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# Aquatic Plant Control Research Program

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## Overseas research for biological control agents—achievements offer exciting potential

by Alfred F. Cofrancesco

U.S. Army Corps of Engineers scientists and researchers from the U.S. Department of Agriculture (USDA) began overseas research in the late 1960s to find biological control agents for use in aquatic plant management. This search for natural plant enemies (insects and fungal pathogens) has led researchers to the native ranges of noxious aquatic plants, located throughout the continents of Africa, Asia, Europe, and Australia.

For Corps aquatic plant managers, the two most troublesome aquatic plants are the exotic species Eurasian watermilfoil (*Myriophyllum spicatum*) and hydrilla (*Hydrilla verticillata*). These species, which account for more than two thirds of all noxious aquatic weed acreage in the United States, have similar characteristics. They are rooted submersed macrophytes that grow to the water's surface, forming extensive mats of vegetation that restrict navigation and recreational use of waterways. Records document the establishment of milfoil in the United States by 1881 (Balciunas 1982) and hydrilla, by the late 1950s or early 1960s (Balciunas 1985).

In their native range overseas, milfoil and hydrilla comprise a small component of a diverse assemblage of aquatic plants. They generally do not cause problems because they are exposed to various pressures or stresses that restrict their growth, reproduction, or distribution.

Classical biological control focuses on identifying stress-causing organisms that impact plant populations. The introduction of these host-specific agents in the new range often reduces the target plant population below problem levels. Releases of the alligatorweed flea beetle (*Agasicles hygrophila*) have proven the effectiveness of this control method.



Hydrilla is collected to help researchers find natural plant enemies

### Native range

As preliminary steps toward implementing biological control of milfoil and hydrilla, it was necessary to identify the native range of each plant and to conduct surveys to find potential biological control agents for the plants.

Information from the literature and from botanical experts indicated that milfoil was native to regions of Europe, Asia, and Africa (Godfrey and Wooten 1981). The native range of hydrilla has been debated extensively. However, most botanists have claimed it is native to Asia, Africa, and Australia (Godfrey and Wooten 1979).

The four continents that comprise the native range of milfoil and hydrilla (Africa, Europe, Asia, and Australia) represent over 60 percent of the world's land mass, or approximately 92.5 million square kilometers. In general, this area is contained between latitude 85° N to 42° S and from longitude 18° W eastward to 170° W, and comprises more than 40 percent of the total world surface.

Many areas on these four continents may be unsuitable for the growth of milfoil and hydrilla. Nevertheless, this represents a huge area to survey, and researchers often must travel great distances between sites. In addition, travel in much of the area is complicated by problems related to political concerns and limited accessibility to remote areas.



When the surveys were begun, over 30 years ago, more than 31.5 million square kilometers of the total area to be surveyed had significant restrictions on movement of researchers.

## Insect surveys

In the late 1960s when researchers began surveying milfoil, major portions of the plant's native range were in countries where the government either denied visits or restricted movement, making research, surveys, and travel extremely difficult.

Researchers focused their efforts on regions of the plant's native range for which only minimal information on the insect fauna was available. For this reason, the surveys initially focused on the regions around India, Pakistan, and Yugoslavia. Surveys in western Europe were not initially programmed, because extensive general studies on the aquatic invertebrate fauna had been conducted for other research efforts.

In 1967 the Commonwealth Institute of Biological Control (CIBC) began surveys in Pakistan to identify insect biological agents of milfoil. This survey work continued into the early 1970s, with exploration of Pakistan, India, Yugoslavia, and Bangladesh. Only incidental collecting for milfoil agents occurred between the early 1970s and the late 1980s (Table 1).

Research on hydrilla biological control began in 1968, with CIBC survey efforts in India. These initial surveys were followed by work in Pakistan (Baloch, Phil, and Sana-Ullah 1976) and Malaysia (Balciunas 1985). Initial surveys in Africa (Kenya and Tanzania) were conducted by Dr. Robert Pemberton during a 4-month period in 1976.

By 1976, research efforts on milfoil and hydrilla had identified more than 35 herbivorous insects

associated with these two plant species (Table 1), indicating that potential insect biocontrol agents existed.

