

# BIOLOGICAL CONTROL OF PADDY AND AQUATIC WEEDS IN THAILAND

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## ABSTRACT

*Attempts to achieve biological control of major paddy and aquatic weeds in Thailand are described. The target weed species subjected to natural, augmentative and classical biological control were *Alternanthera philoxeroides*, *Eichhornia crassipes*, *Ludwigia adscendens*, *Mimosa pigra*, *Myriophyllum spicatum*, *Pistia stratiotes* and *Salvinia cucullata*. The major biological control agents utilized were insects, both endemic and introduced. The degree of success ranged from partial to substantial or highly successful.*

## INTRODUCTION

Paddy and aquatic ecosystems are rich in vegetation of high diversity, ranging from single-celled microflora to standing perennial shrubs and trees. The relative abundance of each species varies according to geographical area and location: for example, the vegetation associated with upland rice differs significantly from that found with lowland or deepwater rice. The weed species associated with lowland and deepwater rice are essentially aquatic, and can also be found in other water resources.

At one extreme, according to Moody (1989), more than 1,800 weed species have been identified in association with rice in South and Southeast Asia alone. At the other extreme, Suwatabandhu (1950) lists only 37 weed species in paddy fields in Thailand. In between, Pancho and Soerjani (1978) enumerated 113 species of weeds in 43 families as aquatic weeds in Southeast Asia. Of the 116 species of weeds listed as major weeds in Thailand by Noda *et al.* (1984), a few are considered to be serious. In Indonesia, Soerjani, Kostermans and Tjitrosoepomo (1987) recorded 266 species of weeds associated with rice, belonging to 54 families. In Thailand, a thorough investigation on the vegetation associated with paddy and aquatic ecosystems has yet to be carried out. As far as biological control is concerned,

relatively few paddy and aquatic weeds of economic importance have been selected as being amenable to biological control methods, whether natural, augmentative or classical.

This paper discusses the attempts at biological control of major paddy and aquatic weeds in Thailand, carried out from the early 1970s up until the present. Some of these attempts have already been reported in Julien (1982, 1987), Napompeth (1982, 1983, 1989, 1990, 1992) and Napompeth *et al.* (1977).

## CONTROL OF AQUATIC WEEDS IN THAILAND

### *Alternanthera philoxeroides* – Alligator Weed

Alligator weed is supposed to be an introduced species, but there is no record of its date of introduction. Several insect species have been found associated with the weed in Thailand, the most common of which are *Psara basalis*, *Hymenia recurvalis* and *Nanophyes* sp. However, none of these insects showed any potential for further utilization as biological control agents. As a result, the chrysomelid *Agasicles hygrophila* was introduced from Australia in 1981. Field releases made since then have resulted in the permanent

Key words: Biological control, paddy weeds, aquatic weeds, Thailand

establishment of the chrysomelid, giving substantial control in the Central, Northern Highland and Northeastern regions of Thailand. The insect is now spreading into all areas where the alligator weed occurs, and damage can often be observed, particularly during the cooler months of the year (November to January).

### ***Eichhornia crassipes* – Water Hyacinth**

Of all the insects found associated with waterhyacinth in Thailand, the waterhyacinth grasshopper, *Gesonula punctifrons*, is the most common. It can be found laying egg capsules in the petioles of the plant. The newly hatched nymphs and early instars feed gregariously on the leaves, but seem to cause no significant damage. In certain areas, several hundred nymphs and adults can be detected per square meter of plant. Other insect species found in association with water-hyacinth were grasshoppers (*Atractomorpha crenulata* and *Oxyaminima*) and the cutworm *Spodoptera mauritia*. However, none of these insects were of any biological control potential, and all of them are known crop pests.

The pathogens recorded from waterhyacinth in Thailand were *Alternaria eichhorniae*, *Myrothecium roridum* and *Rhizoctonia solani*. Only *A. eichhorniae* was found to be specific to waterhyacinth, and these pathogens are commonly associated with plant senescence. A combined attack by grasshoppers and pathogens could reduce plant populations, but had no significant effect on overall infestation.

It was in 1896 that waterhyacinth was deliberately introduced from Indonesia into Thailand as an ornamental plant. Over time it has become so naturalized that it now harbors a large number of insects and other microorganisms. Since these insects are euryphagous, they cannot be utilized augmentatively. In 1977, the first consignment of the mottled waterhyacinth weevil, *Neochetina eichhorniae*, was introduced from Florida. The first consignment proliferated so well that a second was introduced in 1979. Altogether, 1,002 adults were introduced. After necessary host specificity tests and other quarantine clearance had been made, the weevils were released in major water sources all over Thailand. This extensive field release program has resulted in permanent establishment of the weevils all over the country. The weevils have also spread naturally to neighboring countries, especially Malaysia.

In areas where the weevils are achieving

control of waterhyacinth, this weed will eventually be replaced by other aquatic plant species such as *Monochoria* spp. It is now fairly common to observe feeding scars on the leaves of waterhyacinth plants in all major bodies of water in Thailand.

