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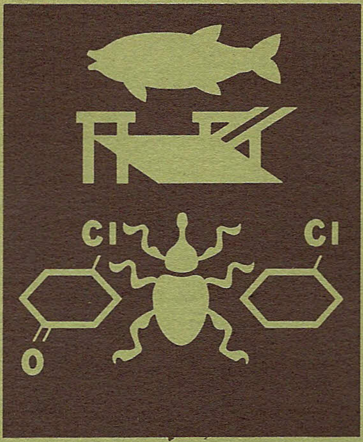

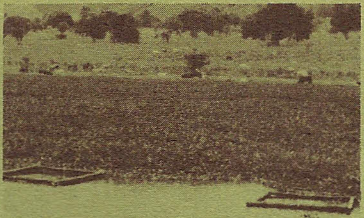

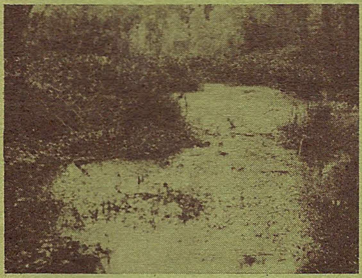

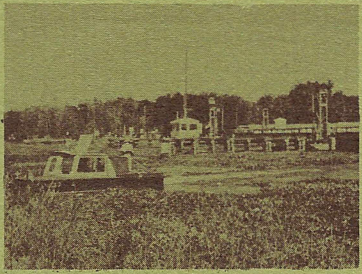

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AQUATIC PLANT CONTROL RESEARCH PROGRAM

Information Exchange Bulletin

USE OF INSECTS AND PATHOGENS FOR MANAGEMENT OF WATERHYACINTH IN LOUISIANA

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INTRODUCTION

The Waterways Experiment Station is conducting a large-scale operations management test (LSOMT) of insects and pathogens for the management of waterhyacinth in Louisiana. The test, part of the Aquatic Plant Control Research Program (APCRP), is funded by the U.S. Army Engineer District, New Orleans. The LSOMT includes a series of field studies designed to determine whether the use of biological control agents, demonstrated to be effective in the laboratory and in small-scale field studies, is effective at an operational level.

The general objectives of the LSOMT are to determine:

- Necessary and sufficient means for the establishment of effective populations of three introduced insect species imported from Argentina and one pathogen endemic to the southern United States.
- Environmental limiting factors to the maintenance of an effective population for each of the four biocontrol agents.

THE PROBLEM

Before man's intervention during the latter part of the nineteenth century, the range of waterhyacinth was restricted primarily to tropical South America. This is quite a contrast from its range today, which extends throughout virtually all tropical and subtropical freshwater systems of the world. Waterhyacinth occurs throughout the waters of the Gulf Coast states, extends northward to South Carolina, and has been observed in the waterways of California.

Waterhyacinth was introduced into the United States in 1884 by Japanese entrepreneurs, who gave away individual plants as souvenirs to those attending the Cotton States Exposition in New Orleans. Waterhyacinth outbreaks had reached such proportions by 1896 that local citizens interested in navigation of the Tickfaw River in Louisiana petitioned Congress for help. Congress responded in the River and Harbor Act of 1899, which authorized the U.S. Army Corps of Engineers to check and remove obstacles to navigation.

Initial control efforts by the Corps included placing barriers to prevent downstream movement, employing mechanical systems designed to physically remove the plants, and using an effective but toxic chemical, sodium

* At the time this article was written, Dr. Perfetti, a member of the faculty of the University of Tennessee at Chattanooga, was working as an Aquatic Botanist on an Intergovernmental Act agreement between the University and the Environmental Laboratory, Waterways Experiment Station.

