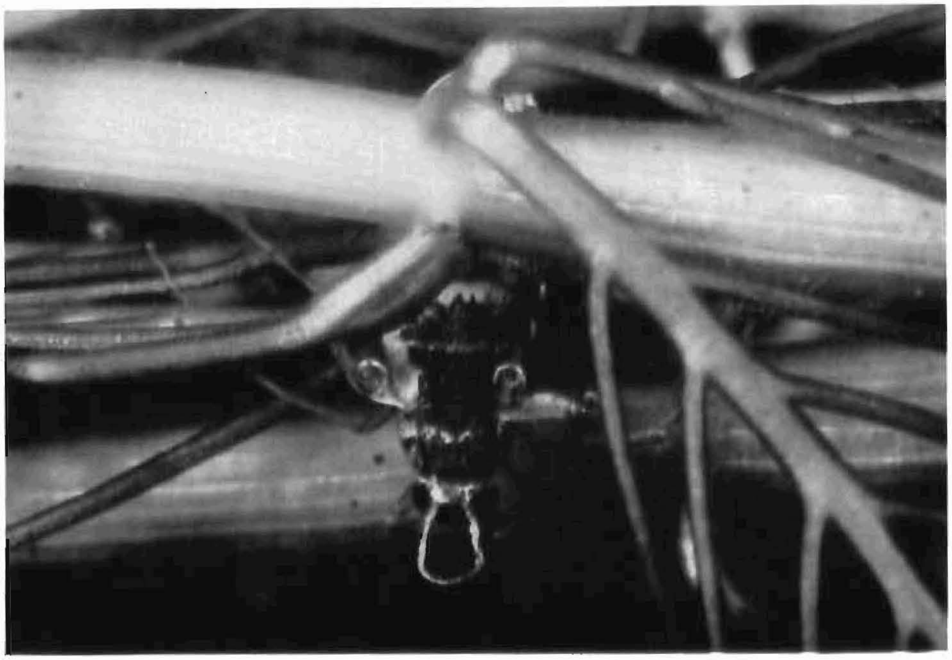

Figure 16. *Acentria nivea* (Olivier) larva (Lepidoptera: Pyralidae) (Photo courtesy of Dr. Gary Buckingham)

the subfamily Schoenobinae. The larvae were observed feeding on leaves and boring into stems. Most of the tips of *M. spicatum* at St. Lawrence Lake showed *Acentria* feeding damage. Although most *M. spicatum* tips were at or near the surface, most boring damage was found 1.5 m from the tips, and almost no boring damage was closer than 0.9 m from the tips. The adult females of this species are unusual since some are wingless and therefore flightless (Figure 17), a highly unusual modification for a moth species. These wingless females, which have been known from Europe and America for many years (Treat 1955), remain just below the water surface after emerging from their pupal cases, awaiting insemination by the males that are winged. While an individual *Acentria* larva causes considerable damage to its host plant, it remains to be determined whether populations occurring in the field are high enough to measurably reduce host levels.

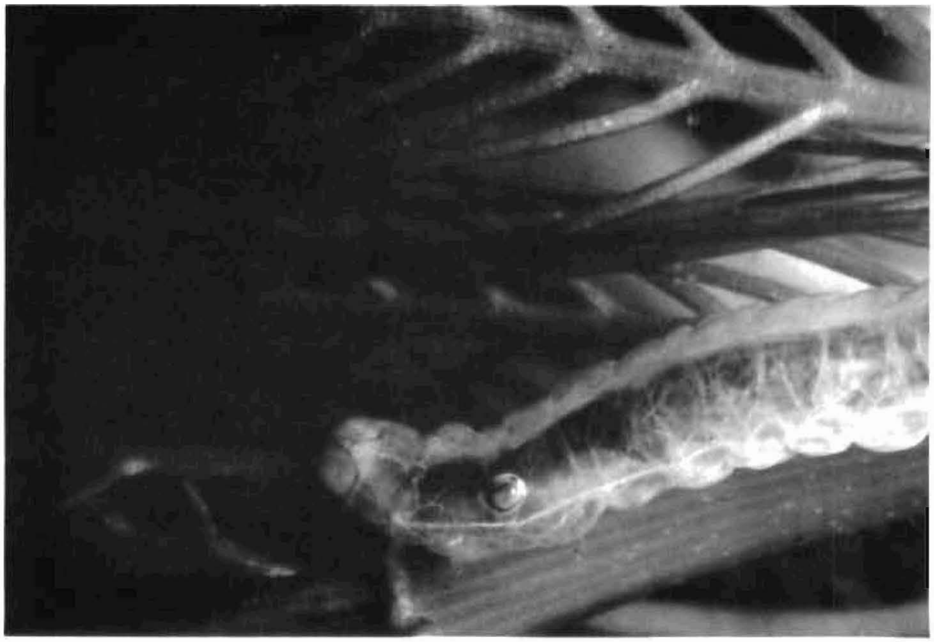

Figure 17. *Acentria nivea* flightless female on *M. spicatum* below water surface (Photo courtesy of Dr. Gary Buckingham)

27. *Eoparargyractis* sp. - one larva from Georgia (collection 78501). While the biology of the members of this genus is poorly known, it is believed that most feed on algae or detritus (D. H. Habeck, personal communication).

*28. Prob. *Oxylophila callista* (Forbes) - 2 specimens from Texas (collection 79555). This species has not been recorded since it was first described in 1922 (Munroe 1972). While the larvae of this species are unknown, Dr. Dale Habeck, an expert on aquatic Lepidoptera, believes that these 2 larvae are this species, based on unique characteristics that separate them from the known genera of aquatic moth larvae and because they were collected in the same area as the type specimens. The feeding habits of this species are unknown, but they probably feed on aquatic macrophytes.

*29. *Parapoynx obscuralis* (Grote) - 3 larvae in 3 collections from Crystal River, Florida (collections 79525, 79527, and 79529). The larvae of this species, like those of other members of the genus, are highly adapted to an aquatic existence, having branched gills (Figure 18). This species feeds on a wide variety of aquatic vascular plants and has been recorded from 16 species of aquatic plants, including *M. aquaticum* (Habeck 1975). *Myriophyllum spicatum* appears, however, to be a new host record.

*30. *Synclita obliteralis* (Walker) - 6 larvae from 5 collections in Alabama, Florida, and Louisiana (collections 78514, 78517, 79539, 79559, 79560). This is one of the most commonly encountered aquatic moth species; it feeds on a very wide variety of plants. Almost 36 aquatic plant species have been recorded as hosts, including *M. aquaticum* and *M. heterophyllum* (Habeck 1975). However, this appears to be the first record of *S. obliteralis* feeding on *M. spicatum*.

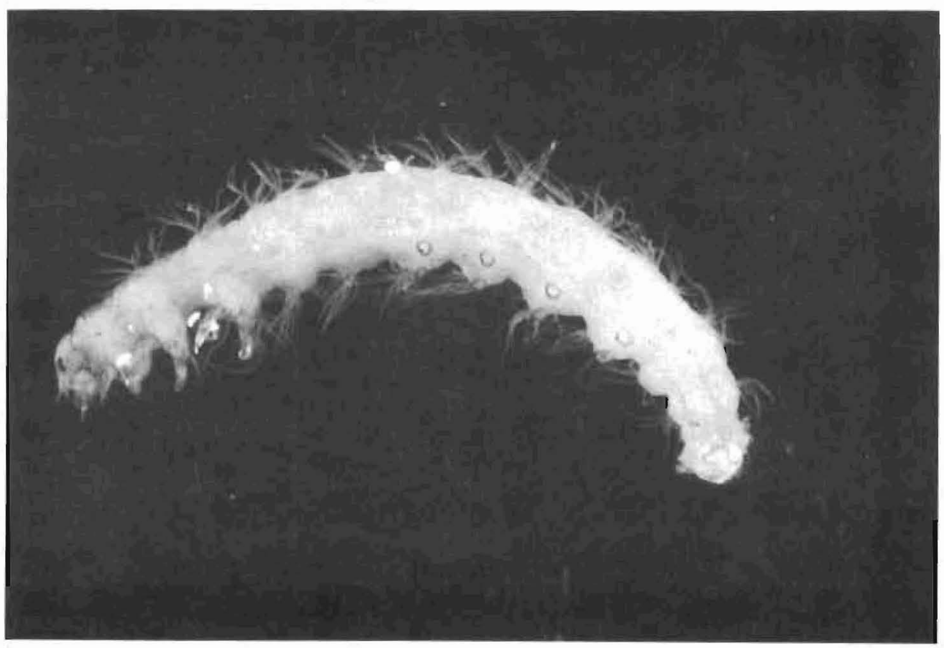

Figure 18. *Parapoynx obscuralis* (Grote) larva (Lepidoptera:Pyralidae)

Coleoptera (Beetles)

Many families of beetles are aquatic as larvae and/or adults and are frequently abundant in aquatic vegetation (Balciunas 1977). However, aquatic beetles were relatively scarce in Eurasian watermilfoil collections, with the most common beetle group on *M. spicatum* being the subaquatic weevils.

Family CURCULIONIDAE (Weevils)

The weevil family contains some 40,000 species, most of which are strictly terrestrial. However, this family includes some species, especially in the tribe Bagoini, in which adults swim on or below the surface of the water and the larvae infest various portions of aquatic plants (O'Brien 1977). An additional 7 subfamilies of weevils have members which are aquatic or subaquatic (O'Brien 1977). All the weevils collected in this study are members of the subfamily Ceutorhynchini. They are all subaquatic in that they are associated with emerged portions of aquatic plants but spend relatively brief periods of time on or below the surface of the water.

*31. *Eubrychiopsis velatus* (Beck) - a larva and 9 adults from Wisconsin (collections 79530, 79531, 79532, 79533, and 79534) and a larva from New York (collection 78506). This species has been previously recorded feeding on *M. spicatum* in Europe, although it was too rarely encountered to be studied (Lekic and Mihajlovic 1970). It was found in all 5 Wisconsin collections of Eurasian watermilfoil but was not abundant, at least during the sampling period in mid-September.

*32. *Litodactylus leucogaster* (Marsham) - 1 adult from Wisconsin (collection 79530) and 2 adults from California (collection 78514). This species (Figure 19) was considered a potential biological control agent on *M. spicatum* when it was discovered feeding on the flowers of this plant in Yugoslavia (Lekic and Mihajlovic 1970). It was later discovered to be

Figure 19. *Litodactylus leucogaster* (Marsham) adult (Coleoptera:Curculionidae) on *M. spicatum* flower spike (Photo courtesy of Dr. Gary Buckingham)

identical to the American species *Phytobious griseomicans*. Dr. Gary Buckingham has evaluated its potential for controlling Eurasian watermilfoil (1979). This weevil species does not appear to be very common in the United States and was the least abundant species of weevil found during this survey. It feeds on the flowers and seeds of *M. spicatum*.

*33. *Perenthis vestitus* Dietz - 38 adults and 3 larvae from Alabama and Florida (collections 78502, 79535, 80506, and 80507). This tiny weevil was abundant on the flowers of Eurasian watermilfoil at Guntersville Reservoir, Alabama, and Crystal River, Florida. It is easily overlooked in the collections since it resembles a small piece of detritus, especially when dead. It, and the other aquatic weevils, are most easily collected by examining *M. spicatum* flowers while slowly wading or floating in the water. The feeding habits of this species are similar to those of *L. leucogaster* (Buckingham 1979).

Family DYTISCIDAE (Predacious Diving Beetles)

This group of aquatic beetles was rarely encountered in the Eurasian watermilfoil collections, although they are frequently abundant in other aquatic vegetation such as waterhyacinth (Balciunas 1977). These beetles are predatory both as larvae and adults and should not directly impact on *M. spicatum*. However, Gaevskaya (1969) reported that a Russian researcher found 2 species of dytiscids feeding on *Ceratophyllum* and *Vallisneria* (Berezina 1958).

34. *Liodessus flavicollis* (LeC.) - 17 adults from 5 collections in Florida and Texas (78520, 795527, 79548, 79556, and 79557). These tiny beetles (Figure 20) were the only adult beetles, other than the weevils, found in this survey. Being predators, they probably do not directly damage aquatic plants.

Figure 20. *Liodessus flavicollis* (LeC.) adult (Coleoptera:Dytiscidae)

Family HYDROPHILIDAE (Water Scavenger Beetles)

Most adult members of this family are detrivorous or herbivorous, while the larvae are usually predacious. With only 2 specimens, this family was very poorly represented in this survey.

35. *Berosus* sp. larvae - 2 specimens from Alabama and Tennessee (collections 79535 and 79543). This is one of the few hydrophilid species that frequents deeper water (Leech and Chandler 1968).