During most of the 1980s, overseas surveys focused almost exclusively on insect biological control agents of hydrilla. In 1985, while conducting other overseas research projects in Africa for CIBC, Markham (1986) was able to survey five countries for potential biocontrol agents of hydrilla. He found only two herbivorous insects associated with the very sparse hydrilla populations that he located in the countries surveyed.

The most extensive surveys for hydrilla biological control agents were conducted between 1981 and 1983 (Balciunas 1985). Dr. Joseph Balciunas visited five countries in 1981, six countries in 1982, and seven countries in 1983. During 3 years of survey work, he collected over 40 species of phytophagous insects feeding on hydrilla.

The surveys by Dr. Balciunas indicated that the greatest potential for insect agents existed in areas of Australia and Southeast Asia. Based on that information, the U.S. Department of Agriculture in 1985 established a research facility in eastern Australia, where Dr. Balciunas based his research efforts. From this facility, extensive surveys of eastern Australia were completed, and host-specificity testing was undertaken. Having a scientist in residence overseas allowed four insect biocontrol agents from Asia and Australia to be screened and eventually approved for release in the United States as biological control agents of hydrilla.

Development of the Sino American Biological Control Laboratory (SABCL) in 1989 allowed researchers access to areas in the native range of milfoil and hydrilla that had been closed for over 40 years. As a result, U.S. researchers have been able to

conduct supervised surveys in certain regions of the People's Republic of China (PRC) for biological control agents of both milfoil and hydrilla. In general, these surveys have consisted of a 1- to 2-month effort each year.

The SABCL has been extremely beneficial for the initial screening of agents. Researchers located northern populations of *Hydrellia pakistanae* at survey sites outside of Beijing. After host-specificity testing and quarantine screening, this agent was released into the more northern U.S. range of hydrilla.

Additional research on insect biocontrol agents has also been reported from the former Soviet Union (FSU) and Southeast Asia. With funding from the Corps' Aquatic Plant Control Research Program (APCRP), Zaitzev and others (1996) collected information on 25 insect biocontrol agents feeding on milfoil in areas of the FSU.

The USDA has recently established a close working relationship with researchers in Thailand, and this has allowed easier access to areas for surveys. In 1997, USDA researchers reported that they had collected two weevil species and other phytophagous insects feeding on hydrilla in Thailand (Cofrancesco 1998).

## Pathogen surveys

Overseas pathogen surveys for biological control agents of milfoil and hydrilla have received attention only recently. Although early surveys indicated that both insects and pathogens were involved, most surveys did not examine the impact of pathogens. The one exception was survey work in Yugoslavia, reported by Lekic (1972), in which more than eight pathogens were collected from milfoil. Since these surveys in the early 1970s, only sporadic efforts have been

**Table 1. Chronological Listing of Biological Control Surveys, 1967-1996**

<b>Continent / Country</b>	<b>Target</b>	<b>Year</b>	<b>Type of Survey</b>	<b>Survey Duration</b>	<b>Potential Agents</b>
Asia / Pakistan	Milfoil	1967-69	Insect	Periodic In country	11 insect spp.
Europe / Yugoslavia	Milfoil	1967-72	Insect/ pathogen	Periodic In country	15 insect spp. 8 fungi
Asia / India	Hydrilla	1968	Insect	Periodic In country	1 insect sp.
Asia / Pakistan	Hydrilla	1971-76	Insect	Periodic In country	8 insect spp.
Asia / Malaysia	Hydrilla	1976	Insect	Periodic In country	2 insect spp.
Africa / Kenya, Tanzania	Hydrilla	1976	Insect	4 months	1 insect sp.
Africa / Kenya, Uganda, Rwanda, Burundi, Malawi	Hydrilla	1981-84	Insect	Periodic In country	2 insect spp.
Asia / India	Hydrilla	1982	Insect	1 month	1-3 insect spp.
Asia / Sri Lanka, Burma, Thailand, Malaysia, Indonesia	Hydrilla	1982	Insect	5 months	15-18 insect spp.
Australia / Australia					
Asia / Philippines, Papua, New Guinea, India, Malaysia, Burma	Hydrilla	1983	Insect	5 months	20-24 insect spp.
Australia / Australia					
Asia / India	Hydrilla	1985	Insect	1 month	4-6 insect spp.
Australia / Australia	Hydrilla	1985-90	Insect	Periodic In country	25-27 insect spp.
Asia / China	Milfoil Hydrilla	1989-95	Insect	1-2 months annually	11 insect spp.
Asia / China	Milfoil Hydrilla	1993-94	Pathogen	1 month annually	200 isolates
Europe / England, Ger- many, Wales, Ireland, Switzerland, Italy, France, Austria, Scotland, Slovenia, Spain, Portugal	Milfoil	1993-94	Pathogen	Periodic In country	291 isolates
Europe & Asia / Former Soviet Union	Milfoil Hydrilla	1996	Pathogen/ insect	Periodic In country	25 insect spp. 7 fungi

