Prognosis For Control Of Water Hyacinth By Arthropods

JACK R. COULSON, Assistant to Branch Chief
Insect Identification and Parasite Introduction Research Branch
Entomology Research Division, Agricultural Research Service,
U.S. Department of Agriculture
Beltsville, Maryland

INTRODUCTION

The search for natural enemies of water hyacinth, under the U.S. Corps of Engineers' Expanded Project for Aquatic Plant Control, was begun in 1961 in South America, the native home of this aquatic weed. In that year, an Agricultural Research Service (ARS) supported PL 480 project was initiated in Uruguay, under Ing. A. Silveira-Guido. By the time this project was terminated in 1965, over 30 species of insects and mites had been found to attack water hyacinth to various degrees (1). The more important of these arthropod enemies of hyacinth were studied in some detail during the course of the Uruguay project, both as to their life histories and biologies and to their effect on the plant.

In 1962, the Entomology Research Division established a laboratory in Argentina for the study of natural enemies of aquatic weeds. From 1962 to 1967, work at this laboratory was concentrated on alligatorweed. This work resulted in the importation and release of the *Agasicles* n. sp. flea beetle and a thrips, *Amynothrips andersoni* O'Neill. A third enemy of alligatorweed, a phycitid stem-boring caterpillar *Vogtia malloi* Pastrani, is presently undergoing final testing preliminary to release, at the Entomology Research Division laboratory at Albany, California.

In 1968, primary emphasis at the Argentina laboratory shifted to natural enemies of water hyacinth. Also in 1968, a contract was negotiated between the Argentina laboratory and Ing. Silveira-Guido's laboratory in Uruguay, to provide additional research on several insect enemies of the weed at the latter laboratory.

The aquatic weed research in South America is supported by funds provided by the Corps of Engineers. This work is conducted along three lines. 1) Field surveys and observations are conducted to locate new natural enemies of the weed and to study the field biologies of these species. 2) Intensive studies of the more promising arthropods are conducted in the laboratory. The laboratory work includes a study of the biology and life history of the species, a study of its effectiveness as a potential control agent for the weed, and detailed testing of its feeding specificity and food preference. These specificity and preference tests are conducted on all feeding stages of the species being studied. The plants selected for inclusion in the tests are those which are ecologically related (in aquatic weed studies, rice is always included in the tests) or taxonomically related to the target weed. The tests are generally of two types —starvation tests in which the arthropod is confined to the test plant until significant feeding or starvation occurs, and preference tests in which the arthropod is offered a choice between the test plant and the target weed. 3) Finally, the natural enemies selected and cleared for importation are collected and/or cultured in the laboratory in quantities for shipment to the California laboratory. Depending upon the situation, additional studies of the arthropods may or may not be conducted in California prior to the field release of the species.

CURRENT STUDIES IN SOUTH AMERICA

Although the search for and preliminary testing of new enemies of water hyacinth is continuing in South America, present research is concentrated on five promising species of arthropods.

One of these arthropods is already present in the United States, apparently having entered this country along with water hyacinth. This species is an oribatid mite, *Orthogalumna terebrantis* Wallwork. It is known to be present in Uruguay, Paraguay, Argentina, Brazil, Surinam, Guyana, and Jamaica, and in the United States, in Florida and Louisiana. The mite has been found only on species of *Eichhornia* and *Pontederia.* The mites bore into and form 4-6 mm. long feeding galleries just below the upper surface of the leaves of water hyacinth.

Experiments are underway in Argentina to determine whether there are any significant differences between North American and South American populations of *O. terebrantis* which might warrant the introduction of the South American form into the United States.

A second arthropod, the bagoine weevil, *Neochetina bruchi* Hustache, is also being studied in Argentina. This species is recorded from Guyana, Brazil, Uruguay, and Argentina, feeding only upon species of Pontederiaceae. The adult weevils damage water hyacinth by surface feeding on the foliage. The weevil larvae tunnel and feed in the stem and crown of the plant—young larvae in the petioles, older larvae forming "feeding pockets" in the crowns. There may be from 1 to 12 larvae per plant. A rot usually follows the larval tunneling and the stem and leaf are completely killed. The larvae pupate underwater, forming cocoons from dead root hairs of the plant. Neochetina is apparently limited to a completely aquatic environment, although plants nearest the shore receive the most damage.