Diptera (Flies)

Flies constitute one of the larger orders of insects, with some 86,000 species (Borror and White 1970), many of which live in water. Although the adults of some species may contact the water briefly (e.g., when emerging from a submersed pupa or while ovipositing), only the immatures spend extended periods in or on the water. Since almost all fly larvae live in a moist environment (plant and animal tissues, decaying organic material, feces, etc.), they may all be considered aquatic in the broad sense. However, flies, as well as other insects, are considered truly aquatic only if a portion of the life cycle is spent in or on the water. All the flies listed in this survey are truly aquatic.

Family CHIRONOMIDAE (Midges)

Midge larvae, some of which are colloquially known as "blood worms," were very abundant, with 513 specimens distributed through almost half of the collections. This family accounted for 31 percent of all insects collected during this survey. This is not unusual, as Coffman (1978, p 345) notes, "The number of chironomid species. . .usually accounts for at least 50 percent of the combined macroinvertebrate species composition." Adult midges usually do not feed, but the larvae have extremely varied feeding habits, ranging among predatory, parasitic, detrivorous, herbivorous, and omnivorous. As a group, most feed on algae (especially diatoms) and/or detritus, although there are leaf-mining and stem-boring species. Most of the latter build tubes in plant tissue through which they then draw water and injest diatoms (Oliver 1971). A few species feed directly on leaves or other aquatic plant tissue.

Subfamily TANYPODINAE

36. *Clinotanypus* sp. - 2 specimens found in Florida (collection 80504). The larvae of this genus are generally carnivorous, feeding on other chironomid larvae, small crustaceans, oligochaete worms, and diatoms (Roback 1978; Oliver 1971).

37. *Natarsia* prob. *baltimoreus* (Macquart) - 4 specimens found in 3 collections from Alabama, Florida, and New York (collections 78503, 79525, and 79536). The larvae of this species appear to be tolerant indicator organisms (Simpson and Bode 1980). They are carnivorous, feeding on Cladocera, ostracods, copepods, and other chironomids (Roback 1978).

38. *Procladius* prob. *sublettee* Roback - 7 specimens found in 3 collections in Florida (collections 79522, 79524, and 79525). This species occurs over a wide range of environmental conditions and is possibly epibenthic, feeding primarily upon algae and detritus (Oliver 1971).

Subfamily ORTHOCLADIINAE - 21 specimens belonging to this subfamily could not be identified to genus due to the absence or masking of key taxonomic characters.

39. *Brilla* sp. - 1 specimen found in Florida (collection 80501). The larvae of this genus have been described by Coffman (1978) as shredders and detrivores. This genus has been recorded from *M. spicatum* in North Florida (Kobylinski et al. 1980).

40. *Cricotopus bicinctus* (Meigen) - 2 specimens found in one sample in Florida (collection 80505). Larval members of this species are very adaptable and opportunistic, being present in diverse, well-balanced communities, and increasing in

abundance when stresses eliminate more sensitive species. The larvae are microphagous, feeding on small plants and animals as well as on detritus (Oliver 1971). Menzie (1980) recorded this species on *M. spicatum* in the Hudson River.

41. *Cricotopus* prob. *intersectus* group - 1 specimen found in New York (collection 78503). Feeding habits of this group are similar to those of *Cricotopus bicinctus*. Larvae of this group are found in medium to large size rivers and canals, including sluggish areas subjected to severe organic waste loading (Simpson and Bode 1980). Feeding habits are varied but similar to other Orthocladiinae.

42. *Cricotopus* sp. - 20 specimens found in New York and Wisconsin collections (78509 and 79530). The larvae of this species are similar to those of the *Cricotopus* prob. *sylvestris* group, with only subtle differences in the labial plate. They probably have similar feeding habits.

43. *Cricotopus* prob. *sylvestris* group - 85 specimens found in 13 collections from Florida, Louisiana, New York, Oklahoma, and Wisconsin (collections 78503, 78504, 78508, 78519, 79530, 79533, 79547, 79549, 79550, 79551, 79552, 79560, and 80506). The larvae of *C. sylvestris* (Figure 21) were the most abundant species of Orthocladiinae, comprising more than 65 percent of all Orthocladiinae found. Most larvae of this group are microphagous, feeding on small plants and detritus (Oliver 1971). Menzie (1980) reported this species the most common chironomid on *M. spicatum* at his study site on the Hudson River. Three other specimens from Florida (collections 80505 and 80506) could not be positively identified to genus due to damaged or masked parts but were probably also *Cricotopus*. This genus has been recorded on *M. spicatum* from North Florida (Kobylinski et al. 1980).

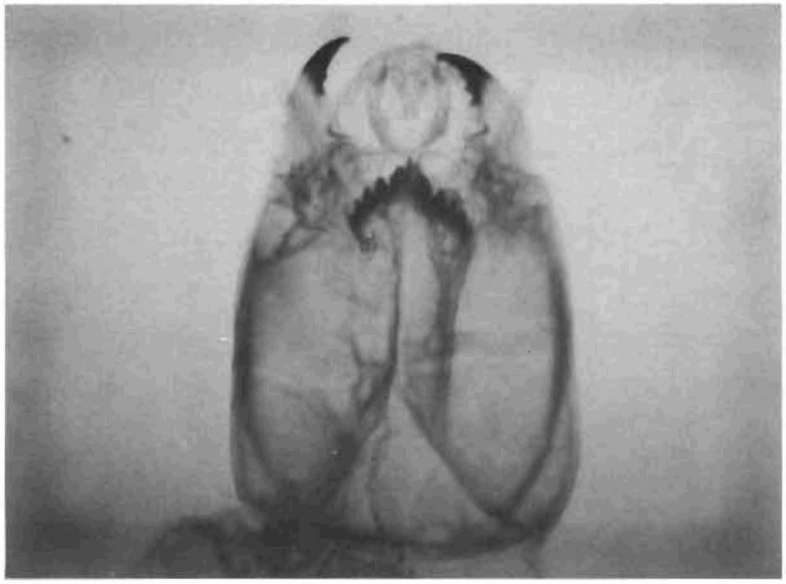

Figure 21. *Cricotopus* prob. *sylvestris*
(Chironomidae:Orthocladiinae)

44. *Eukiefferiella* sp. - 1 specimen from Florida (collection 80505). Larvae of this genus are often associated with filamentous green algae, on which they probably feed.

45. *Orthocladius* sp. - 6 specimens from Alabama, Florida, New York, and Oklahoma (collections 78504, 79537, 79549, and 80501). Larvae of this genus are common in most river systems but have rarely been recorded from canals and sluggish bodies of water. Coffman (1978) lists probable foods as diatoms, detritus, and filamentous algae. Quality and quantity of food are described as one of the most important factors determining the abundance of this genus.

Subfamily CHIRONOMIDAE tribe CHIRONOMINI - 21 specimens belonging to this tribe could not be identified.

46. *Cryptochironomus fulvus* group - 1 specimen found in Florida (collection 80501). Larvae of this group are most commonly found in bottom samples, although Beck (1977) has reported

C. fulvus as occurring over a wide range of habitat types and water quality conditions. The larvae are predacious and are known to feed on other chironomid larvae and oligochaete worms (Darby 1962). Menzie (1980) also recorded this species on *M. spicatum*.

47. *Dicrotendipes neomodestus* (Malloch) - 92 specimens found in 10 collections from Florida, New York, Oklahoma, and Texas (collections 78503, 78509, 78511, 79549, 79552, 79553, 80503, 80504, 80505, and 80507). This is a common chironomid species (Figure 22) which thrives in areas containing high levels of nutrients and organic wastes (Simpson and Bode 1980). *Dicrotendipes neomodestus* was the most abundant chironomid species found in this survey. The larvae are filter-feeders, straining small plant and animal material from the water with nets made from salivary secretions (Walshe 1951). Menzie (1980) found this species on *M. spicatum* in New York.

48. *Dicrotendipes nervosus* (Staeger) type 1 - 6 specimens found in 4 collections from Alabama, Florida, New York, and Oklahoma (collections 78509, 79537, 79552, and 80503). Often associated with slow currents and high levels of organic matter, *D. nervosus* larvae are often found associated with *Glyptotendipes lobiferus* (Roback 1974). Probable food sources are detritus, diatoms, and filamentous algae (Walshe 1951). Menzie (1980) recorded this species on *M. spicatum*.

49. *Endochironomus nigricans* (Johannsen) - 10 specimens from 3 collections in Florida, New York, and Texas (collections 78504, 80504, and 80509). The larvae of *E. nigricans* are commonly encountered in canal sections with large waterways where they are especially prevalent in areas of high nutrient and organic content. Coffman (1978) lists *E. nigricans* as a

Figure 22. *Dicrotendipes neomodestus* Malloch (Chironomidae:Chironomini)

herbivore and a shredder. Berg (1950) described *E. nigricans* living in rolled leaves of *Potamogeton* and spinning nets for feeding. The larvae have also been found associated with *Glyptotendipes lobiferus* and *Dicrotendipes neomodestus* (Roback 1974).

50. *Endochironomus subtendens* (Townes) - 35 specimens found in 6 collections from Florida, New York, Texas, and Wisconsin (collections 78504, 78509, 79533, 80502, 80504, and 80509). The larvae of this species (Figure 23) are reportedly less common than those of *E. nigricans*; however, this survey does not substantiate this trend. Food preferences and require-

Figure 23. *Endochironomus subtendens* Townes
(Chironomidae:Orthocladiinae)

ments are probably similar to those of *E. nigricans*. Walshe (1951) described the larval feeding mechanism of this genus.

51. *Glyptotendipes lobiferus* (Say) - 40 specimens from 7 collections in Florida, Louisiana, New York, Oklahoma, and Wisconsin (collections 78504, 78509, 78517, 79532, 79550, 79552, and 80505). Larvae of this species (Figure 24) are common to slow-moving streams and canals, often becoming a dominant species in areas high in organic matter or polluted by sewage wastes. Abundance of *G. lobiferus* is often accompanied by high numbers of *Dicrotendipes nervosus* Type II and *Dicrotendipes neomodestus*. Beck (1977) described *G. lobiferus* as a burrower preferring standing water. Larvae of *Glyptotendipes* construct tubular cases that are permanently attached to the substrate. Food consists primarily of particulate matter entrapped in a saliva net spun across one end of the

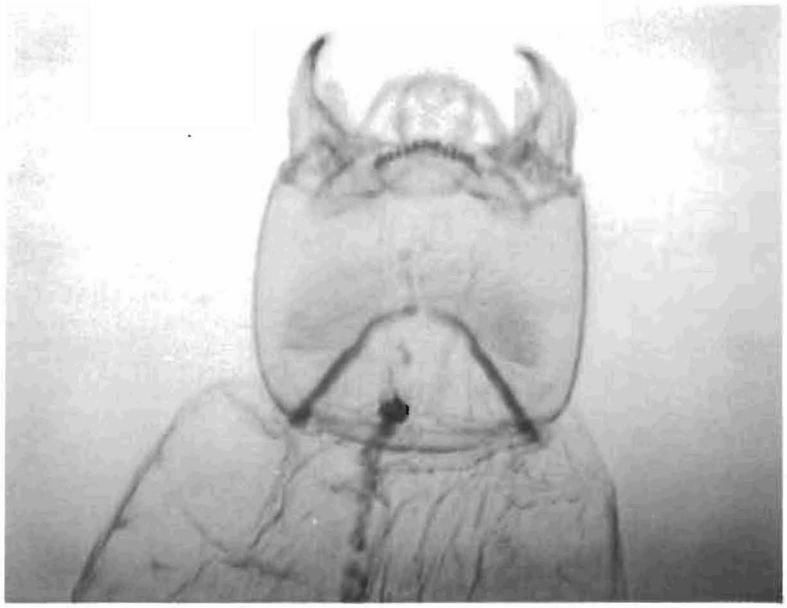

Figure 24. *Glyptotendipes lobiferus* Say
(Chironomidae:Chironomini)

case (Walshe 1951). Menzie (1980) also found this species on *M. spicatum* in New York.

52. *Glyptotendipes* sp. A - 11 specimens found in New York (collection 78504). Several specimens of this species sent to Dr. William M. Beck (Florida A&M, Tallahassee, Fla.) could be identified only to genus. No information on the distribution and ecology of this species is available due to the single sample and the limited number of specimens collected.

53. *Glyptotendipes* sp. B - 1 specimen found in Louisiana (collection 78519). This larva is similar to *Glyptotendipes lobiferus* except that the median tooth of the labial plate is smaller.

54. Chironomini prob. *Phaenopsectra* - 1 specimen found in Wisconsin (collection 79533). Beck (1977) has classified this genus as scavengers occurring on rather than in substrates.

The genus has been found to occupy a variety of habitats and to possess a wide range of tolerances. Feeding habits closely resemble those of other Chironomini and vary with habitat.

55. *Parachironomus abortivus* (Malloch) - 1 specimen found in Florida (80503). A widespread chironomid that has been described as tolerant of most toxic and organic wastes and that is often found where more sensitive species have been repressed (Mason, Lewis, and Anderson 1971). Larvae of this species are microphagous (filter-feeders).