conducted to identify pathogens from the native range of milfoil and hydrilla.

Recently there has been a resurgence of interest in exotic plant pathogens for milfoil and hydrilla. In research supported by the APCRP, Harvey and Evans (1997) surveyed 12 western European countries for potential pathogen

biological agents of milfoil. These researchers collected 291 isolates over 3 years. Based on subsequent testing, 15 isolates appear to be effective for milfoil control.

Dr. Judy Shearer (1997) conducted surveys in the PRC during the summers of 1994 and 1995. She collected more than 120 isolates from milfoil and 85 isolates

from hydrilla. These isolates are currently undergoing screening at the USDA quarantine facility in Frederick, MD. A preliminary survey in the FSU (Zaitzev and others 1996) reported seven fungal species associated with milfoil.

Pathogen surveys have just begun to explore and identify the numerous potential agents that are

associated with problem aquatic plant species.

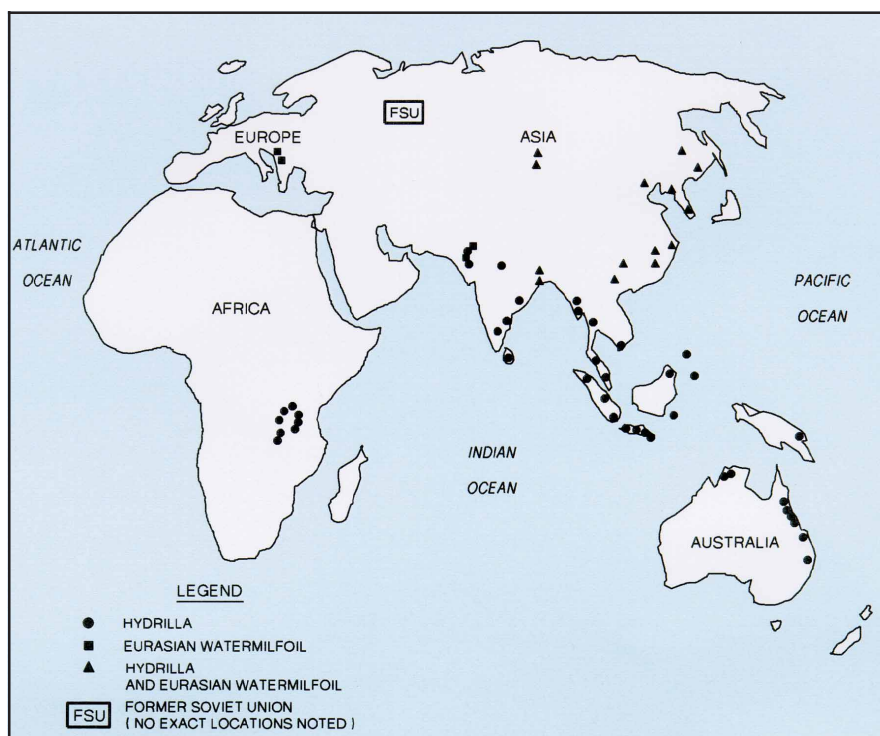
## Results to date

The areas surveyed for insect and pathogen biological control agents of Eurasian watermilfoil and hydrilla are shown in Figures 1 and 2. A number of sites have been identified. However, in most cases the time spent by a researcher at individual sites has been limited to a few days. It has often been difficult for the researcher to locate populations of the target plant, since it usually represents only a small portion of the total plant community. For example, Pemberton (1980) did not locate hydrilla populations until the fourth month of his survey.