In laboratory starvation tests, *N. bruchi* adults will feed upon several species of Commelinaceae,[1] and on cabbage and lettuce. This feeding is not extensive and occurs only in the absence of pontederaceous plants; no feeding occurs on these plants if water hyacinth is present.

Neochetina larvae will feed only upon water hyacinth and *Pontederia* in laboratory tests, and the larvae apparently cannot complete their development on other than water hyacinth.

Recently, *Neochetina* material in Argentina has been found to include a second species, which is probably un-

[1]/ The Commelinaceae family is closely related to the Pontederiaceae "Economically it is of little importance except for a few members of 11-12 genera grown to a limited extent as garden ornamentals." Quoted from Lawrence 1951, p. 402 (2).

described. Adults of this new species have not fed upon any other plants than *Pontederia* and water hyacinth in laboratory tests to date.

No parasites of *Neochetina* weevils have yet been found, although several predators and a fungus disease have been noted.

At the Uruguay laboratory, final testing is being conducted on a fourth arthropod, *Acigona infusella* (*Walker*)[2], a crambine moth. This moth occurs throughout South and Central America from Guatemala to Uruguay and Argentina. The larvae of this moth are stem borers, and have been recorded only from species of Pontederiaceae. Eggs are laid on the leaves and the caterpillars bore into and feed in the petioles and stems, causing the plant to wither and die.

In laboratory starvation tests, *Acigona* caterpillars will feed on several species of the families Commelinaceae and Araceae, and on rice and sugarcane. However, prolonged feeding on these occurs only in the absence of species of Pontederiaceae. The caterpillars are able to complete their development only on *Eichhornia or Pontederia*.

At least 3 species of hymenopterous parasites have been found to attack *Acigona* larvae in South America.

The fifth and last species under full-scale investigation, in Uruguay, is an acridid grasshopper, *Cornops aquaticum* Bruner. This grasshopper lays its eggs in the leaf petiole tissues of pontederiaceous plants. The young nymphs feed on the leaf epidermis and larger nymphs and the adults feed on other leaf and petiole tissue. Heavy feeding results in complete defoliation of plant.

In the laboratory, *Cornops* will feed on commelinaceous plants and rice and sugarcane. Field preference, however, is always for members of the family Pontederiaceae, which are often attacked very heavily. Studies to date indicate *C. aquaticum* can only reproduce, that is oviposit, on Pontederiaceae. Other plants such as rice, etc. could possibly be in danger of receiving some damage from this species if growing near water hyacinth just treated with herbicides.

DOMESTIC STUDIES

Before introducing exotic natural enemies to control a weed, it is desirable to learn what natural enemies already attack that weed in the areas in which the introductions are to be made, and what effect these species may have on the weed and to what extent they may compete with or affect any introduced species.

To get information of this type, ARS supported a 4-year grant at Louisiana State University to study the insects associated with aquatic weeds of foreign origin in Louisiana. In 1969, an ARS entomologist surveyed water hyacinth in Florida, Louisiana, and eastern Texas, and recorded the natural enemies found (4). An entomologist from the Commonwealth Institute of Biological Control (CIBC) station in Trinidad, has also recorded natural enemies of water hyacinth in Florida and Louisiana (5).

Of the 15 species of arthropods found during these studies and surveys to feed to some extent on water hyacinth in southeastern United States, only 2 are considered important enemies of the weed. One is the oribatid mite, *O. terebrantis,* discussed above. The other species is a noctuid moth, *Arzama densa* (Walker), whose larvae behave in much the same manner as the South American caterpillar *Acigona infusella,* that is they tunnel and feed in the stems of water hyacinth.

Arzama densa is a native of North America, ranging from Maryland to Florida and along the Gulf Coast to Texas. Its original food plants, before the arrival of water hyacinth, were apparently the native North American species of *Pontederia.* Water hyacinth, being sufficiently closely related to *Pontederia,* has become a very satisfactory additional food plant for *A. densa.*

The biology and life history of *A. densa,* and its importance as a control agent for water hyacinth, have been studied extensively at Louisiana State University (6, 7). Vogel and Oliver of that institution report, and the ARS and CIBC investigations also indicate, that this species can be an important controlling agent for water hyacinth, but that unfortunately severe damage to the weed occurs only locally or sporadically. One factor limiting the effectiveness of *Arzama* is parasitism. Vogel and Oliver record 5 species of parasites of the egg, larvae, and pupae of *Arzama* in Louisiana, with a percentage of parasitism in the neighborhood of 50% (7).