56. *Polypedilum* prob. *illinoense* (Malloch) - 4 specimens found in 3 collections from Florida (collections 79559, 80501, and 80502). The larvae of *Polypedilum* are filter-feeders and their distribution seems governed by current speed and the amount of suspended food particles. This genus is often found with *Rheotanytarsus exiguus*, another species indicative of a community with an abundance of suspended foodstuffs (Simpson and Bode 1980). Menzie (1980) recorded this species on *M. spicatum* from the Hudson River.

57. *Polypedilum* nr. *scalaenum* (Schrank) - 9 specimens found in 5 collections from Florida, New York, and Wisconsin (collections 78504, 79525, 79532, 80501, and 80502). Larvae of this group have feeding habits similar to those of *P. illinoense*. Many problems exist in identifying larvae of this genus; therefore, distributional patterns and ecological information at the species level are limited. Coffman (1978) does list 12 ecological references for the genus *Polypedilum*.

58. *Pseudochironomus* sp. - 2 specimens found in Florida (collection 79559). This species primarily inhabits the littoral zone of meso-oligtrophic lakes and slow-flowing rivers. The

larvae live on sandy or gravelly substrates overgrown by algae. Their food consists of detritus and periphyton (Saether 1977).

Subfamily CHIRONOMINAE tribe TANYTARSINI - 34 specimens from this tribe could not be further identified.

59. *Paratanytarsus* spp. - 40 specimens found in 5 collections from Florida, New York, Oklahoma, and Texas (collections 78509, 79552, 79560, 80507, and 80508). No water quality preferences have been discerned for this genus. The larvae are generally clingers, building cases out of sand, silt, and/or detritus. Many species feed on microorganisms and detritus through filtering and gathering. Very few species within the genus can be identified with certainty.

60. Tanytarsini prob. *Paratanytarsus* spp. - 5 specimens found in 3 collections from California, New York, and Wisconsin (collections 78509, 78514, and 79533). These five specimens could not be positively identified to genus due to missing or damaged parts, primarily antennae.

61. *Rheotanytarsus* prob. *exiguus* group - 15 specimens found in 3 collections from Florida and Oklahoma (collections 78511, 79549, and 79552). The larvae of this group (species) are prevalent in areas with moderate flow and high amounts of suspended organic particles. Food is obtained by straining and filtering passing water with strands of salivary secretions strung between the arms of their cases (Walshe 1951). This group, with its widespread distribution, probably represents several species. With improved larval taxonomy, narrower environmental requirements for certain species may be observed.

62. Tanytarsini prob. *Rheotanytarsus* - 28 specimens found in 3

collections from Florida, New York, and Oklahoma (collections 78509, 78511, and 79525). These 28 specimens could be only tentatively identified to genus due to various missing or damaged parts. Menzie (1980) also recorded this genus as associated with *M. spicatum* in New York.

Family CULICIDAE (Mosquitoes)

Although mosquito larvae are frequently associated with aquatic vegetation, only 2 pupae were found in all the milfoil collections. This may be due to the sampling of deeper waters that are not usually favored by mosquito larvae. Most mosquitoes feed on small particulate matter. A few species, mostly in the genus *Mansonia*, puncture submerged portions of aquatic plants to obtain air. None of these species were found in this survey.

63. Culicid pupae - 2 pupae from Alabama and Tennessee (collections 79536 and 79541).

Family STRATIOMYIDAE (Soldier Flies)

The larvae of soldier flies, which feed primarily on fine particulate matter, were infrequently encountered during this survey.

64. Prob. *Euparyphus* sp. - 6 larvae in 3 collections from Tennessee and Texas (collections 79540, 79542, and 79555) (Figure 25).

Unidentified Diptera pupae and larvae (identification pending) - 2 larvae and 3 pupae, possibly not aquatic.

Figure 25. *Euparyphus* sp. (Diptera:Stratiomyidae)

PART IV: DISCUSSION

Collection Site Locations and Times

50. An attempt was made to sample the major Eurasian watermilfoil infestations in as many diverse locations as possible. Most of the major infestations in the United States, with the notable exceptions of Chesapeake Bay and Currituck Sound, were sampled.

51. Most out-of-state collection sites were visited during the fall of 1978 or 1979. Since most of these sites could be sampled only once, sampling was concentrated in the fall season when insect densities traditionally peak and when most Eurasian watermilfoil infestations are still flowering, thus increasing the chance of finding insects that feed only on the flowers. However, flowering had terminated by the time collections were made in California, Oklahoma, Texas, and Washington.

Collection Site Parameters

52. In Appendix B, it is apparent that Eurasian watermilfoil grows under a variety of water quality conditions. *Myriophyllum spicatum* was collected in waters as shallow as 15 cm and as deep as 2.0 m. Average depth for the Crystal River, Bagley Cove, collections was 0.81 m (SD = ±0.24), while the average depth for the other sites was 1.28 m (SD = ±0.54). The watermilfoil was at or just below the surface at the majority of the collection sites. Water temperature averaged 24.2°C (SD = ±3.8°C) in Florida and 20.3°C (SD = ±2.6°C) elsewhere. Salinity reached a maximum of 6.5 parts per thousand (ppt) in the estuarine mouth of Homosassa River but was 0 in all freshwater areas. In the brackish water of Bagley Cove at Crystal River, salinity ranged from 0.5 to 1.7 ppt. Conductivity, which is highly correlated with salinity, averaged 2013 (SD = ±661) μmhos at Bagley Cove, but mean salinity for nonestuarine areas was only 233 (SD = ±126) μmhos, with a maximum of 650 μmhos. Of the 72 *M. spicatum* collections, 25 contained at least one other plant species as well, although in rather small

quantities (x = 9.1 g dry weight). The lower leaves were in slightly worse condition; otherwise, top, middle, and lower portions of the plant showed similar damage.

Insect Species Collected

53. A total of 1665 insect specimens were collected and are listed in Part III. A total of 64 insect species were collected; 37 of these were present in Florida. The damselfly nymphs of the family Coenagrionidae were the most frequently encountered, being present in 47 collections. The midge larvae, with 513 specimens, were the most abundant insect group, although they were present in only 34 collections. The caddisflies, with 285 larvae in 35 different collections, were also well represented. The caddisflies *Fabria* sp., as well as *Leptocercus americanus* and *Oecetis cinerascens*, are possible feeders on *M. spicatum*, with evidence for *Fabria* being exceptionally strong.

54. With 117 specimens, the moth larvae were reasonably abundant. They are the most important group in terms of causing direct damage to Eurasian watermilfoil. *Acentria nivea* was the most abundant and was frequently encountered in the northeast. In some locations, almost all *M. spicatum* shoots exhibited feeding damage from this species. Table 3 is a summary of the insect species collected that feed on *M. spicatum*.

55. Several insect species feed on the aerial portions (i.e. flower spikes) of *M. spicatum*. These include the aphid *Rhopalosiphum nymphaeae* and the weevils *Eubrychiopsis velatus*, *Litodactylus leucogaster*, and *Perenthis vestitus*. *Litodactylus* were rare in the collections. It is doubtful that any of these species significantly stress Eurasian watermilfoil, although their feeding scars may serve as entryways for pathogens that might damage the plants.

Other Macroinvertebrates Collected on *M. spicatum*

56. Compared with a floating macrophyte such as waterhyacinth, M. spicatum has relatively low insect abundances, both in numbers and

species (Balciunas 1977). The most common macroinvertebrates on *M. spicatum* were snails (Gastropoda); with 4153 specimens, they were 215 times more abundant than the insects (1665 specimens). They were found in most (50) of the collections and were present in every state. The snail genera collected are listed in Table 4. The most common snail in Florida was *Littoridina* sp., with 1105 specimens. *Gyraulus* sp. was very abundant (1717 specimens) and was collected in 10 of the 11 states. *Physa* sp. (564 specimens) and *Vivaparus* sp. (599 specimens) were also fairly common, collected in 9 and 5 states, respectively. The majority of freshwater snails feed on epiphytic algae, although *Physa* and *Lymnaea* are scavengers and essentially omnivorous (Pennak 1978). None of the snails collected in this survey appeared to be causing direct damage to *M. spicatum*.

57. Table 5 lists other invertebrates collected on *M. spicatum*. A large variety of organisms, including leeches, mites, crustaceans, and even some clams, were present. The crustaceans were abundant and almost equalled the insects in number of specimens. Scuds (Amphipoda) were the most commonly collected crustacean, with over 800 specimens recorded.

Comparison with *Myriophyllum exalbescens*

58. The insect fauna in the two collections of *M. exalbescens*, compared to collections from nearby *M. spicatum*, had a smaller number of insects, but the species present were also found on the adjacent *M. spicatum*. The lower number of insects on *M. exalbescens* is not unexpected as it was growing in widely separated clumps, and small aquatic invertebrates usually prefer the shelter provided by large beds of aquatic plants, such as *M. spicatum*.

Quantitative Studies

59. As can be seen in Appendix C, quantitative sampling was essentially limited to Crystal River, Florida. The sampler was too large and awkward to transport readily by plane, and required the availability

of a stable, flat-bottomed watercraft with low gunwhales at the intended collecting site. Since the Crystal River-Homosassa River Eurasian water-milfoil infestation is the largest in Florida, it was chosen for the quantitative studies.

60. The quantitative studies were initiated in May of 1979 at a portion of Crystal River near the mouth of Miller's Creek. However, during the summer of 1979, this site became part of a large portion of the Crystal River area whose aquatic vegetation was being intensively managed on a long-term basis by the use of herbicides. To avoid the complicating factor of herbicide effects on the flora and fauna, this collection site was dropped after visible herbicide residues were noted several times. A new location, Bagley Cove, about 2 km downstream from the previous collecting area, was chosen for the quantitative studies, and sequential sampling began in August 1979 and was continued through July 1980. *Myriophyllum spicatum* plants were so sparsely distributed in March 1980 that the quantitative sampler was not used.

61. The quantitative data for Crystal River are presented in Appendix C. For ease of interpretation, mean values for plant dry weight and numbers of insects and snails for Bagley Cove are plotted in Figure 26. Seasonality in biomass and numbers of fauna is dramatically illustrated. Inspection of this graph indicates that *M. spicatum* biomass peaked at almost 300 g/m^2 in September 1979, declined rapidly to a low of less than 10 g/m^2 in December, then began regrowth in May 1980. In 1979, insect abundance peaked at almost 70 $specimens/m^2$ in November, dropped to a low of less than 2 $specimens/m^2$ in April, and had reached a level of 100 $specimens/m^2$ in July of 1980. Snails were usually more abundant than insects. No snails were present in the December samples, but by July 1980 more than $230/m^2$ were collected.

62. During the 12-month study period, the collections averaged 124 g/m^2 (SD = ±103) dry weight of *M. spicatum* and approximately 36 insects (SD = ±40) and 74 snails (SD = ±95) per square metre in each collection. The insect fauna was comprised mainly of damselfly (Zygoptera) and mayfly (Ephemeroptera) nymphs and a few midge (Chironomidae) larvae.

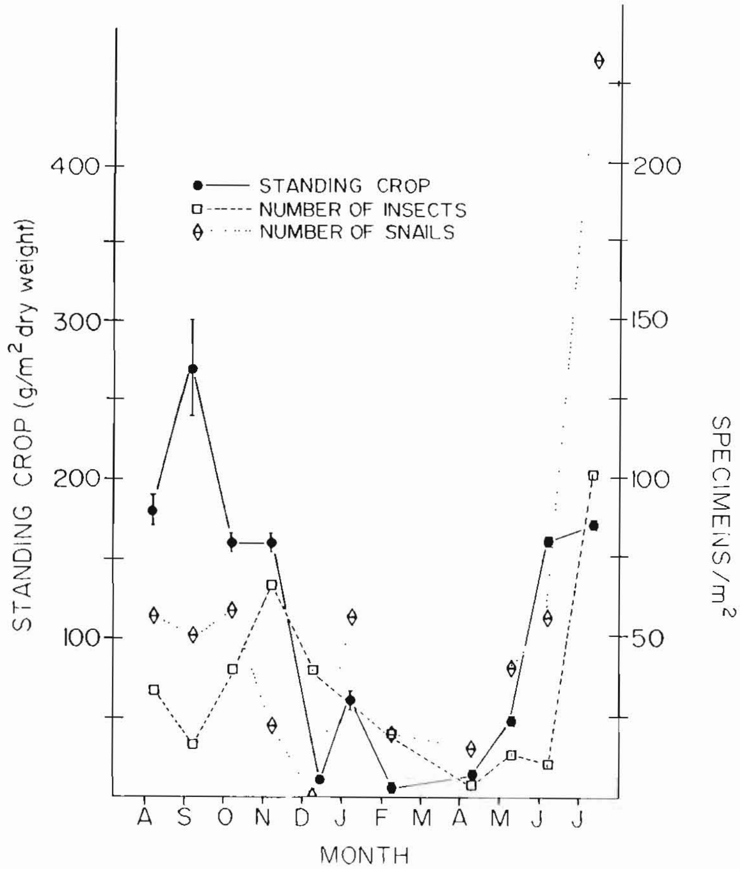

Figure 26. Graph of seasonal changes in *M. spicatum* standing crop and densities of associated insects and snails in Crystal River, 1979-1980

Adequacy of Present Survey

63. The major shortcoming of this survey was the low number (48) of out-of-state collections. It was not possible to find every insect species associated with *M. spicatum* over its broad U. S. range. Species not active in the fall are probably missing from the collections.