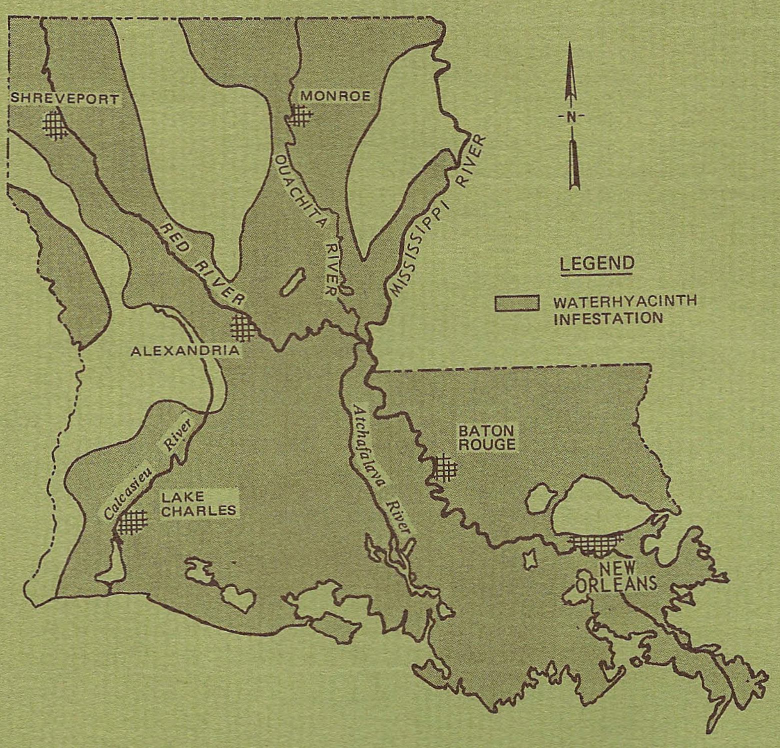

Figure 1. Distribution of waterhyacinth in Louisiana in the 1930s

arsenite. Despite all of these control efforts, waterhyacinth flourished in waterways throughout the entire state of Louisiana by the late 1930s (Figure 1).

The mechanical approach to the management of waterhyacinth gave way to a chemical approach with the advent of modern plant-growth regulators, in particular 2,4-D (2,4-dichlorophenoxyacetic acid), in the early 1940s. Chemical control by use of 2,4-D has proved to be remarkably effective in maintaining nearly 3000 miles of open water in Louisiana waterways and has remained the predominant method of control up to the present time.

While effective in open waterways, chemical control is not suitable for a significant portion of Louisiana's extensive backwater areas, which consist of dense hardwood swamps that are inaccessible for chemical application. These swamps, in turn, serve as breeding grounds for waterhyacinths. The reproductive potential of the swamp nurseries was revealed during the high-water period following the flood of 1973, when waterhyacinth again became distributed throughout the entire Louisiana water system. A peak infestation of 1,720,500 acres of waterhyacinth was recorded in 1975.

Since the chemical approach is at best a temporary stopgap approach, alternative management methods were sought.

BIOLOGICAL CONTROL

The Corps began research into biological control because it promised not only long-range permanent effects with little harm to the environment, but also because control could be maintained with minimal continuing operational costs beyond the initial capital costs of finding, quarantining, evaluating, and releasing the biological agents. It was thought that implementation of a biocontrol program in the backwater areas would reduce the reproductive rate of waterhyacinth sufficiently to provide relief from the problem.

Since it is assumed that many exotic plants become pestiferous due to the lack of natural enemies, the classical approach in biocontrol is to search for enemies of the target species in and around their native habitat. Field explorations, conducted by the U.S. Department of Agriculture (USDA) and funded by the APCRP, were begun in the early 1960s. Three Argentine insects were identified as a result of these searches: the chevroned waterhyacinth weevil *Neochetina bruchi* Hustache (Figure 2); the mottled waterhyacinth weevil *Neochetina eichhorniae* Warner (Figure 3); and the Argentine waterhyacinth moth *Sameodes albiguttalis* Warren (Figure 4). Following extensive testing abroad and in USDA quarantine facilities in the United States, these insects were approved for release in the United States in the early 1970s.