In April, 1970, the Entomology Research Division established a laboratory at Gainesville, Florida, for the biological control of aquatic weeds. This laboratory was created to handle the release and dissemination and evaluation of alligatorweed insects, and to continue survey work and field observations on water hyacinth and other aquatic weeds. Eventually this laboratory will also handle the liberation of water hyacinth insects and their evaluation. The Gainesville laboratory is a satellite of the Biological Control of Weeds Laboratory at Albany, California.

OTHER RESEARCH ON THE BIOLOGICAL CONTROL OF WATER HYACINTH

Investigations on arthropod enemies of water hyacinth are also being conducted at the Trinidad Station of the Commonwealth Institute of Biological Control. Dr. Fred D. Bennett of that station has conducted surveys in the southeastern United States, as already mentioned, and in northern South America, Central America, and the Antilles (5, 8). Over 35 species of arthropods were found feeding on water hyacinth during these surveys, some of which were, of course, the same as those found in Argentina and Uruguay. The Trinidad station is currently conducting feeding tests on several important water hyacinth enemies including *Acigona infusella,* a *Cornops* grasshopper closely related to the one being studied in Uruguay, and *Epipagis albiguttalis* (Warren), a pyraustine stem boring caterpillar. Cultures of several water hyacinth enemies, including *Neochetina, Acigona,* and *Epipagis,* have recently been sent from Trinidad to the CIBC station in India, for laboratory culture and study there, and eventual release against water hyacinth in that country. There is a mutual interest and close cooperation maintained between CIBC and ARS concerning the research on arthropod enemies of water hyacinth.

From 1962 to 1967, ARS supported a PL 480 grant in India for the study of natural enemies of several aquatic weeds, including water hyacinth, in that country. As in the United States, water hyacinth is an introduced weed in India, and, therefore, any native enemy of water hyacinth in India will have necessarily become secondarily adapted to feeding upon that plant. The feeding ranges of such

---

2/ Until recently, this species was called *Acigona ignitalis* (Hampson) (also *Chilo ignitalis*). Recent taxonomic studies indicate *ignitalis* is a synonym of *infusella* (3).

adapted natural enemies are not likely to be restrictive enough for consideration as biological control agents. In India, there are no native species of the family Pontederiaceae, and thus no enemies, such as our own *Arzama densa,* restricted to that family which could have some potential as a control agent for water hyacinth. Thus, the most important enemy of water hyacinth found in India, an acridid grasshopper, was found to have too wide a feeding range to consider it for importation in other countries (9). A new PL 480 project concerns the study of several fungus pathogens[3]/found during the earlier survey work attacking the weed (10, 11, 12).

Other research has been and is being conducted by the Plant Science Research Division of ARS and other institutions and organizations concerning the possibilities of using biological agents other than arthropods—such as pathogens, snails, fish, and manatees—for controlling water hyacinth. These studies are outside the scope of this paper and will not be discussed here.

PROCEDURES FOR INTRODUCING WEED-FEEDING ARTHROPODS INTO THE UNITED STATES

The importation and interstate movement of plant-feeding organisms is regulated by the Quarantine Agricultural/Inspection Division (AQI) of the USDA. Permits from AQI must be secured before any such movement can be made.

Although the final decision to allow or deny importation of an organism into the United States for the biological control of weeds rests with AQI, this Division has for the past decade been aided in making this decision by a Subcommittee of the Joint Weed Committees of the U.S. Departments of Agriculture and of Interior. The present composition of this Subcommittee, called the Subcommittee on Biological Control of Weeds, includes representatives from the Forest Service and the Agricultural Quarantine Inspection, Plant Protection, Plant Science Research, and Entomology Research Divisions of the USDA, and the Bureau of Sports Fisheries and Wildlife and of Land Management of the USDI, and of the National Arboretum.

This Subcommittee 1) reviews the adequacy of the specificity tests on organisms proposed for introduction; 2) suggests additional tests and studies if thought desirable to insure the safety of the introduction; 3) identifies and helps resolve conflicts of interest which sometimes arise in connection with the biological control of weeds; 4) recommends for or against the proposed importation.

After an importation is approved by this Subcommittee, permits are sought from AQI for the introduction. The Entomology Research Division also seeks approval from each State in which introductions of weed-feeding arthropods are planned. The concurrence of Canadian authorities is also solicited on a reciprocal basis.