64. The use of a rake and hands as the primary collecting method allows highly mobile species, such as larger beetles, to avoid capture. Insects associated with *M. spicatum* flowers, because of their small size and buoyancy, were frequently lost with water draining from the sample; therefore, their actual abundances are probably underrepresented. For

this reason, whenever flowers were present at a collection site, they were visually inspected, and hand collection of insects supplemented the rake collections.

65. In spite of some drawbacks, this survey of the fauna associated with *M. spicatum* is the most extensive conducted in the United States to date, and many new species have been added to those previously reported. Kobylinski et al. (1980) recorded only nine genera of insects and two snail genera associated with *M. spicatum* compared with sixty-four taxa of insects and nine genera of snails collected during this study. Crystal River, Florida, alone produced thirty-five insect species and seven snail genera. Menzie (1980) recorded twenty-nine insect taxa associated with *M. spicatum* growing in the Hudson River in New York. Twenty-six of these were chironomid species, the same number as found in this survey. However, Menzie included species collected in benthic samples, which were excluded from the present study. Menzie (1980) also recorded four chironomid species as commonly associated with *M. spicatum* (rather than bottom sediments); all four of these species were also recorded in this survey.

66. The efficiency of collecting for this survey can also be demonstrated graphically. A species accumulation curve is constructed in Figure 27 by plotting the additional number of insect species added by each new collection. Each of the first few collections adds a large number of new species, and the graph rises rapidly in an essentially linear manner. After the common species have been collected, new species are found less often, and the curve flattens out. A greater number of collections (or new collecting areas) are required to add each additional species. Thus, after 5 collections, 38 percent of the eventual 64 species had been collected; after 10 collections, 52 percent; after 25 collections, 70 percent; and after 50 collections, 84 percent. The last 20 collections added only 10 new species (15.6 percent). Thus, it is apparent that the common insect species associated with *M. spicatum* in the United States were found. It is possible that some species with limited distribution are locally abundant in areas not visited during this survey and were therefore not included.

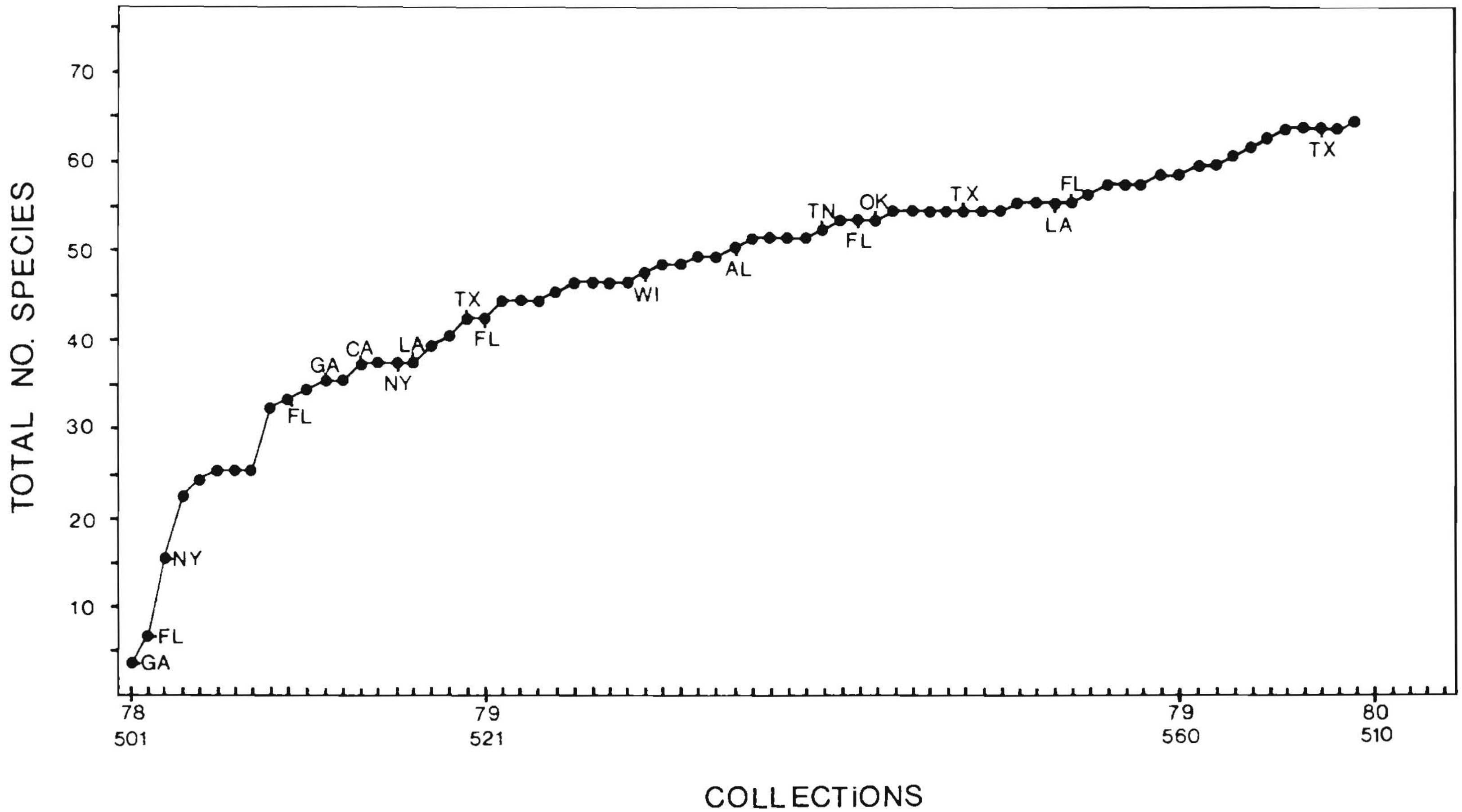

Figure 27. Species accumulation curve for insects collected on *M. spicatum* in the United States

67. The species accumulation curve for Crystal River, Florida, shown in Figure 28, is of interest. The curve flattens much more gradually than the curve in Figure 27. After 5 collections, 29 percent of the final 35 insect species had been collected; after 10 collections, 49 percent; after 15 collections, 86 percent. The many new species collected during the first half of 1980 are probably colonizing species rather than previously overlooked rare species since many of them were present at high densities. This gradually flattening species accumulation curve indicates that the *M. spicatum* community at Crystal River is maturing and has not yet reached a stable composition. The increasing amount of organic material deposited in the sediments appears to favor increased chironomid levels along with increased plant density.

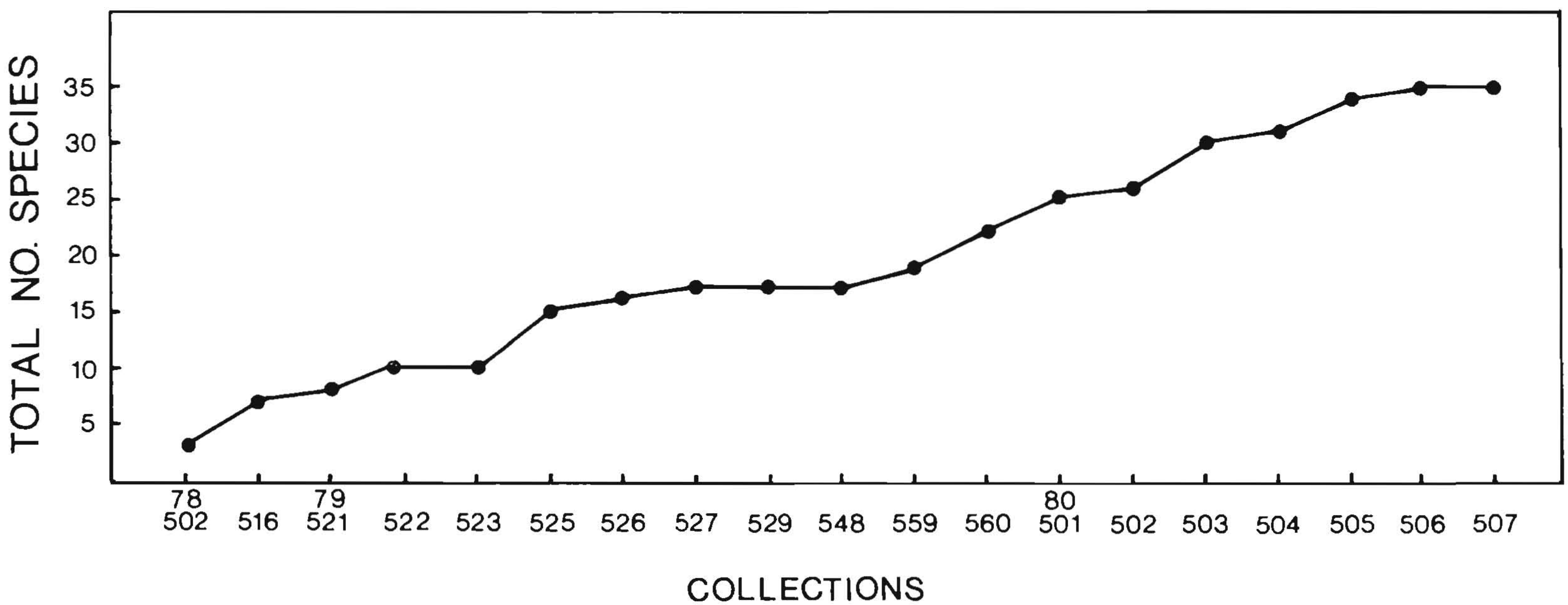

Figure 28. Species accumulation curve for insects collected on *M. spicatum* in Crystal River, Florida

PART V: SUMMARY

68. Seventy-one collections of Eurasian watermilfoil and its associated fauna and three collections of *M. exalbescens* were made in eleven states; twenty-three of those collections were from Florida. A total of 1665 insects were collected and 64 insect taxa were identified.

69. The damselfly nymphs were the most frequently encountered insects, being present in two thirds of the collections, but the midge larvae were the most abundant both in species and numbers, although they were found in less than half of the collections. Caddisfly larvae and aquatic moth larvae were also fairly well represented.

70. The moth larvae fed on *M. spicatum* voraciously and caused the most severe damage of any insect group. Three species of caddisflies are considered probable or possible feeders on *M. spicatum*. An aphid and three weevil species fed on the emersed flower spikes, but their direct impact on this pest is thought to be minimal. Some midge larvae damaged *M. spicatum*, through their burrowing activities, although most used this plant as a substrate for attaching their cases rather than as a direct source of nutrition.

71. Quantitative sampling at Crystal River, Florida, indicated large seasonal fluctuations in the biomass of *M. spicatum* and its associated insects and snails. Snail density seemed to correspond to the amount of plant material available. Insect population levels did not appear as synchronized to the levels of *M. spicatum*.

72. This is the most extensive survey of the fauna associated with *M. spicatum* completed in the United States to date. Most of the insect species previously recorded on *M. spicatum* were also recorded in this survey as were many additional species. Inspection of the species accumulation curve for insect species associated with *M. spicatum* indicates that most common species were probably collected. Only 10 new insect species were added by the last 20 collections.

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Table 1

Chronology of Search for Insect Enemies of Eurasian Watermilfoil

Date	Item
1967	Commonwealth Institute of Biological Control initiates survey of insects associated with *Myriophyllum* species in Pakistan.
1967	Lekic begins PL-480 studies of insects associated with *M. spicatum* in Yugoslavia.
1969	Preliminary report by Habib-ur-Rehman et al. (1969) indicates 11 species of insects associated with 3 species of *Myriophyllum* in Pakistan and Bangladesh.
1970	Lekic and Mihajlovic (1970) report 15 species of phytophagous insects associated with *M. spicatum* in Yugoslavia. Most were uncommon or not specific to *M. spicatum.* Of the 7 moth species recorded, *A. nivea* (=*Acentropus niveus*) is already present in the United States, while, of the remaining moth species, only *Parapoynx stratiotata* shows a definite association with *M. spicatum.* Of the remaining 8 insect species, only the weevil *L. leucogaster* is considered specific to *M. spicatum*, but it also is already present in the United States.
1970	Lekic reports on the feeding tests and biology of *P. stratiotata.* In his laboratory tests, this moth species shows a marked preference for *M. spicatum.*
1972	Baloch et al. report on their studies of 4 insect species considered to be the most promising among the 11 species previously reported on *Myriophyllum* spp. in Pakistan. Of these 4 species, the moth *Aristotelia* sp. is found to attack 2 milfoil species but not *M. spicatum.* The remaining 3 insect species were weevils. Two of these weevil species, both of them in the genus *Bagous*, would breed only on *M. spicatum* stranded on shorelines. The weevil *Phytobius* sp. was not very specific in its feeding habits.
1975-77	Batra studies on bionomics of *Acentria nivea* in the laboratory in Maryland. In the laboratory, this species caused considerable damage to *M. spicatum* and *H. verticillata* although other aquatic plant species were fed upon also.
1976	*Parapoynx stratiotata* received at Gainesville. Attempts to establish laboratory colony are unsuccessful.
1977	Habeck studies *P. stratiotata* in Italy.
1978	Buckingham begins laboratory studies of *A. nivea*.