In 1972, the opportunity to conduct research into the potential of endemic enemies for the control of waterhyacinth presented itself in the naturally declining populations of waterhyacinth in the Rodman Reservoir, Florida. Under APCRP, the Corps funded studies by the University of Florida that resulted in the isolation of a fungal pathogen *Cercospora rodmanii* Conway as the cause of the decline. The University of Florida, recognizing

The commercial potential of the pathogen as a biocontrol agent, patented its use as such and granted the right to develop a marketable product to Abbott Laboratories, Chicago, Illinois.

Fungal pathogen

Cercospora rodmanii Conway is a fungus belonging to the form class Deuteromycetes (Fungi Imperfecti). It reproduces asexually by means of spores. University of Florida laboratory studies of this fungus have shown that the fungus gains entrance into the interior of the leaf via the stomates. The predominant growth form of the fungus in its vegetative condition is the filament that grows and proliferates parasitically within the leaf. The effects of this parasitism are manifested externally as disease symptoms on the waterhyacinth leaves. In the initial stages of the disease, punctuate leaf spots occur, followed by a coalescence of leaf spots and the beginning of tip dieback (Figure 5). In the later stages, rapid death of the entire leaf occurs.

Several studies were carried out with the fungus prior to the large-scale field study using multiple biological agents. A pilot field study was carried out from 1977-80 in southeastern Louisiana to determine: first, whether the fungus would establish itself under the environmental conditions specific to Louisiana; and second, whether once established it would quickly reach epiphytotic levels. The fungus became established at the field sites but only at low levels, and it was apparent that a commerical formulation was needed for mass propagation. Abbott developed a wettable powder formulation and obtained an experimental use permit from the Environmental Protection Agency.

A second laboratory study was conducted at the WES using waterhyacinths grown in tanks in the spring and fall of 1979. This study was designed to determine the treatment rate and optimal time of the year for application of the Abbott formulation to achieve adequate infectivity and pathogenicity on waterhyacinth. There were no significant differences in plant response among treatment rates used in either the spring or fall studies although the treatments produced significantly greater infection and disease development than occurred in untreated control plants. For this reason, the lowest application rate tested, equivalent to 4 x 10^6

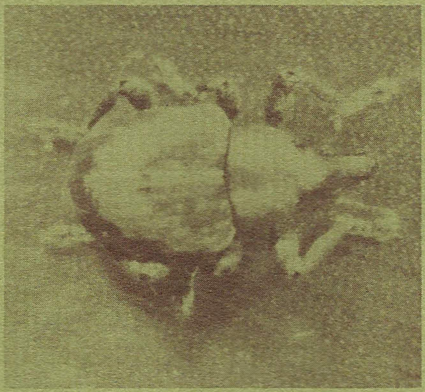

Figure 2. Chevroned waterhyacinth weevil, easily identified by the distinctive markings on its back