In addition, many of the early studies performed by local researchers in foreign countries addressed many target weeds. Thus, the amount of time devoted specifically to Eurasian watermilfoil and hydrilla was not as long as the total study time might indicate.

It is obvious that biological control research has thus far explored only a small portion of the distribution of these target plants. It might appear that a "hit or miss" approach was used in site selection for surveys. However, often it was the type of funding that dictated the locations that were surveyed. In the case of the surveys conducted by CIBC, funding was tied to a specific country. Surveys funded by the Corps and other organizations followed agendas set by the funding institutions. However, these surveys were often adjusted to accommodate the political and travel restrictions in individual countries.

Researchers now have a better overall picture of the key locations that appear promising for potential biological control agents of milfoil and hydrilla. The lack of extensive surveys for pathogens until 1993



**Figure 1. Sites surveyed for insect biological control agents of hydrilla and Eurasian watermilfoil**

and the wealth of potential agents identified by Harvey and Evans (1997) and Shearer (1997) indicate that pathogen surveys should continue.

The recent accessibility to regions such as the Former Soviet Union means that a wealth of habitat for potential agents is now available. The current economic situation in these regions of the world may work to our advantage in the exploration process. Many well-trained scientists are available throughout the FSU, and the cost of having them conduct the surveys would significantly reduce the cost of these projects.

To identify hydrilla populations genetically similar to the problem populations in the United States, the USDA recently conducted studies to compare the genotypes of hydrilla found in the States with hydrilla from other regions of the world. Based on these studies, it appears that hydrilla populations from Southeast Asia are the most

similar to hydrilla found in the United States. This information, along with the extensive list of potential agents collected by Dr. Balciunas during three survey trips, pinpoints this area for intensive future research.

## Future direction

Findings to date provide insight for the future direction of biological control research for aquatic plant management. Recommendations are summarized below.

- ♦ Overseas surveys and research should be continued. Wherever possible, local collaborators should be used, to help reduce cost and increase survey efficiency.
- ♦ All overseas surveys should simultaneously focus on insect and pathogen biological control agents.
- ♦ Surveys for agents of Eurasian watermilfoil should be directed at key regions of eastern Europe and western Asia, particularly the areas of the former Soviet Union that



have been closed to researchers since the late 1940s.

♦ Based on the genotype studies by the USDA, surveys for biological control agents of hydrilla need to be directed to Southeast Asia, particularly Thailand.

## References

- Balciunas, J. K. (1982). "Insects and other macroinvertebrates associated with Eurasian watermilfoil in the United States," Technical Report A-82-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg MS.
- Balciunas, J. K. (1985). "Final report on the overseas surveys (1981-1983) for insects to control hydrilla," Technical Report A-85-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg MS.
- Baloch, G. M., Phil, M., and Sana-Ullah. (1976). "Insect and other phytophagous organisms which attack Florida elodea (*Hydrilla verticillata*) in Pakistan," Final Report (April 1971-March 1976), Commonwealth Institute of Biological Control, Pakistan Station, Rawalpindi.
- Cofrancesco, A. F. (1998). "Overview and future direction for biological control technology," *Journal of Aquatic Plant Management* 36, 49-54.
- Godfrey, R. K., and Wooten, J. W. (1979). *Aquatic and wetland plants of southeastern United States: Monocotyledons*. The University of Georgia Press, Athens, GA.
- Godfrey, R. K., and Wooten, J. W. (1981). *Aquatic and wetland plants of southeastern United States: Dicotyledons*. The University of Georgia Press, Athens, GA.
- Harvey, J. L., and Evans, H. C. (1997). "Assessment of fungal pathogens as biocontrol agents of *Myriophyllum spicatum*," Miscellaneous Paper A-97-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Lekic, M. (1972). "Establishing of insect species, causes of disease and other parasitic organisms which reduce the numerical strength of the population of the Eurasian water