(Continued)

Table 1 (Concluded)

Date	Item
1978	Balciunas begins survey of insects associated with *M. spicatum* in the United States.
1979	Habeck reports on *P. stratiotata* studies in Italy. Recommends that this species not be imported into the United States since it feeds on a wide array of plants both in the field and in the laboratory.
1980	Buckingham reports results of laboratory studies of the moth *Acentria nivea* and the weevil *Litodactylus leucogaster*. *Litodactylus*, which feeds on milfoil flowers, was found to be quite specific to *M. spicatum* while *Acentria* feeds on a wide range of aquatic plants. However, both insect species may play some role in controlling *M. spicatum*, especially if a complex of biocontrol agents is used.
1980	Balciunas reports results of field survey of United States for insects attacking *M. spicatum*. Several moth species caused the most direct damage. Most of these species, however, were scarce even at the sites where they were collected, except *A. nivea*, which was occasionally locally common. Three species of weevils, including *L. leucogaster*, were found on *M. spicatum*, but their impact was thought to be negligible. Midge larvae were abundant at some locations and a few species tunneled into the *Myriophyllum* stems. While the chironomid damage did not appear directly to be great, the tunnels may serve as an entry point for pathogens that might have dramatic effects on milfoil infestations.

Table 2

Locations and Dates for Collections of Eurasian Watermilfoil and Associated Fauna

Collection No.	Date	Site	Location	County/Parish
		Alabama		
79535	18 Sep 1979	Guntersville Reservoir	Upper Honeycomb Creek	Marshall
79536	18 Sep 1979	Guntersville Reservoir	North Sauty Embayment	Jackson
79537	18 Sep 1979	Guntersville Reservoir	Comer Bridge (SR 35), in bay	Jackson
79538	18 Sep 1979	Guntersville Reservoir	Comer Bridge (SR 35), in river	Jackson
79539	18 Sep 1979	Guntersville Reservoir	Crow Creek	Jackson
		California		
78514	20 Oct 1978	Pilarcitos Reservoir	Along north shore	San Mateo
78515	23 Oct 1978	South Alamo Canal	Bridge over Carr Rd.	Imperial
		Florida		
78502	31 Jul 1978	Crystal River	Bagley Cove, north end	Citrus
78510	3 Oct 1978	Crystal River	Mouth of Miller's Creek	Citrus
78511	3 Oct 1978	Salt Springs Run	Along Spring Run	Marion
79521	8 Mar 1979	Crystal River Canal	Miller's Creek Canal	Citrus
79522	11 Apr 1979	Crystal River Canal	Miller's Creek Canal	Citrus
79523	10 May 1979	Crystal River	Mouth of Miller's Creek	Citrus
79524	7 Jun 1979	Crystal River	Mouth of Miller's Creek	Citrus
79525	12 Jul 1979	Crystal River	Mouth of Miller's Creek	Citrus
79526	9 Aug 1979	Crystal River	Bagley Cove, north end	Citrus
79527	9 Aug 1979	Crystal River	Bagley Cove, north end	Citrus
79528	21 Aug 1979	Homosassa River	Near mouth	Citrus
79529	11 Sep 1979	Crystal River	Bagley Cove, north end	Citrus
79547	10 Oct 1979	Salt Springs Run	1/2 mi from mouth	Marion
79548	11 Oct 1979	Crystal River	Bagley Cove, north end	Citrus
79559	9 Nov 1979	Crystal River	Bagley Cove, north end	Citrus
79560	14 Dec 1979	Crystal River	Bagley Cove, north end	Citrus

(Continued)

Table 2 (Continued)

Collection No.	Date	Site	Location	County/Parish
80501	10 Jan 1980	Crystal River	Bagley Cove, north end	Citrus
80502	11 Feb 1980	Crystal River	Bagley Cove, north end	Citrus
80503	12 Mar 1980	Crystal River	Bagley Cove, north end	Citrus
80504	7 Apr 1980	Crystal River	Bagley Cove, north end	Citrus
80505	6 May 1980	Crystal River	Bagley Cove, north end	Citrus
80506	10 Jun 1980	Crystal River	Bagley Cove, north end	Citrus
80507	8 Jul 1980	Crystal River	Bagley Cove, north end	Citrus
		Georgia		
78501	28 Jul 1978	Lake Seminole	West Island	Seminole
79578	10 Nov 1979	Lake Seminole	Mouth of fish pond drain	Seminole
		Louisiana		
78517	15 Nov 1978	False River Lake	Inlet at Lighthouse Fish Camp	Pointe Coupee
78518	15 Nov 1978	Toledo Bend Reservoir	SR 6 Bridge, mile post 4.5	Sabine
78519	15 Nov 1978	Toledo Bend Reservoir	E. shore on SR 475, mile post 2	Sabine
79558	30 Oct 1979	Toledo Bend Reservoir	E. shore on SR 475, mile post 2	Sabine
		New York		
78503.0	20 Sep 1978	St. Lawrence Lake	Across from Robert Moses St. Pk.	Lawrence
78504.0	21 Sep 1978	Pair of small ponds	Entrance Robert Moses St. Park	Lawrence
78505.0	21 Sep 1978	Small stream	1/2 mi E. of Wescott Beach St. Park	Jefferson
78506.0	22 Sep 1978	Cayuga Lake	North end	Cayuga
78507.0	22 Sep 1978	Seneca Lake	East side	Seneca
78508.1	23 Sep 1978	Owasco Lake	North end, Burtis Point	Cayuga
78508.2	23 Sep 1978	Owasco Lake	North end, Burtis Point	Cayuga
78508.3	23 Sep 1978	Owasco Lake	North end, at Boat Channel	Cayuga
78509.1	23 Sep 1978	Lake Ontario	S.W. corner of Sodus Bay	Wayne
78509.2	23 Sep 1978	Lake Ontario	S.W. corner of Sodus Bay	Wayne
78516.0	28 Oct 1978	Cayuga Lake	North end	Cayuga

(Continued)

Table 2 (Continued)

Collection No.	Date	Site	Location	County/Parish
		Oklahoma		
79549	23 Oct 1979	Illinois River	Gravel pits, N. of Gore Landing	Sequoyah
79550	23 Oct 1979	Lake Kerr	1/2 mile S. of Canadian River	Haskell
79551	23 Oct 1979	Lake Kerr	Diversion dike for Canadian River	Haskell
79552	23 Oct 1979	Illinois River	Beside SR 64 and 100 bridge	Sequoyah
		Tennessee		
79510	18 Sep 1979	Nickajack Reservoir	Unknown	Marion
79541	19 Sep 1979	Chickamauga Reservoir	Dry branch	Hamilton
79542	19 Sep 1979	Tennessee River	Spring Run	Hamilton
79543	19 Sep 1979	Old Catfish Pond	Near Piney Creek	Rhea
79544	20 Sep 1979	Clinch River	Across from Bull Run Power Plant	Roane
79545	20 Sep 1979	Pond by Clinch River	Dammed portion of McCoy Branch	Roane
79546	20 Sep 1979	Ft. Loudon Reservoir	Unknown	Blount
		Texas		
70520	15 Nov 1978	Toledo Bend Reservoir	Pendleton Harbor Marina	Sabine
79553	24 Oct 1979	Barton Creek	100 mi from mouth at Towne Lake	Travis
79554	25 Oct 1979	Lake Austin	At boat house	Travis
79555	26 Oct 1979	San Marcos River	Aquarena Springs entrance	Hayes
79556	29 Oct 1979	Lake Conroe	Mouth of Lewis Creek	Montgomery
79557	30 Oct 1979	Toledo Bend Reservoir	Bridge over Carrice Creek	Sabine
80508	26 Oct 1980	Barton Springs	At Towne Lake	Travis
80509	25 Oct 1980	San Marcos River	At Aquarena Springs	Hayes
80510	26 Oct 1980	Barton Springs	100 mi from mouth at Towne Lake	Travis
		Washington		
78512	18 Oct 1978	Lake Washington	Union Bay, north side	King
78513	18 Oct 1978	Lake Washington	Union Bay, south side	King

(Continued)

Table 2 (Concluded)

Collection No.	Date	Site	Location	County/Parish
		Wisconsin		
79530	13 Sep 1979	Lake Wingra	Villas Park Lagoons	Dane
79531	13 Sep 1979	Lake Wingra	Bay at end of Villas Dr.	Dane
79532	13 Sep 1979	Lake Wingra	NW end, near Knickerbocker Dr.	Dane
79533	14 Sep 1979	Lake Mendota	Tenney Park Lagoon	Dane
79534	14 Sep 1979	Buffalo Lake	NE side by Montello	Marquette

Table 3

Insect Species Collected That Feed on *M. spicatum*

Common Name	Species No. (see Part III)	Scientific Name	No. of Specimens	No. of Collection	Type of Damage
Aphid	11	*Rhopalosiphum nymphaeae*	11	3	Sap-sucking on aerial portion
Pyralid moths	26	*Acentria nivea*	106	9	Leaf-feeder
	28	*Oxylophila callista*	2	1	Probable leaf-feeder
	29	*Parapoynx obscuralis*	3	3	Leaf-feeder
	30	*Synclita obliteralis*	6	5	Leaf-feeder
Caddisflies	25	*Fabria* sp.	1	1	Feeds on vascular plants
	22	*Leptocerus americanus*	35	4	*?Plant feeder
	23	*Oecetis cinerascens*	47	8	*?Plant feeder
Weevils	31	*Eubrychiopsis velatus*	10	5	Feeds primarily on aerial portions (flowers and seeds)
		Litodactylus leucogaster	3	2	Feeds primarily on aerial portions (flowers and seeds)
	33	*Perenthis vestitus*	41	4	Feeds primarily on aerial portions (flowers and seeds)

*? Possible feeders; although generally not considered to feed on vascular tissue, some authors report these species as feeding on vascular aquatic plants.

Table 4

Snails (Gastropoda) Found with *M. spicatum*

Name	State	No. of Specimens	Collection Numbers
Family Hydrobiidae			
Littoridina sp.	Alabama	31	79535, 79536
	Florida	1105	79522, 79523, 79524, 79525, 79526, 79527, 79528, 79548, 79559, 80506, 80507
Hyalopyrgus sp.	Florida	14	78502, 78510, 79525, 79526, 79527
Family Neritidae			
Neritina sp.	Florida	23	79522, 79523, 79525, 79526, 79527, 79529, 79548, 79559, 80506, 80507
Family Physidae			
Physa sp.	Alabama	19	79539
	California	58	78515
	Florida	48	78510, 78511, 79523, 79524, 79525, 79526, 79529, 79548, 79559, 80506
	Georgia	43	78501
	New York	249	78503, 78506, 78507, 78508, 78509
	Tennessee	70	79540, 79541, 79542, 79544, 79546
	Texas	57	78520, 79533, 79534, 79537, 79553, 79554, 79555, 80509
	Washington	1	78512
	Wisconsin	19	79530, 79531
Family Pleuroceridae			
Goniobasis sp.	Alabama	1	79539
	Texas	67	79553, 80510
	Florida	1	79528
Family Planorbidae			
Gyraulus sp.	Alabama	89	79535, 79536, 79539

(Continued)

Table 4 (Concluded)

Name	State	No. of Specimens	Collection Numbers
Gyraulus sp. (cont)	California	5	78514, 78516
	Florida	198	78510, 79523, 79524, 79525, 79527, 79529, 79548, 79559, 80506, 80507
	Georgia	109	78501
	Louisiana	428	78517, 78518, 78519, 78520
	New York	190	78502, 78503, 78505, 78506, 78507, 78508, 78509
	Tennessee	485	79540, 79541, 79542, 79544, 79545, 79546
	Texas	115	79533, 79555, 79556, 80509, 80510
	Washington	72	78512, 78513
	Wisconsin	26	79530, 79531, 79532, 79534, 79557
Helisoma sp.	Tennessee	11	79544
Family Viviparidae			
Lioplax sp.	Alabama	8	79538, 79539
	Florida	9	80506
	Tennessee	3	79544
Vivaparus sp.	Louisiana	27	78518
	New York	473	78503, 78505, 78506, 78507, 78508, 78509, 79549
	Oklahoma	2	79549
	Texas	95	79553, 79554, 79555, 80509
	Wisconsin	2	79537