The chevroned waterhyacinth weevil, *Neochetina bruchi*, was introduced in 1990 from Florida via Australia, in collaboration with the Australian Centre for International Agricultural Research (ACIAR). The weevil has now been released and has become established in many locations, together with *N. eichhorniae*. It is still too soon to evaluate its performance, either alone or in combination with *E. eichhorniae*.

### ***Hydrilla verticellata* – Hydrilla**

A moth, *Parapoynx* sp., is very abundant in many areas where hydrilla occurs in Thailand. The larvae feed on the plant, and it might be possible to utilize them augmentatively, although they can also be found feeding on another aquatic plant, *Potamogeton malainus*. *Parapoynx* sp. is believed to be doing an excellent job in controlling hydrilla naturally, so that hydrilla is not a serious problem in Thailand.

### ***Ludwigia adscendens* – Water Primrose**

A chrysomelid, *Altica foeveicollis*, which is an endemic species, is very effective in the natural control of *L. adscendens* and other *Ludwigia* spp. in Thailand. The larvae with their gregarious feeding habit can bring about rapid defoliation and destruction of the weed. In addition, two sphingids, *Theretra oldenlandiae* and *Theretra pinastrina*, were also observed feeding on the plant, but they did not seem to cause any significant reduction of the plant population.

*A. foeveicollis* has been mass-reared and released in areas where it does not occur naturally for the control of water primrose, and as a result damage to the weed is now widespread all over Thailand.

### ***Mimosa pigra* – Giant Sensitive Plant**

Introduced deliberately into Thailand, probably in the 1950s or 1960s, *M. pigra* is now considered one of the Thailand's most serious weeds, together with its close relative, *Mimosa invisa*, the creeping sensitive plant. *M. pigra* can thrive in standing water, and on fallow paddy land, roadsides and uplands from sea level up to 1,600 meters above

sea level. It should be considered an “amphibious” weed, because it can adapt to either an aquatic or a terrestrial ecosystem.

An attempt to achieve biological control of this weed was initiated with a survey and evaluation of native insect candidates, but no suitable insects were found. A cerambycid, *Milothris irrorata*, was introduced from Indonesia in 1981 for trial, but was found to be unsuitable for any further manipulation and this program was terminated.

In collaboration with the Commonwealth Scientific and Industrial Research Organization (CSIRO) and the Department of Primary Industry and Fisheries (DPIF), Northern Territory, Australia, and with support from the Australian Centre for International Agricultural Research (ACIAR), a number of biological control agents have been introduced into Thailand since 1983. The insects are all from the native range of *M. pigra* in Central and South America. These insects were: two seed bruchids, *Acanthoscelides puniceus* and *Acanthoscelides quadridentatus*, in 1983; a terminal shoot feeder, *Chlamisus mimosae*, in 1985; a gracillariid, *Neurostrotra gunniella*, in 1988; a sessiid, *Carmenta mimosae*, in 1989; and an apion, *Apion aculeatum*, in 1989. All of these introduced species have been tested and released with the exception of *N. gunniella*, which might cause damage to *Neptunia natans*, a common vegetable in Thailand and Southeast Asia. The culture was thus destroyed.

Both seed bruchids, *A. puniceus* and *A. quadridentatus*, were found to be highly effective, and as much as 50% seed destruction could be observed in many locations, while an average of 5–15% seed destruction was very common. In terms of plant infestation, a 100% infestation rate has now been detected in all release locations. The bruchids are now spreading to neighboring countries, and have been recovered in Myanmar, Laos, Malaysia, Singapore and Indonesia.

The remaining insects are not performing as well as the bruchids. *C. mimosae* was recovered once, and then disappeared from its release sites. *C. mimosae* seems to have difficulty in become established, and laboratory rearing of this species has been very cumbersome. *A. aculeatum* is yet to be recovered after field releases. Work on these biological control agents is still in progress, and additional agents, including rust fungi, are in the process of being introduced.

### ***Myriophyllum spicatum* – Parrot Feather**

We do not know exactly when the original *M.*

*spicatum* was introduced into Thailand, but we know it was introduced as an aquarium plant in the early 1970s. It was initially found being used for fish spawning in some locations, especially those associated with fisheries projects. Since then it has escaped into the open water, and became a serious problem in the late 1970s. It is now disappearing as a result of destruction by *Spodoptera mauritia*.

### ***Pistia stratiotes* – Water Lettuce**

Water lettuce is now cosmopolitan in its distribution, although it is believed to be of Central American origin. It is very rich in associated insect species in Thailand, at least one of which has been utilized successfully in the augmentative biological control of this weed. The more common insects found on water lettuce in Thailand are: aphids; the pygmy grasshopper, *Criotettix* sp.; the noctuid moth, *Epipsammia pectinicornis*; *Nymphula turbata* and *Parapoynx diminutalis*. Of these insects, the noctuid *E. pectinicornis* has been successfully used as a biological control agent.