PRESENT STATUS[4] OF THE ENTOMOLOGY RESEARCH DIVISION PROGRAM, AND PROGNOSIS

It is expected that both species of *Neochetina* weevils, *Acigona infusella* and possibly *Cornops,* will soon be sent to the Albany, California, laboratory for further testing there under quarantine. It is likely that one or more of these insects will be released in the United States against water hyacinth within the next year. Detailed summaries of the South American studies and tests on each of these insects are now being prepared for submission to the Subcommittee on Biological Control of Weeds for approval of the importations.

The *Neochetina* weevils would appear to be first on the list to be introduced, and also at this time appear to be the more promising of the insects being considered for importation. Although 2 species of stem-boring weevils have been found to occasionally feed on water hyacinth in the United States, neither is specific to that plant nor would they offer any competition at all to *Neochetina.* This is not to say that the native *Arzama densa* offers any serious competition to *Acigona infusella;* on the contrary the South American *Acigona* appears to be needed to complement the North American *Arzama.* However, *Acigona* will likely be subject to attack by some of the same parasites presently attacking *Arzama,* which of course would reduce the effectiveness of the South American species. At present, there are no known insect parasites of *Neochetina.*

It is difficult to predict how an introduced insect will respond to a new environment. However, experience with accidentally introduced insect pests of crop plants, and previous experience with introductions of weed-feeding insects leads to an expectation of some degree of success with these water hyacinth insects. In an ecological sense the massed stands of water hyacinth presents a situation similar to that of a monocultured crop, such as wheat, corn, or cotton. Thus an insect enemy of water hyacinth could be expected to behave much in the same way as an introduced crop pest; that is, with an abundance of food and few natural enemies, populations of these water hyacinth insects should increase and disperse rapidly, just as the *Agasicles* flea beetle is doing in some of the areas where alligatorweed is a problem.

There is good reason to expect that populations of one or more of these South American insects proposed for introduction will increase to the point where at least the aggressive character of water hyacinth will be reduced, and that the problems caused by this weed in waterways in the Southeast and Gulf Coast States will be alleviated. However, to what extent these problems will be reduced will not be known for certain until several years following the release of these insects.

3/ *Marasmiellus inoderma* (Berk.) Sing., *Myrothecium roridum* Tode ex Fr., and *Alternaria.*

4 Since the presentation of this paper the new species of *Neochetina* discussed above has been described as *N. eichhorniae* Warner (13), and permission for its importation for further study under quarantine in California has been granted by the Sub-committeee on Biological Control of Weeds; also, the alligatorweed stem-boring moth, *Vogtia malloi,* has now been released in the United States.

LITERATURE CITED

1. Silveira-Guido, A. 1965. Natural enemies of weed plants. Final report. (Unpublished report, Department Sanidad Vegetal, Univ. de La Republic, Montevideo, Uruguay).
2. Lawrence, G. H. M. 1951. Taxonomy of vascular plants. MacMillan Co., New York. 823. pp.
3. Bleszynski, S. 1967. Studies on the Crambinae (Lepidoptera). Part 44, New Neotropical genera and species. Preliminary checklist of Neotropical Crambinae. Acta Zool. Cracovien. 12 (5):39-110.
4. Gordon, R. D. and J. R. Coulson. 1969. Report on field observations of arthropods on water hyacinth in Florida, Louisiana, and Texas, July, 1969. (Unpublished report, Insect Identification and Parasite Introduction Research Branch, Entomology Research Division, ARS, USDA). [Appeared as "Appendix F" in Gangstad, E. O. *et al.,* Technical Report of the Potential Growth of Aquatic Plants of the Cross-Florida Barge Canal, Review of the Aquatic Plant Control Research Program and Summary of the Research Area Development Operations in Florida. U.S. Army Corps of Engineers, 191 pp., Feb. 1971].
5. Bennett, F. D. 1970. Insects attacking water hyacinth in the West Indies, British Honduras and the USA. Hyacinth Control Jour. 8.2:10-14.