Table 5

Invertebrates (Excepting Insects and Snails) Collected with *M. spicatum*

Name	State	No. of Specimens	Collection Numbers
Phylum Annelida			
Class Hirudinea (leeches)	Florida	3	79521, 79524, 79525
	Louisiana	1	78519
	Tennessee	6	79546, 79555
	Wisconsin	5	79534
Phylum Arthropoda			
Class Arachnoidea	Alabama	2	79539
Order Hydracarina (watermites)	Florida	63	78502, 79523, 79524, 79525, 79548, 80501, 80504, 80506, 80507
	Louisiana	10	78518
	Tennessee	4	79540, 79541
	Texas	9	78520, 79554, 79555
	Wisconsin	21	79530, 79534, 79557
Class Crustacea Order Amphipoda (scuds)	Florida	736	79521, 79522, 79523, 79525, 79526, 79527, 79528, 79548, 79559, 79560, 80501, 80502, 80503, 80504, 80505, 80506, 80507
	Louisiana	14	78518, 78519
	New York	1	78503
	Tennessee	11	79542, 79546
	Texas	39	78510, 78520, 79553
	Washington	20	78513
Order Decapoda (crayfish, shrimp, crabs)			
Family Cambarinae			
Procambus sp.	Florida	2	79524

(Continued)

Table 5 (Concluded)

Name	State	No. of Specimens	Collection Numbers
Family Palaemonidae			
Machrobrachium ohione	Tennessee	1	79544
Palaemonetes intermedius	Florida	2	80507
Palaemonetes pugio	Florida	9	79527, 79548, 80505, 80506, 80507
	Oklahoma	1	79550
Palaemonetes sp.	Florida	11	79523, 79526, 79527, 79560
Orcanectes sp.	Florida	10	78511, 80503
Family Cancridae	New York	1	78503
Carcinus sp.	Florida	1	79524
Family Grapsidae			
Planes sp.	Florida	8	79524, 79559, 80502, 80505, 80506
Unidentified Decapoda sp.	Florida	310	78511, 80502, 80503, 80504, 80505, 80507
Order Isopoda (aquatic sow bugs)	Florida	30	79522, 79525, 79541, 79548, 79560, 80501, 80502, 80503, 80506
	Tennessee	1	79542
	Wisconsin	5	79530
Order Mysidacea (opossum shrimps)	Florida	8	79560, 80502, 80505
Subclass Ostracoda (seed shrimps)	Florida	8	80506
Class Mollusca			
Order Pelcypoda (clams, mussels)	Florida	24	79526, 79527, 79528, 79529, 79548, 79559, 79560, 80506
	Oklahoma	16	79549, 79552
	Texas	1	79553
	Wisconsin	2	79537, 79557

APPENDIX A: EURASIAN WATERMILFOIL COLLECTIONS

COLLEC_NO	NO_SAMPL	SMP_METH	HOST PLNT	DATE	SITE	LOCATION	COUNTY	STATE
78501.0	1	RAKE	MYRIOPH SPICATUM	28JUL1978	LAKE SEMINOLE	WEST ISLAND	SEMINOLE CO.	GA
78502.0	1	RAKE	MYRIOPH SPICATUM	31JUL1978	CRYSTAL RIVER	BAGLEY COVE, NORTH END	CITRUS CO.	FL
78503.0	1	RAKE	MYRIOPH EXALBESCENS	20SEP1978	ST. LAWRENCE LAKE	ACROSS FROM ROBERT MOSES ST. PK.	LAWRENCE CO.	NY
78504.0	1	RAKE	MYRIOPH SPICATUM	21SEP1978	PAIR OF SMALL PONDS	ENTRANCE ROBERT MOSES ST. PARK	LAWRENCE CO.	NY
78505.0	1	RAKE	MYRIOPH SPICATUM	21SEP1978	SMALL STREAM	1/2 MI. E OF WESCOTT BEACH ST. PARK	JEFFERSON CO.	NY
78506.0	1	RAKE	MYRIOPH SPICATUM	22SEP1978	CAYUGA LAKE	NORTH END	CAYUGA CO.	NY
78507.0	1	RAKE	MYRIOPH SPICATUM	22SEP1978	SENECA LAKE	EAST SIDE	SENECA CO.	NY
78508.1	1	RAKE	MYRIOPH SPICATUM	23SEP1978	OWASCO LAKE	NORTH END, BURTIS POINT	CAYUGA CO.	NY
78508.2	1	RAKE	MYRIOPH EXALBESCENS	23SEP1978	OWASCO LAKE	NORTH END, BURTIS POINT	CAYUGA CO.	NY
78508.3	1	RAKE	MYRIOPH SPICATUM	23SEP1978	OWASCO LAKE	NORTH END, AT BOAT CHANNEL	CAYUGA CO.	NY
78509.1	1	RAKE	MYRIOPH SPICATUM	23SEP1978	LAKE ONTARIO	S.W. CORNER OF SODUS BAY	WAYNE CO.	NY
78509.2	1	RAKE	MYRIOPH EXALBESCENS	23SEP1978	LAKE ONTARIO	S.W. CORNER OF SODUS BAY	WAYNE CO.	NY
78510.0	1	RAKE	MYRIOPH SPICATUM	3 OCT1978	CRYSTAL RIVER	MOUTH OF MILLER'S CREEK	CITRUS CO.	FL
78511.0	1	RAKE	MYRIOPH SPICATUM	3 OCT1978	SALT SPRINGS RUN	ALONG SPRING RUN	MARION CO.	FL
78512.0	1	RAKE	MYRIOPH SPICATUM	18OCT1978	LAKE WASHINGTON	UNION BAY, NORTH SIDE	KING CO., SEATTLE	WA
78513.0	1	RAKE	MYRIOPH SPICATUM	18OCT1978	LAKE WASHINGTON	UNION BAY, SOUTH SIDE	KING CO., SEATTLE	WA
78514.0	1	RAKE	MYRIOPH SPICATUM	20OCT1978	PILARCITOS RESERVOIR	ALONG NORTH SHORE	SAN MATEO CO.	CA
78515.0	1	RAKE	MYRIOPH SPICATUM	23OCT1978	SOUTH ALAMO CANAL	BRIDGE OVER CARR RD.	IMPERIAL CO.	CA
78516.0	1	RAKE	MYRIOPH SPICATUM	28OCT1978	CAYUGA LAKE	NORTH END	CAYUGA CO.	NY
78517.0	1	RAKE	MYRIOPH SPICATUM	15NOV1978	FALSE RIVER LAKE	INLET AT LIGHTHOUSE FISH CAMP	POINTE COUPEE PRSH	LA
78518.0	1	RAKE	MYRIOPH SPICATUM	15NOV1978	TOLEDO BEND RESERVOIR	SR 6 BRIDGE, MILE POST 4.5	SABINE PARISH	LA
78519.0	1	RAKE	MYRIOPH SPICATUM	15NOV1978	TOLEDO BEND RESERVOIR	E. SHORE ON SR 475, MILE POST 2	SABINE PARISH	LA
78520.0	1	RAKE	MYRIOPH SPICATUM	15NOV1978	TOLEDO BEND RESERVOIR	PENDLETON HARBOR MARINA	SABINE CO.	TX
79521.0	1	RAKE	MYRIOPH SPICATUM	8 MAR1979	CRYSTAL RIVER CANAL	MILLER'S CREEK CANAL	CITRUS CO.	FL
79522.0	1	RAKE	MYRIOPH SPICATUM	11APR1979	CRYSTAL RIVER	MILLER'S CREEK CANAL	CITRUS CO.	FL
79523.0	9	SMP+LG	MYRIOPH SPICATUM	10MAY1979	CRYSTAL RIVER	MOUTH OF MILLER'S CREEK	CITRUS CO.	FL
79524.0	5	SMP+LG	MYRIOPH SPICATUM	7 JUN1979	CRYSTAL RIVER	MOUTH OF MILLER'S CREEK	CITRUS CO.	FL
79525.0	5	SMP+LG	MYRIOPH SPICATUM	12JUL1979	CRYSTAL RIVER	MOUTH OF MILLER'S CREEK	CITRUS CO.	FL
79526.0	5	SMP+LG	MYRIOPH SPICATUM	9 AUG1979	CRYSTAL RIVER	BAGLEY COVE, NORTH END	CITRUS CO.	FL
79527.0	5	SMP+LG	MYRIOPH SPICATUM	9 AUG1979	CRYSTAL RIVER	BAGLEY COVE, NORTH END	CITRUS CO.	FL
79528.0	1	RAKE	MYRIOPH SPICATUM	21AUG1979	HOMOSASSA RIVER	NEAR MOUTH	CITRUS CO.	FL
79529.0	5	SMP+LG	MYRIOPH SPICATUM	11SEP1979	CRYSTAL RIVER	BAGLEY COVE, NORTH END	CITRUS CO.	FL
79530.0	1	RAKE	MYRIOPH SPICATUM	13SEP1979	LAKE WINGRA	VILLAS PARK LAGOONS	DANE CO., MADISON	WI
79531.0	1	RAKE	MYRIOPH SPICATUM	13SEP1979	LAKE WINGRA	BAY AT END OF VILLAS DR.	DANE CO., MADISON	WI
79532.0	1	RAKE	MYRIOPH SPICATUM	13SEP1979	LAKE WINGRA	NW END, NEAR KNICKERBOCKER DR.	DANE CO.	WI
79533.0	1	RAKE	MYRIOPH SPICATUM	14SEP1979	LAKE MENDOTA	TENNEY PARK LAGOON	DANE CO., MADISON	WI
79534.0	1	RAKE	MYRIOPH SPICATUM	14SEP1979	BUFFALO LAKE	N.E. SIDE BY MONTELLO	MARQUETTE CO.	WI
79535.0	1	RAKE	MYRIOPH SPICATUM	18SEP1979	GUNTERSVILLE RESERVOIR	UPPER HONEYCOMB CREEK	MARSHALL CO.	AL
79536.0	1	RAKE	MYRIOPH SPICATUM	18SEP1979	GUNTERSVILLE RESERVOIR	NORTH SAUTY EMBAYMENT	JACKSON CO.	AL
79537.0	1	RAKE	MYRIOPH SPICATUM	18SEP1979	GUNTERSVILLE RESERVOIR	COMER BRIDGE (SR 35), IN BAY	JACKSON CO.	AL
79538.0	1	RAKE	MYRIOPH SPICATUM	18SEP1979	GUNTERSVILLE RESERVOIR	COMER BRIDGE (SR 35), IN RIVER	JACKSON CO.	AL
79539.0	1	RAKE	MYRIOPH SPICATUM	18SEP1979	GUNTERSVILLE RESERVOIR	CROW CREEK	JACKSON CO.	AL
79540.0	1	RAKE	MYRIOPH SPICATUM	18SEP1979	NICKAJACK RESERVOIR	UNKNOWN	MARION CO.	TN
79541.0	1	RAKE	MYRIOPH SPICATUM	19SEP1979	CHICKAMAUGA RESERVOIR	DRY BRANCH	HAMILTON CO.	TN
79542.0	1	RAKE	MYRIOPH SPICATUM	19SEP1979	TENNESSEE RIVER	SPRING RUN	HAMILTON CO.	TN
79543.0	1	RAKE	MYRIOPH SPICATUM	19SEP1979	OLD CATFISH POND	NEAR PINEY CREEK	RHEA CO.	TN
79544.0	1	RAKE	MYRIOPH SPICATUM	20SEP1979	CLINCH RIVER	ACROSS FROM BULL RUN POWER PLANT	ROANE CO.	TN
79545.0	1	RAKE	MYRIOPH SPICATUM	20SEP1979	POND BY CLINCH RIVER	DAMMED PORTION OF MCCOY BRANCH	ROANE CO.	TN
79546.0	1	RAKE	MYRIOPH SPICATUM	20SEP1979	FT. LOUDON RESERVOIR	UNKNOWN	BLOUNT CO.	TN
79547.0	1	RAKE	MYRIOPH SPICATUM	10OCT1979	SALT SPRINGS RUN	1/2 MI FROM MOUTH	MARION CO.	FL
79548.0	5	SMP+LG	MYRIOPH SPICATUM	11OCT1979	CRYSTAL RIVER	BAGLEY COVE, NORTH END	CITRUS CO.	FL
79549.0	1	RAKE	MYRIOPH SPICATUM	23OCT1979	ILLINOIS RIVER	GRAVEL PITS, N. OF GORE LANDING	SEQUOYAH CO.	OK
79550.0	1	RAKE	MYRIOPH SPICATUM	23OCT1979	LAKE KERR	1/2 MILE S. OF CANADIAN RIVER	HASKELL CO.	OK
79551.0	1	RAKE	MYRIOPH SPICATUM	23OCT1979	LAKE KERR	DIVERSION DIKE FOR CANADIAN RIVER	HASKELL CO.	OK
79552.0	1	RAKE	MYRIOPH SPICATUM	23OCT1979	ILLINOIS RIVER	BESIDE SR 64 AND 100 BRIDGE	SEQUOYAH CO.	OK
79553.0	1	RAKE	MYRIOPH SPICATUM	24OCT1979	BARTON CREEK	100M FROM MOUTH AT TOWN LAKE	TRAVIS CO.	TX
79554.0	1	RAKE	MYRIOPH SPICATUM	25OCT1979	LAKE AUSTIN	AT BOAT HOUSE	TRAVIS CO.	TX
79555.0	1	RAKE	MYRIOPH SPICATUM	26OCT1979	SAN MARCOS RIVER	AQUARENA SPRINGS ENTRANCE	HAYS CO.	TX
79556.0	1	RAKE	MYRIOPH SPICATUM	29OCT1979	LAKE CONROE	MOUTH OF LEWIS CREEK	MONTOOMERY CO.	TX
79557.0	1	RAKE	MYRIOPH SPICATUM	30OCT1979	TOLEDO BEND RESERVOIR	BRIDGE OVER CARRICE CREEK	SABINE CO.	TX
79558.0	1	RAKE	MYRIOPH SPICATUM	30OCT1979	TOLEDO BEND RESERVOIR	E SHORE ON SR 475, MI. POST 2	SABINE PARISH	LA
79559.0	5	SMP+LG	MYRIOPH SPICATUM	9 NOV1979	CRYSTAL RIVER	BAGLEY COVE, NORTH END	CITRUS CO.	FL
79560.0	5	SMP+LG	MYRIOPH SPICATUM	14DEC1979	CRYSTAL RIVER	BAGLEY COVE, NORTH END	CITRUS CO.	FL
79578.0	1	RAKE	MYRIOPH SPICATUM	10NOV1979	LAKE SEMINOLE	MOUTH OF FISH POND DRAIN	SEMINOLE CO.	GA
80501.0	5	SMP+LG	MYRIOPH SPICATUM	10JAN1980	CRYSTAL RIVER	BAGLEY COVE, NORTH END	CITRUS CO.	FL
80502.0	5	SMP+LG	MYRIOPH SPICATUM	11FEB1980	CRYSTAL RIVER	BAGLEY COVE, NORTH END	CITRUS CO.	FL
80503.0	1	RAKE	MYRIOPH SPICATUM	12MAR1980	CRYSTAL RIVER	BAGLEY COVE, NORTH END	CITRUS CO.	FL
80504.0	5	SMP+LG	MYRIOPH SPICATUM	7 APR1980	CRYSTAL RIVER	BAGLEY COVE, NORTH END	CITRUS CO.	FL
80505.0	5	SMP+LG	MYRIOPH SPICATUM	6 MAY1980	CRYSTAL RIVER	BAGLEY COVE, NORTH END	CITRUS CO.	FL
80506.0	5	SMP+LG	MYRIOPH SPICATUM	10JUN1980	CRYSTAL RIVER	BAGLEY COVE, NORTH END	CITRUS CO.	FL
80507.0	5	SMP+LG	MYRIOPH SPICATUM	8 JUL1980	CRYSTAL RIVER	BAGLEY COVE, NORTH END	CITRUS CO.	FL
80508.0	1	RAKE	MYRIOPH SPICATUM	26OCT1980	BARTON SPRINGS	AT TOWNE LAKE	TRAVIS CO.	TX
80509.0	1	RAKE	MYRIOPH SPICATUM	25OCT1980	SAN MARCOS RIVER	AT AQUARENA SPRINGS	HAYES CO.	TX
80510.0	1	RAKE	MYRIOPH SPICATUM	26OCT1980	BARTON SPRINGS	100 M FROM MOUTH AT TOWNE LAKE	TRAVIS CO.	TX