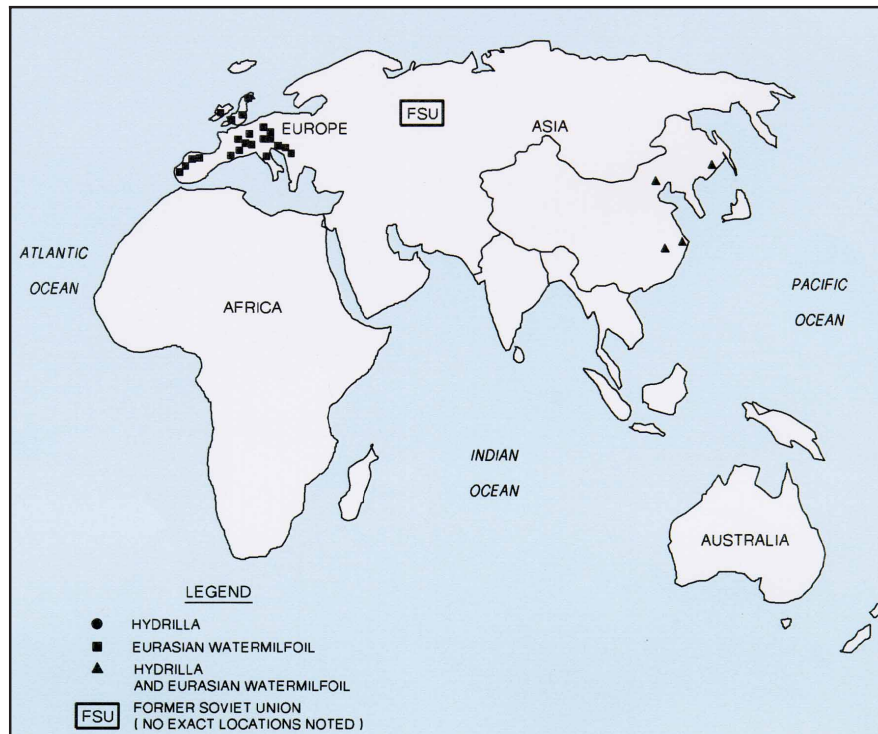


Figure 2. Sites surveyed for pathogen biological control agents of hydrilla and Eurasian watermilfoil

milfoil (*Myriophyllum spicatum* L.)," Final Technical Report, The Institute for Plant Protection, Belgrade, Yugoslavia.

- Markham, R. H. (1986). "Biological control agents of *Hydrilla verticillata*: Final report on surveys in east Africa, 1981-1984," Miscellaneous Paper A-86-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg MS.
- Pemberton, R. (1980). "Exploration for natural enemies of *Hydrilla verticillata* in eastern Africa," Miscellaneous Paper A-80-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Shearer, J. F. (1997). "Classical pathogen biocontrol research in Asia, 1994-1995: Surveys for pathogen agents of *Hydrilla verticillata* (L.f.) Royle and *Myriophyllum spicatum* L.," Technical Report A-97-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Zaitzev, V. F., Volkovitch, M. G., Reznik, S. Ya., Podlipaev, S. A., and Dolgovskaya, M. Yu. (1996). "Russian insects and diseases that could control U.S. waterweeds,"

Final Technical Report, U.S. Army European Research Office, London, England.

### About the author:



**Dr. Alfred F. Cofrancesco** is a Research Entomologist in the Environmental Laboratory, U.S. Army Engineer Waterways Experiment Station. His studies focus on integrated pest management, in particular, biological control of noxious and nuisance plants. Dr. Cofrancesco holds Bachelor and Master of Science degrees and a Ph.D. in Biology from the University of Southern Mississippi. For further information contact Dr. Cofrancesco, (601) 634-3182, [cofrana@mail.wes.army.mil](mailto:cofrana@mail.wes.army.mil).

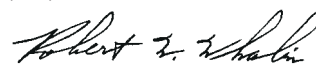
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*This issue describes overseas research being conducted to find natural plant enemies (insects and fungal pathogens) that can be used as biological control agents for problem aquatic plant species. Several control agents have been identified, and the potential value of this method to Corps aquatic plant managers is enormous.*

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## **Aquatic Plant Control Research Program**

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ROBERT W. WHALIN, PhD, PE  
Director

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