6. Vogel, E. and A. D. Oliver, Jr. 1969. Evaluation of *Arzama densa* as an aid in the control of water hyacinth in Louisiana. Jour. Econ. Ent. 62:142-145.
7. Vogel, E. and A. D. Oliver, Jr. 1969. Life History and some factors affecting the population of *Arzama densa* in Louisiana. Ann. Ent. Soc. Amer. 62:749-752.
8. Bennett, F. D. and H. Zwölfer. 1968. Exploration for natural enemies of the water hyacinth in northern South America and Trinidad. Hyacinth Control Jour. 7:44-52.
9. Sankaran, T., D. Srinath and K. Krishna. 1966. Studies on *Gesonula punctifrons* Stäl (Orthoptera: Acrididae: Cyrtacanthacridinae) attacking water-hyacinth in India. Entomophaga 11 (5): 433-440.
10. Nag Raj, T. R. 1965. Thread blight of water hyacinth. Curr. Sci. 34 (2):618-619.
11. Ponnappa, K. M. 1970. On the pathogenicity of *Myriothecium roridum - Eichhornia crassipes* isolate. Hyacinth Control Jour. 8:18-20.
12. Nag Raj, T. R. and K. M. Ponnappa. 1970. Blight of water hyacinth caused by *Alternaria eichhorniae* sp. nov. Trans. Brit. Mycol. Soc. 55 (1):123-130.
13. Warner, R. E. 1970. *Neochetina eichhorniae,* a new species of weevil from waterhyacinth, and biological notes on it and *N. bruchi.* Proc. Ent. Soc. Wash. 72 (4):487-496.

Nitrification Of Aquatic Weed Tissues In Soil

D. N. RIEMER and S. J. TOTH

Department of Soils and Crops
College of Agriculture and Environmental Science
Rutgers—The State University, New Brunswick, New Jersey

INTRODUCTION

When underwater mowers or other mechanical harvesting devices are used to control aquatic weeds, disposition of the harvested plant material is often a problem. One solution would be to compost the harvested plants for agricultural use. This would provide a means of disposal and possibly even help to alleviate the expense of harvesting. For composting to be successful, the tissues would have to decompose and a reasonably high percentage of the nitrogen in the tissue would have to nitrify or be converted to nitrates by nitrifying organisms in the soil. The purpose of this study was to determine the rate and degree of nitrification of dried, ground aquatic weed tissues when added to soil under aerobic conditions.

METHODS AND MATERIALS

Aquatic weeds were collected from various sites in New Jersey, oven-dried and ground in a Wiley Mill to pass through a 30-mesh screen. Analysis for total nitrogen was made on each tissue using the Kjeldahl method. The tissues used in the tests, their dates of collection, and the percent nitrogen in each are presented in Table 1. Except for Spatterdock, the tissues represented the entire top growth of the plants. Spatterdock was separated into leaf blades and petioles because of the large difference in nitrogen content of these two structures.

The tests were conducted by weighing out amounts of dry, ground tissue equivalent to 20 milligrams of nitrogen and adding them to 100 grams of limed Sassafras loam soil in flasks which were loosely stoppered with cotton. The flasks were then incubated at room temperature for 2, 4, 6 or 8 weeks. Adequate moisture for microbial decomposition was maintained throughout the incubation period. At the end of each two-week period, the amount of nitrate-nitrogen in the soil of the designated flasks was determined by the phenoldisulphonic acid method. All analyses were run

TABLE 1. TISSUES USED IN NITRIFICATION TESTS SHOWING COLLECTION DATES AND NITROGEN CONTENTS.

Species	Date Collected	% N*
Alfalfa (*Medicago sativa*)	Sept.	3.77
Broadleaf Watermilfoil (*Myriophyllum heterophyllum*)	7 June	3.51
Cabomba (*Cabomba caroliniana*)	7 June	2.52
Elodea (*Elodea canadensis*)	5 June	3.12
Arrowarum (*Peltandra virginica*)	6 May	3.63
Spatterdock (*Nuphar advena*) Leaf blades	6 May	5.65
Spatterdock (*Nuphar advena*) petioles	6 May	2.43
Bladderwort (*Utricularia sp.*)	10 June	3.57
Burreed (*Sparganium sp.*)	10 June	2.54
Heartleaf Pondweed (*Potamogeton pulcher*)	10 June	2.11
Pickerelweed (*Pontederia cordata*)	9 June	2.03
Duckweed (*Lemna minor*)	8 July	3.38
Common Reed (*Phragmites communis*)	6 May	3.21
Common Reed (*Phragmites communis*)	3 June	1.94
Common Reed (*Phragmites communis*)	25 July	1.30
Common Reed (*Phragmites communis*)	21 Aug.	1.44

*Percent total N on dry-weight basis