APPENDIX B: EURASIAN WATERMILFOIL COLLECTION SITE DATA

COLLEC_NO	DEPTH m	MAT_DEPTH m	H2O_TEMP °C	SALINITY ppt	CONDUC µmho	WET_WGT g	DRY_WGT g	PLNT_SP2	SP2_DWGT	PLNT_SP3	SP3_DWGT	LDMG_TOP	LDMG_MID	LDMG_BOT	SDMG_TOP	SDMG_MID	SDMG_BOT
78501.0	1.80	0.5	.	.	.	.	173.5	NONE	.	NONE	.	.	.	.	.	.	.
78502.0	1.10	TOP	28.0	.	.	.	59.6	NONE	.	NONE	.	.	.	.	.	.	.
78503.0	1.50		17.0	.	.	.	117.0	NONE	.	NONE	.	1.3	3.3	3.9	1.0	1.3	1.3
78504.0	.		.	.	.	.	152.8	NONE	.	NONE	.	1.2	1.6	1.3	1.0	1.6	1.1
70505.0	1.00		.	.	.	.	25.3	NONE	.	NONE	.	1.3	1.6	1.7	1.4	1.6	1.6
78506.0	.		19.0	.	.	.	111.0	NONE	.	NONE	.	1.0	1.5	1.6	1.1	1.4	1.5
70507.0	.	BEL	19.0	.	.	.	397.6	NONE	.	NONE	.	1.0	2.0	2.3	1.0	1.6	1.6
78508.1	.	BEL	.	.	.	.	125.3	NONE	.	NONE	.	2.5	3.6	3.8	1.3	2.1	1.8
78508.2	.	BEL	.	.	.	.	40.7	NONE	.	NONE	.	1.3	2.3	3.4	1.3	1.1	1.1
78508.3	.	BEL	.	.	.	.	98.3	NONE	.	NONE	.	1.0	1.0	1.5	1.3	1.5	1.6
78509.1	.		.	.	.	.	145.5	NONE	.	NONE	.	1.0	1.3	1.2	1.0	1.6	1.4
78509.2	.		.	.	.	.	145.5	NONE	.	NONE	.	1.0	1.0	1.0	1.5	1.6	1.0
78510.0	0.85		24.5	0.5	900	.	42.5	NONE	.	NONE	.	1.0	1.6	1.7	1.1	1.6	1.8
78511.0	.		27.0	3.3	6000	.	114.5	NONE	.	NONE	.	1.1	1.5	1.5	1.1	1.7	1.7
78512.0	2.00		.	.	.	.	100.0	NONE	.	NONE	.	1.0	1.4	1.6	1.6	1.4	1.4
78513.0	1.50		.	.	.	.	67.2	NONE	.	NONE	.	.	.	.	.	.	.
78514.0	.		.	.	.	.	148.4	NONE	.	NONE	.	1.3	2.0	2.1	1.6	2.0	2.2
78515.0	2.00	0.3	.	.	.	.	194.3	NONE	.	NONE	.	1.3	1.3	1.2	1.2	1.6	1.5
78516.0	.		.	.	.	.	198.5	NONE	.	NONE	.	1.4	2.0	2.4	1.7	2.4	2.4
78517.0	1.00		21.5	0.0	200	.	126.1	NONE	.	NONE	.	1.0	1.2	1.0	1.0	1.1	1.0
78518.0	0.30	TOP	22.0	0.0	220	.	47.0	NONE	.	NONE	.	1.0	1.1	1.0	1.1	1.1	1.2
78519.0	0.60	TOP	21.5	0.0	210	.	67.9	NONE	.	NONE	.	1.2	2.0	3.5	1.1	1.9	1.7
78520.0	0.70	TOP	21.5	0.0	220	93.8	58.2	NONE	.	NONE	.	1.4	1.8	3.6	1.5	2.8	2.4
79521.0	.		21.0	0.3	1100	168.0	14.1	NONE	.	NONE	.	.	.	.	.	.	.
79522.0	0.15	TOP	.	1.0	1600	974.8	48.5	CERATOPHYLLUM DEMERSUM	19.6	HYDRILLA VERTICILLATA ;	0.1	1.0	1.0	1.0	1.0	1.0	1.0
79523.0	0.90	TOP	.	1.0	1650	1378.0	153.6	CERATOPHYLLUM DEMERSUM	1.8	HYDRILLA VERTICILLATA	0.2	1.0	1.0	1.0	1.0	1.0	1.0
79524.0	0.50	TOP	.	.	.	461.8	68.2	HYDRILLA VERTICILLATA	5.9	CERATOPHYLLUM DEMERSUM	5.3	1.0	1.0	.	1.8	1.8	.
79525.0	0.60	TOP	31.0	1.5	3050	530.9	53.1	HYDRILLA VERTICILLATA	42.9	CERATOPHYLLUM DEMERSUM	30.9	1.0	1.0	1.0	1.0	1.0	1.0
79526.0	0.60	TOP	.	.	.	966.7	114.9	HYDRILLA VERTICILLATA	2.3	NAJAS GUADALUPENIS	0.4	1.0	1.2	1.3	1.2	1.3	1.5
79527.0	0.60	BEL	.	.	.	954.0	155.5	NONE	.	NONE	0.4	1.0	1.0	1.0	1.0	1.0	1.0
79528.0	0.70	TOP	29.0	6.5	12000	637.5	575.4	SARGASSUM SP.	4.9	ALGAE	0.5	.	.	.	.	.	.
79529.0	1.00	TOP	.	1.0	2050	1179.0	170.9	NONE	.	NONE	.	3.9	3.8	.	3.1	3.7	.
79530.0	0.50	TOP	20.5	0.0	250	1539.0	141.8	NONE	.	NONE	.	1.0	1.0	1.0	1.6	2.1	2.3
79531.0	0.90		22.5	0.0	360	637.6	95.8	CERATOPHYLLUM DEMERSUM	0.6	NONE	.	1.5	1.9	.	1.7	2.4	.
79532.0	1.20	TOP	21.0	0.0	360	1024.0	149.1		4.5	NONE	.	1.1	1.2	1.3	1.6	1.8	1.9
79533.0	0.25	TOP	18.5	0.0	290	846.7	77.4	HYDRILLA VERTICILLATA	0.1	CERATOPHYLLUM DEMERSUM	1.5	3.1	2.6	2.6	2.1	2.3	2.3
79534.0	1.00		18.5	0.0	275	1216.0	121.3	HYDRILLA VERTICILLATA	1.0	NONE	.	.	.	.	.	.	.
79535.0	0.15	TOP	19.5	0.0	195	906.9	135.4	NONE	.	NONE	.	.	.	.	.	.	.
79536.0	0.35	BEL	20.0	0.0	650	1908.0	130.0	NONE	.	NONE	.	1.0	1.0	1.0	1.1	1.1	1.1
79537.0	0.50	TOP	20.0	0.0	165	1379.0	148.2	CERATOPHYLLUM DEMERSUM	0.6	NONE	.	1.4	1.4	1.6	1.6	1.8	1.8
79538.0	1.10	TOP	23.5	0.0	160	1635.0	159.6	NONE	.	NONE	.	2.2	2.4	2.7	2.2	2.4	2.3
79539.0	0.40	TOP	22.5	0.0	105	797.4	142.0	NONE	.	NONE	.	2.1	2.8	.	1.8	1.0	.
79540.0	0.25	TOP	22.0	0.0	115	1079.0	113.7	CERATOPHYLLUM DEMERSUM	0.5	NONE	.	1.0	1.0	1.0	1.1	1.2	1.2
79541.0	0.50	TOP	23.0	0.0	160	1668.0	204.7	NONE	.	NONE	.	2.1	2.1	2.2	2.4	2.5	2.5
79542	1.30	TOP	17.5	0.0	180	1547.0	179.8	NONE	.	NONE	.	1.5	1.7	1.7	1.2	1.4	1.4
79543	0.20	TOP	25.0	0.0	135	1189.0	133.8	NONE	.	NONE	.	1.3	1.4	1.5	1.4	1.8	1.8
79544	.	TOP	20.5	0.0	155	1734.0	272.8	HYDRILLA VERTICILLATA	85.9	VALLISNERIA	2.4	2.2	2.2	2.2	2.2	2.2	2.2
79545	.	TOP	21.5	0.0	190	989.9	135.9	NONE	.	NONE	.	2.2	2.4	2.4	2.3	2.3	2.3
79546	.		.	.	.	338.6	53.0	NONE	.	NONE	.	1.6	1.7	1.7	2.1	2.1	2.0
79547	1.70		.	.	.	.	.	NONE	.	NONE	.	.	.	.	.	.	.
79548	0.50	TOP	.	1.0	2020	965.0	102.1	NAJAS QUADULUPENSIS	0.3	HYDRILLA VERTICILLATA	0.1	2.2	2.1	.	2.5	1.7	.
79549	0.25		13.5	0.0	150	981.5	82.6	ALGAE	9.8	NONE	.	2.4	2.6	2.7	2.4	2.6	2.8
79550	0.40		16.0	0.0	330	1016.0	142.3	NONE	.	NONE	.	2.7	3.0	3.0	3.0	3.3	3.2
79551	0.35		16.5	0.0	350	1045.0	148.0	NONE	.	NONE	.	1.6	1.6	1.6	2.0	2.3	2.2
79552	1.20		16.0	0.0	150	2512.0	129.6	ALGAE	6.8	NONE	.	1.6	1.9	1.9	2.0	2.2	2.2
79553	.		.	.	.	1636.0	137.3	NONE	.	NONE	.	1.2	1.5	1.4	1.5	1.6	2.2
79554	.		.	.	.	619.1	100.6	NAJAS MINOR	1.1	POTOMAGETON NODOSUS	0.3	2.0	2.1	.	2.2	2.3	.
79555	0.70	BEL	22.5	0.0	525	1077.0	117.2	BACOPA MONNIERI	0.4	NONE	.	1.8	2.0	2.0	2.0	1.9	2.0
79556	1.30	TOP	22.0	0.0	150	819.7	116.0	CERATOPHYLLUM DEMERSUM	4.3	NONE	.	2.0	2.1	2.1	2.0	2.4	2.5
79557	1.60	TOP	22.0	0.0	130	740.7	102.7	HYDRILLA VERTICILLATA	2.1	NONE	.	.	.	.	.	.	.
79558	0.60		23.5	0.0	145	.	.	NONE	.	NONE	.	.	.	.	.	.	.
79559	0.50	TOP	22.5	1.7	2540	845.8	98.9	NONE	.	NONE	.	1.7	2.1	.	2.0	2.3	.
79560	0.80	0.4	22.0	1.3	2200	64.5	6.0	CERATOPHYLLUM DEMERSUM	0.3	HYDRILLA VERTICILLATA	0.1	1.0	1.0	.	1.0	1.0	.
79578	.		.	.	.	1283.2	77.3	CERATOPHYLLUM DEMERSUM	2.8	NAJAS MINOR	0.8	1.2	1.4	1.4	1.3	1.7	2.0
80501	0.80	TOP	18.5	0.5	1150	308.5	37.2	NONE	.	NONE	.	1.1	1.1	.	1.2	1.2	.
80502	0.80	0.3	18.5	0.8	1250	590.6	57.9	NONE	.	NONE	.	1.2	1.3	1.8	1.3	1.2	2.0
80503	0.80	BEL	22.5	1.0	1450	381.8	33.1	ALGAE	7.5	CERATOPHYLLUM DEMERSUM	4.9	1.5	1.7	1.8	1.4	1.6	1.3
80504	0.65	BEL	21.0	1.0	1700	153.3	7.7	CERATOPHYLLUM DEMERSUM	0.4	NAJAS QUADULUPENSIS	0.1	1.0	1.0	.	1.0	1.0	.
80505	0.85	TOP	23.0	1.0	1750	1493.0	134.4	CERATOPHYLLUM DEMERSUM	0.1	NONE	.	1.0	1.0	1.0	1.0	1.0	1.0
80506	1.30	0.2	26.0	1.5	3350	854.1	100.0	HYDRILLA VERTICILLATA	0.7	NONE	.	.	.	.	.	.	.
80507	1.10	0.2	28.0	1.3	2690	886.4	104.5	NONE	.	NONE	.	.	.	.	.	.	.