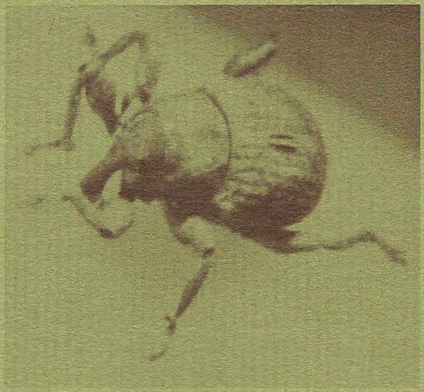

Figure 3. Mottled waterhyacinth weevil

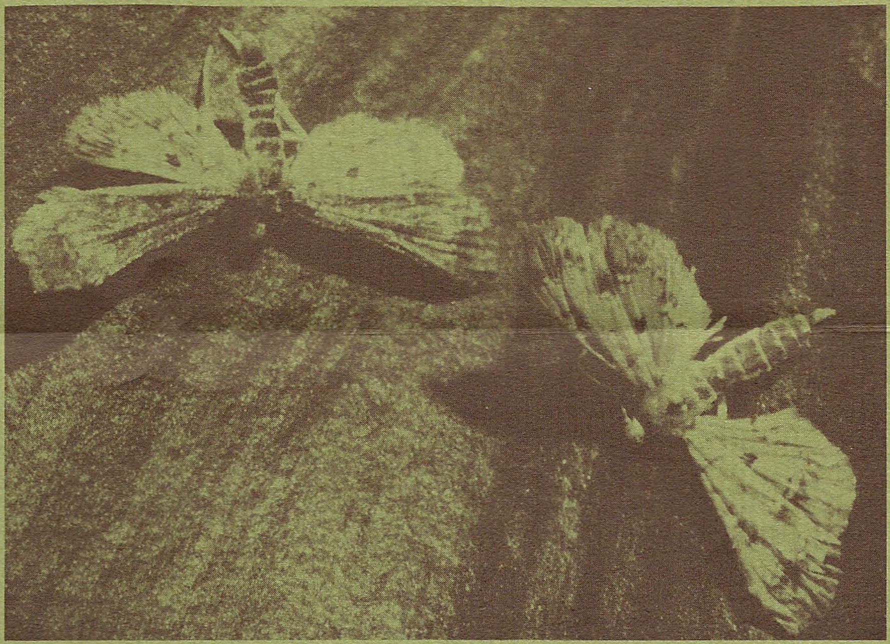

Figure 4. Female and male Argentine waterhyacinth moths (left to right)

Figure 5. Pathogen-infected waterhyacinth plants

CFU/m²*, was suggested for large-scale use.

A field test of the Abbott formulation was conducted in a roadside canal at LaPlace, Louisiana, in the fall of 1979 to verify the infectivity of the formulation on waterhyacinth in the field and to determine the method of application and equipment to be used in field applications. The formulation was applied by means of conventional high-pressure herbicide application equipment. Infectivity was verified by inspection seven weeks after application.

The Abbott formulation has been applied in Louisiana on a large-scale basis at two sites: near Lake Theriot in 1980 and near Centerville in 1981. Summer 1982 monitoring at Lake Theriot revealed a significant reduction in the biomass of waterhyacinth attributable to the combined effects of the fungus and waterhyacinth weevils. The effects due to the fungus alone cannot be determined since the weevils have dispersed throughout virtually all of Louisiana. Statistical analyses have not yet been performed to determine how this reduction compares with the reduction caused at sites infected only with the weevils.

* CFU - Colony Forming Unit.

Argentine waterhyacinth moth

The moth produces several generations per year in the field. Each generation, averaging 30 days under greenhouse conditions, consists of a complete metamorphosis with five molts. Damage to waterhyacinth is accomplished only during the larval period, which lasts 16 to 18 days. The highly mobile adult moths have no mouthparts and die within a few days. The reproductive period of the adults therefore is very brief and highly vulnerable. The adults' high mobility, however, reflects the female's preference for oviposition.

Larval damage to waterhyacinth is observed most often on relatively young plants with bulbous leaf stems, such as are found in the spring of the year, or at the growing fringe of a waterhyacinth mat. The older larvae feed upon the apical bud and the younger leaves surrounding it. Following the destruction of its growing center, the plant eventually dies. When the base of the central leaf is severed, the internal larval damage is manifested externally by a conspicuously wilted leaf in the middle of the waterhyacinth plant (Figure 6).

The USDA released the moth in Florida in 1977, and it spread rapidly and was reported to be well established in 1979. Field release in Louisiana and monitoring were carried out as part of the LSOMT. The moth was released at four sites in southeastern Louisiana (Lake Theriot, Lake Salvador, Pecan Island, and near Centerville) during 1979-81. This species has been identified at 16 sites other than those at which it was released (Figure 7) and is still dispersing.