The grasshopper *Criotettix* sp. has been found attacking water lettuce to such an extent that as many as 100 grasshoppers per square meter is very common. The grasshopper was also found attacking the water fern *Salvinia cucullata*, but did not cause any significant damage.

Since 1976, the potential of *E. pectinicornis* has been investigated as a biological control agent for water lettuce. Under laboratory conditions, the insect at the rate of 300 mixed instar larvae per square meter of weed can destroy the weed as effectively and rapidly as any herbicide. *E. pectinicornis* is relatively easy to mass rear in the laboratory, which makes possible inoculative releases, and at times inundative ones. The insect is now replacing herbicides in the control of water lettuce in water reservoirs in Thailand, under the supervision of the Royal Irrigation Department (RID) and the Electricity Generating Authority of Thailand (EGAT). However, there is some opposition to this program from herbicide advocates in these government agencies.

*P. diminutalis* can be found attacking water lettuce in some isolated areas, but does not seem to exert much natural control of the weed. *N. turbata* is of a similar status, and is also found attacking azolla.

In most parts of Thailand, the effect of *E. pectinicornis* is commonly observed as browning of the weeds similar to the “hopper burn” caused to rice plants by the brown planthopper.

## *Salvinia cucullata* – Water Fern

The water fern, *S. cucullata*, has been monitored closely since the mid 1970s when it was not yet considered serious. This monitoring has been carried out together with monitoring for possible invasion by another water fern, *Salvinia molesta*. *Salvinia molesta* is not yet found in Thailand, although it has had a devastating effect in Malaysia, Indonesia and the Philippines, as well as in Sri Lanka and southern India. Now that water lettuce is being cleared from the surface of waterways, populations of *S. cucullata* are increasing and becoming a serious problem.

Only two insect species have been investigated as possible control agents against *S. cucullata*. These are the pygmy grasshopper, *Criotettix* sp., which also attacks water lettuce (Takara 1981), and the curculionid, *Bagous* sp. nr. *nodieri* (Nasaree 1986). Although there has been a preliminary evaluation of *B. sp. nr. nodieri*, further work is necessary before we can utilize this curculionid for augmentative biological control of *S. cucullata*.

In 1987, a curculionid, *Cyrtobagous salviniae*, was introduced from Australia for trial as a control agent of *S. cucullata*. Although *C. salviniae* is highly effective against *S. molesta*, it is highly host specific and failed to survive on *S. cucullata*.

A plan is now in the pipeline to devote more effort to utilizing *B. sp. nr. nodieri* as a biological control agent of *S. cucullata* in Thailand.

## DISCUSSION

It should be noted that within the concept of pest management, not all non-crop plant species are weeds. In certain habitats, such as a paddy or aquatic ecosystem, key weed species should be identified and management strategies devised. In many situations, an integrated management approach might be necessary, but is not always the only possible strategy. For many paddy and aquatic weeds, biological control, whether natural, augmentative or classical, can play an important role, as exemplified in various biological control programs against paddy and aquatic weeds in Thailand.

It should also be noted that not all weed species are amenable to biological control. Even if a certain weed species is amenable in some situations, this degree of control may not be achieved in all ecosystems or geographical areas, even if these are adjacent to areas where control has been successful.

Likewise, not all attempts in biological control of weeds end in success. Failures are not unusual, and can be expected. The outcome of successful programs of biological control of weeds is that control is permanent, and invisible in that the weed simply disappears, so that all previous attempts are overlooked and are not appreciated.

Almost all biological control agents being used in Thailand can be used elsewhere, provided that they do not provoke the conflict of interest which is rather typical of biological control. The noctuid moth, *E. pectinicornis*, introduced to Florida from Thailand, has recently been released. The mottled waterhyacinth weevil, *N. eichhorniae*, has been introduced from Thailand to Myanmar, Sri Lanka and Vietnam. It has also found its way into Malaysian waterways. The seed bruchids, *A. puniceus* and *A. quadridentatus*, are now found in countries bordering Thailand, and have also been introduced into Vietnam.

## CONCLUSION

Concern over environmental quality in tropical agroecosystems means that the conventional solution of weed problems by the use of herbicides has to be reconsidered and amended. The mere safe and effective use of chemical herbicides may not be adequate to cope with pressing weed problems. Outstanding among the forgotten alternatives are biological control and related activities such as the development of mycoherbicides. Also important among the biological control agents are the arthropods such as insects and mites which have been successfully used in many parts of the world, giving permanent weed suppression. There is no single herbicide, no matter how effective it is claimed to be, which can yet show any comparable success in the solution of weed problems, not to mention the fact that herbicides are not environmentally friendly and may not be compatible with a healthy ecosystem.

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## DISCUSSION

Dr. Mochina asked whether any good biocontrol agent was available to use against sedges. Dr. Napompeth replied that sedges seemed less amenable to control by insects than Graminae and broadleaf weeds. One exception is the sedge *Cyperus rotundus*, which is infected sometimes by a tuber moth borer (*Becchia* sp.). However, this breaks the tuber up into pieces and tends to promote the faster growth of the sedge.