N=71

APPENDIX C: QUANTITATIVE EURASIAN WATERMILFOIL SAMPLE RESULTS

CLLEC_NO	DATE	LOCATION	SAMPL_NO	WET_WGT	DRY_WGT	INSECTS	SNAILS
79523	10MAY1979	MOUTH OF MILLER'S CREEK	0.3	208.5	29.9	0	12
79523	10MAY1979	MOUTH OF MILLER'S CREEK	0.4	156.8	14.9	0	16
79523	10MAY1979	MOUTH OF MILLER'S CREEK	0.5	148.1	12.3	0	0
79523	10MAY1979	MOUTH OF MILLER'S CREEK	0.6	254.5	26.2	0	0
79523	10MAY1979	MOUTH OF MILLER'S CREEK	0.7	310.4	33.5	0	5
79523	10MAY1979	MOUTH OF MILLER'S CREEK	0.8	149.2	16.5	0	4
79523	10MAY1979	MOUTH OF MILLER'S CREEK	0.9	150.0	20.3	0	10
79524	07JUN1979	MOUTH OF MILLER'S CREEK	0.1	119.9	21.6	1	5
79524	07JUN1979	MOUTH OF MILLER'S CREEK	0.2	91.0	11.8	1	17
79524	07JUN1979	MOUTH OF MILLER'S CREEK	0.3	76.3	9.1	0	10
79524	07JUN1979	MOUTH OF MILLER'S CREEK	0.4	66.3	8.8	0	13
79524	07JUN1979	MOUTH OF MILLER'S CREEK	0.5	108.3	16.9	0	7
79525	12JUL1979	MOUTH OF MILLER'S CREEK	0.1	163.7	15.9	5	20
79525	12JUL1979	MOUTH OF MILLER'S CREEK	0.2	152.7	13.2	6	15
79525	12JUL1979	MOUTH OF MILLER'S CREEK	0.3	15.1	8.8	6	19
79525	12JUL1979	MOUTH OF MILLER'S CREEK	0.4	72.8	0.1	3	40
79525	12JUL1979	MOUTH OF MILLER'S CREEK	0.5	126.6	15.1	1	37
79526	09AUG1979	BAGLEY COVE, NORTH END	0.1	123.7	15.6	5	.
79526	09AUG1979	BAGLEY COVE, NORTH END	0.2	143.0	16.4	3	.
79526	09AUG1979	BAGLEY COVE, NORTH END	0.3	189.6	23.0	11	.
79526	09AUG1979	BAGLEY COVE, NORTH END	0.4	253.4	29.5	6	.
79526	09AUG1979	BAGLEY COVE, NORTH END	0.5	257.0	30.4	4	.
79527	09AUG1979	BAGLEY COVE, NORTH END	0.1	125.1	20.5	15	48
79527	09AUG1979	BAGLEY COVE, NORTH END	0.2	347.4	55.2	8	21
79527	09AUG1979	BAGLEY COVE, NORTH END	0.3	152.5	25.1	3	15
79527	09AUG1979	BAGLEY COVE, NORTH END	0.4	154.6	24.4	8	47
79527	09AUG1979	BAGLEY COVE, NORTH END	0.5	174.4	30.3	9	33
79529	11SEP1979	BAGLEY COVE, NORTH END	0.1	174.8	25.9	2	5
79529	11SEP1979	BAGLEY COVE, NORTH END	0.2	250.3	27.3	2	6
79529	11SEP1979	BAGLEY COVE, NORTH END	0.3	241.8	28.9	2	8
79529	11SEP1979	BAGLEY COVE, NORTH END	0.4	294.9	63.5	1	4
79529	11SEP1979	BAGLEY COVE, NORTH END	0.5	217.0	25.4	3	9
79548	11OCT1979	BAGLEY COVE, NORTH END	0.1	207.3	21.8	12	11
79548	11OCT1979	BAGLEY COVE, NORTH END	0.2	214.4	20.8	3	7
79548	11OCT1979	BAGLEY COVE, NORTH END	0.3	202.1	19.1	1	2
79548	11OCT1979	BAGLEY COVE, NORTH END	0.4	131.8	16.0	7	6
79548	11OCT1979	BAGLEY COVE, NORTH END	0.5	209.4	24.4	1	10
79559	09NOV1979	BAGLEY COVE, NORTH END	0.1	154.4	16.9	6	4
79559	09NOV1979	BAGLEY COVE, NORTH END	0.2	135.6	16.3	5	0
79559	09NOV1979	BAGLEY COVE, NORTH END	0.3	182.2	22.1	8	7
79559	09NOV1979	BAGLEY COVE, NORTH END	0.4	207.9	25.2	5	3
79559	09NOV1979	BAGLEY COVE, NORTH END	0.5	165.7	18.4	10	0
79560	14DEC1979	BAGLEY COVE, NORTH END	0.1	6.7	0.7	5	0
79560	14DEC1979	BAGLEY COVE, NORTH END	0.2	10.5	1.0	3	0
79560	14DEC1979	BAGLEY COVE, NORTH END	0.3	11.4	1.0	4	0
79560	14DEC1979	BAGLEY COVE, NORTH END	0.4	9.8	0.9	3	1
79560	14DEC1979	BAGLEY COVE, NORTH END	0.5	26.1	2.4	9	0
80501	10JAN1980	BAGLEY COVE, NORTH END	0.1	31.6	3.6	0	6
80501	10JAN1980	BAGLEY COVE, NORTH END	0.2	74.1	9.5	2	18
80501	10JAN1980	BAGLEY COVE, NORTH END	0.3	24.5	2.4	1	1
80501	10JAN1980	BAGLEY COVE, NORTH END	0.4	76.8	9.2	0	5
80501	10JAN1980	BAGLEY COVE, NORTH END	0.5	101.5	12.5	0	8
80502	11FEB1980	BAGLEY COVE, NORTH END	0.1	8.7	0.9	0	1
80502	11FEB1980	BAGLEY COVE, NORTH END	0.2	13.3	1.3	3	2
80502	11FEB1900	BAGLEY COVE, NORTH END	0.3	4.8	0.2	1	0
80502	11FEB1980	BAGLEY COVE, NORTH END	0.4	23.8	1.5	0	4
80502	11FEB1980	BAGLEY COVE, NORTH END	0.5	4.9	0.2	3	1
80504	07APR1980	BAGLEY COVE, NORTH END	0.1	67.0	4.1	1	6
80504	07APR1980	BAGLEY COVE, NORTH END	0.2	25.7	1.1	0	0
80504	07APR1980	BAGLEY COVE, NORTH END	0.3	27.2	1.2	0	0
80504	07APR1980	BAGLEY COVE, NORTH END	0.4	10.5	0.6	0	3
80504	07APR1980	BAGLEY COVE, NORTH END	0.5	22.9	0.7	0	0
80505	06MAY1980	BAGLEY COVE, NORTH END	0.1	73.9	3.7	0	2
80505	06MAY1990	BAGLEY COVE, NORTH END	0.2	116.3	4.5	0	0
80505	06MAY1980	BAGLEY COVE, NORTH END	0.3	51.5	4.6	2	3
80505	06MAY1980	BAGLEY COVE, NORTH END	0.4	109.4	9.3	4	9
80505	06MAY1980	BAGLEY COVE, NORTH END	0.5	91.0	7.3	3	14
80506	10JUN1990	BAGLEY COVE, NORTH END	0.1	176.9	19.0	0	7
80506	10JUN1980	BAGLEY COVE, NORTH END	0.2	127.0	18.5	10	10
80506	10JUN1980	BAGLEY COVE, NORTH END	0.3	196.7	20.0	1	5
80506	10JUN1980	BAGLEY COVE, NORTH END	0.4	146.2	20.1	6	11
80506	10JUN1980	BAGLEY COVE, NORTH END	0.5	207.3	22.4	4	5
80507	08JUL1980	BAGLEY COVE, NORTH END	0.1	160.4	19.5	5	33
80507	08JUL1980	BAGLEY COVE, NORTH END	0.2	144.8	18.4	2	36
80507	08JUL1980	BAGLEY COVE, NORTH END	0.3	210.0	23.7	28	29
80507	08JUL1980	BAGLEY COVE, NORTH END	0.4	199.4	22.7	[illegible]	14
80507	08JUL1980	BAGLEY COVE, NORTH END	0.5	[illegible]1.8	20.2	15	32

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Balciunas, Joseph K.
  Insects and other macroinvertebrates associated with Eurasian watermilfoil in the United States / by Joseph K. Balciunas (Aquatic Plant Management Laboratory, Agricultural Research Service, U.S. Department of Agriculture). -- Vicksburg, Miss. : U.S. Army Engineer Waterways Experiment Station ; Springfield, Va. ; available from NTIS, 1982.
  87 p. in various pagings : ill. ; 27 cm. -- (Technical report ; A-82-5)
  Cover title.
  "October 1982."
  Final report.
  "Prepared for Office, Chief of Engineers, U.S. Army under Interagency Agreement No. USDA/SEA 12-14-7001-995."
  "Monitored by Environmental Laboratory, U.S. Army Engineer Waterways Experiment Station."
  At head of title: Aquatic Plant Control Research Program.
  Bibliography: p. 69-73.

Balciunas, Joseph K.
  Insects and other macroinvertebrates associated with : ... 1982.
(Card 2)

  1. Aquatic weeds. 2. Insects. 3. Invertebrates. 4. Weed control--Biological control. I. United States. Agricultural Research Service. II. United States. Army. Corps of Engineers. Office of the Chief of Engineers. III. Aquatic Plant Control Research Program. IV. U.S. Army Engineer Waterways Experiment Station. Environmental Laboratory. V. Title VI. Series: Technical report (U.S. Army Engineer Waterways Experiment Station) ; A-82-5.
TA7.W34 no.A-82-5