Waterhyacinth weevils

The life cycles of the two weevil species are quite similar. Each has a complete metamorphosis with a generation time of approximately 100 days. Both have three larval stages and develop underwater in cases attached to the small living roots of the waterhyacinth. Since adults live as long as 9 months with reproductive

Figure 6. Wilted center leaf of waterhyacinth caused by larval moth damage

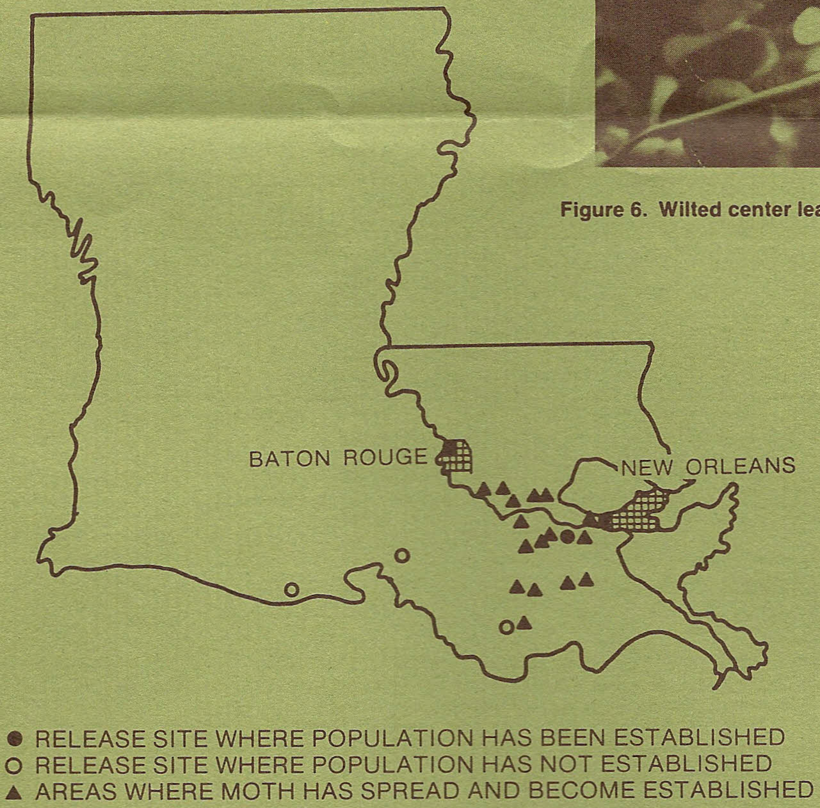

Figure 7. Distribution of Argentine waterhyacinth moth in Louisiana in October 1981

periods almost as long, generations usually overlap. Consequently most lifestages of the weevil are found at any point in time throughout the growing season of waterhyacinth in Louisiana.

Damage to waterhyacinth is caused by the feeding behavior of both the larvae and adult weevils. Internal damage is caused by the feeding and tunneling of larvae in the stems and crown. Adult damage, by contrast, is readily identifiable externally as round feeding spots primarily on the upper surface of the leaf (Figure 8).

The weevils, released by the Louisiana Department of Wildlife and Fisheries from 1974 to 1977, were the first of the biocontrol agents to be introduced into Louisiana and to date are the agents that have exerted the greatest impact.

Their long life span, which ensures overlapping generations, and the feeding behavior of the larvae are the factors most responsible for the weevils' effectiveness.

SUCCESS STORY

As shown in Figure 9, waterhyacinth underwent a dramatic decline in acreage from 1.7 million acres in 1975 to approximately 0.3 million acres in 1980 and 1981. This reduction in acreage resulted from the combined effects of biocontrol agents and climatic conditions. The peak infestation in 1975 followed record floods in 1973 and 1974 when waterhyacinth plants were washed out of backwater nursery areas. The problem was further aggravated by mild winters that prevented much waterhyacinth dieback. These same mild winters, however, provided

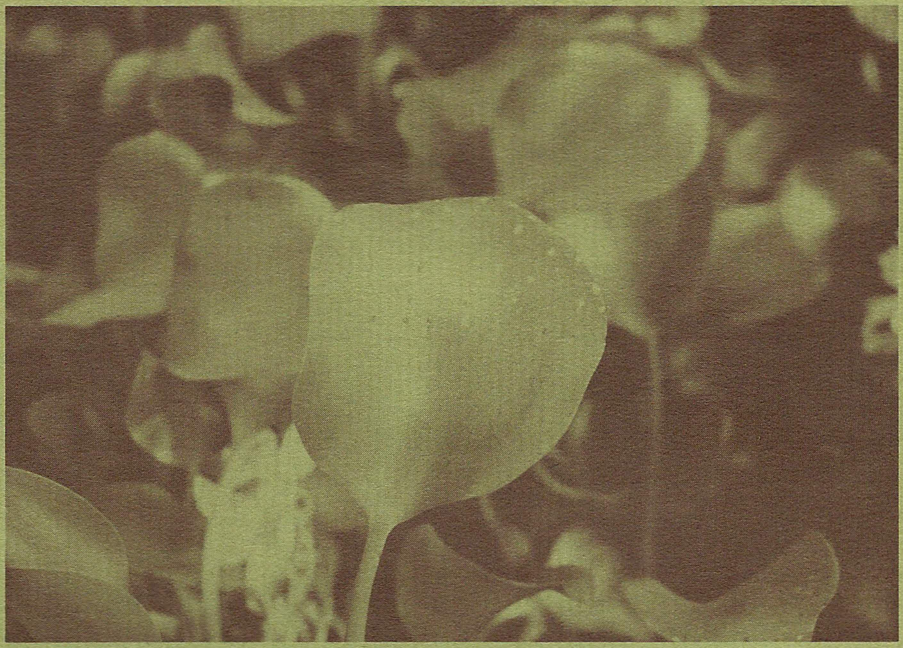

Figure 8. Weevil-feeding scars on waterhyacinth leaf.

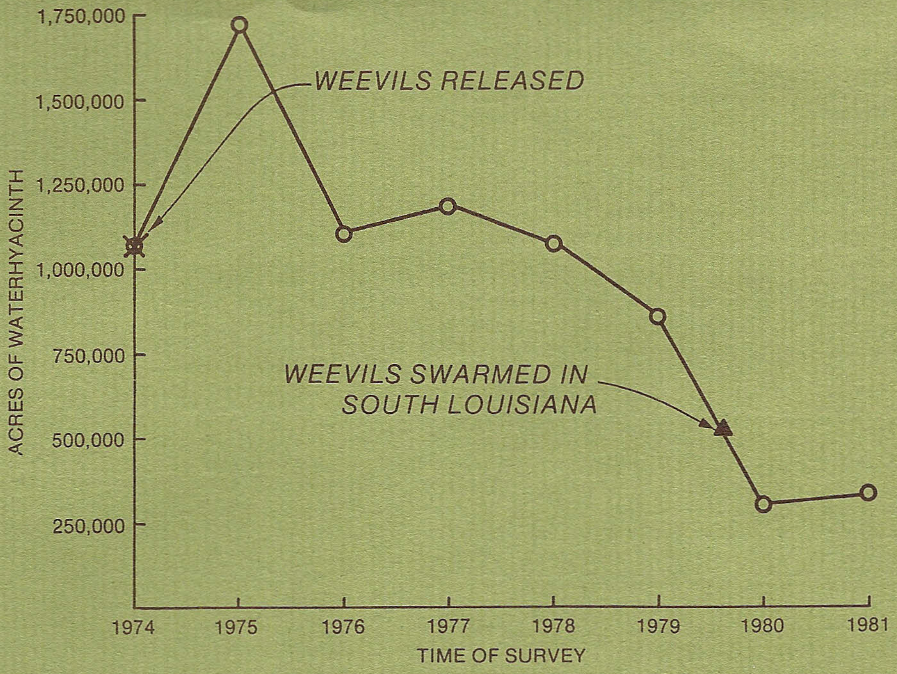

Figure 9. Decline of waterhyacinth population in Louisiana (recorded by the Louisiana Department of Wildlife and Fisheries)

ideal conditions for the establishment of the waterhyacinth weevils. As the result of receding water levels and much colder winters, the acres of waterhyacinth infestation in 1976 and 1977 were well below 1975 levels. In 1976, temperatures below freezing were recorded on 25 days (a typically mild winter in the area would be one in which temperatures below freezing would be recorded on fewer than 10 days). The winter of 1977 was also severe. Presumably, the adult weevil population also experienced a setback under these harsh conditions.

The weevils began increasing in numbers in 1978 and continued to increase through 1980, when the population buildup of the weevils had reached swarming levels. Mild winters in 1978 and 1979, which allowed the weevils to overwinter in large numbers, followed by an exceptionally dry year in 1980, which concentrated the waterhyacinth, combined to give the weevils the competitive edge. During this time period, the weevils stressed waterhyacinth so severely that some waterhyacinth populations dropped out and others required just one chemical spray per year rather than two. The economic investment in the biocontrol program is thus beginning to pay off.

DISCUSSION

The above account of the weevil success emphasizes the need both for a sufficient time period and appropriate environmental conditions if the biocontrol agents are to be effective in destroying waterhyacinth. Firmly established in the waterways of Louisiana, the weevils are expected to have a positive long-term impact on the waterhyacinth population particularly in the backwater areas, hopefully defusing the plant population bomb set off with each new flood.

It is still too early to tell how significant an impact will be made by either the plant pathogen or the moth in combination with the weevils. The pathogen may build up to epiphytotic levels and severely retard waterhyacinth growth or completely eliminate local populations as occurred in Rodman Reservoir, Florida. The moth may follow the same pattern as observed in Florida where it is now making a significant impact: after 5 years in the dispersal phase, high moth population levels have caused localized patches of brownouts in the waterhyacinth mats and these brownouts have become increasingly more numerous as time goes on.

The combined biological agents used in Louisiana may act synergistically to stress the waterhyacinth and make it increasingly more manageable. If the other biocontrol agents prove to be nearly as successful as the weevils, use of biocontrol agents will provide a cost-effective, once and for all, long-term management scheme that will not damage precious timber resources and other biota.

The waterhyacinth remains a serious problem in Louisiana, 'especially in navigable channels where the maintenance activities do not allow the biocontrol agents to build up. Nonetheless, it is hoped that this long-time problem in Louisiana will be reduced to a tolerable level through the continuing development of biocontrol management strategies together with the very effective stopgap chemical control programs of the New Orleans District and the Louisiana Department of Wildlife and Fisheries.

This bulletin is published in accordance with Army Regulation 310-2. It has been prepared and distributed as one of the information dissemination functions of the Environmental Laboratory of the Waterways Experiment Station. It is principally intended to be a forum whereby information pertaining to and resulting from the Corps of Engineers' nationwide Aquatic Plant Control Research Program (APCRP) can be rapidly and widely disseminated to Corps District and Division offices as well as other Federal agencies, State agencies, universities, research institutes, corporations, and individuals. Contributions are solicited and will be considered for publication so long as they are relevant to the management of aquatic plants as set forth in the objectives of the APCRP, which are, in general, to provide tools and techniques for the control of problem aquatic plant infestations in the Nation's waterways. These management methods must be effective, economical, and environmentally compatible. This bulletin will be issued on an irregular basis as dictated by the quantity and importance of information to be disseminated. Communications are welcomed and should be addressed to the Environmental Laboratory, ATTN: J. L. Decell, U. S. Army Engineer Waterways Experiment Station, P. O. Box 631, Vicksburg, Miss. 39180, or call 601-634-3494.

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