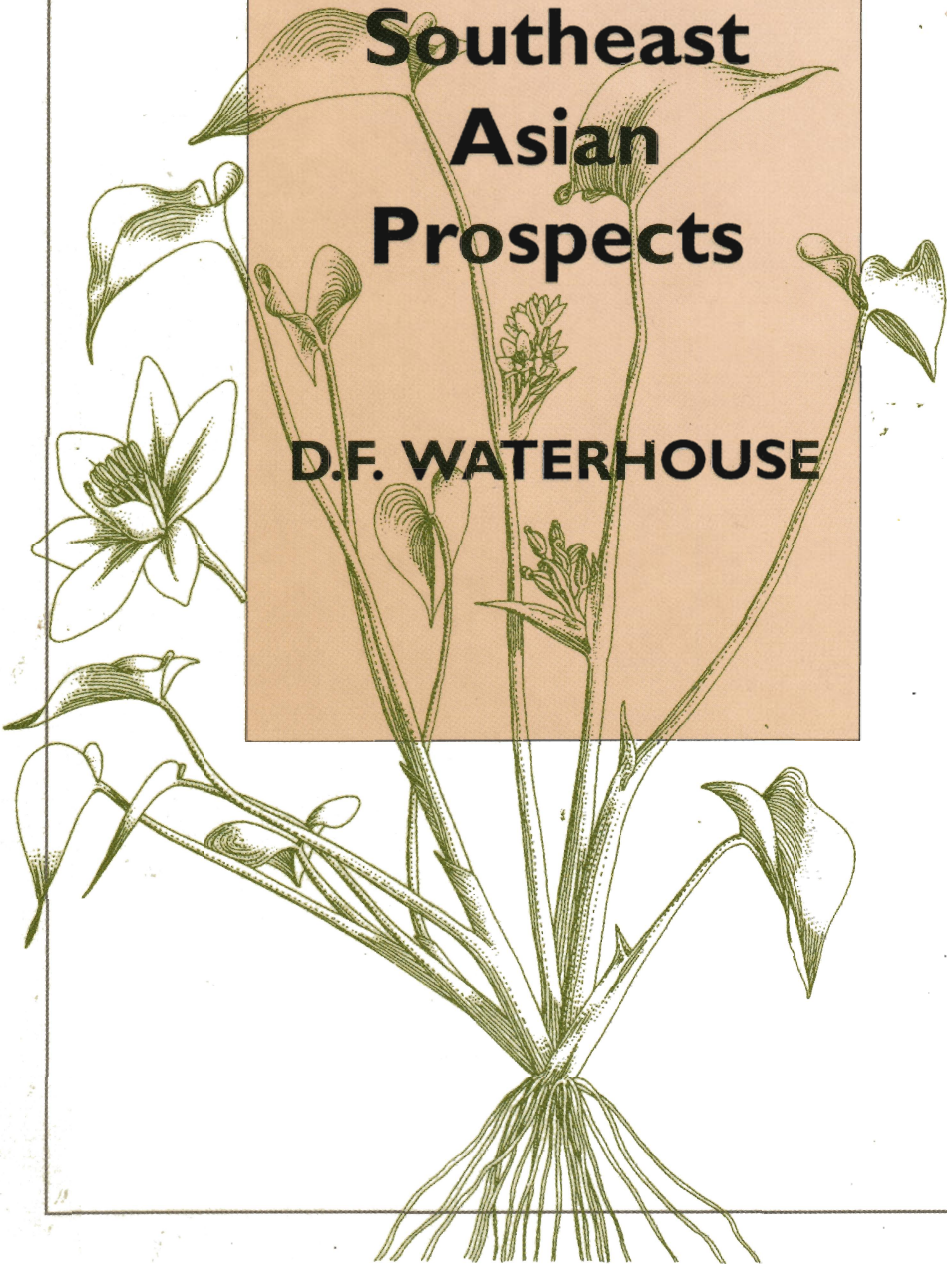


**Biological  
Control of  
Weeds:  
Southeast  
Asian  
Prospects**

**D.F. WATERHOUSE**



# **Biological Control of Weeds: Southeast Asian Prospects**

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**ACIAR**

(Australian Centre for International Agricultural Research)

Canberra  
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# Foreword

From its very beginning in 1982 ACIAR has been a strong supporter of biological control as a sustainable and environmentally friendly alternative to the steadily growing use of pesticides. This alternative has achieved great success in regions of the world (e.g. Australia, New Zealand, Oceania, California) where many of the major insect pests and weeds have been introduced from outside the region. Although a smaller proportion of the major weeds in Southeast Asia are introduced than in many other regions, a recent survey commissioned by ACIAR (Waterhouse 1993a) identified 28 major weeds that merited evaluation as possible targets for biological control. Even if only half of these weeds proved to be attractive targets, this number would require several decades of research, major resources in personnel and equipment and strong support within the region.

The aim of the present volume is to summarise for the major exotic weeds of agriculture in Southeast Asia what is known about their natural enemies and the prospects for classical biological control. The book is intended to serve two purposes. Firstly, to facilitate, for the countries of the region, the selection of promising, individual or collaborative, priority weed targets. Secondly, to provide donor agencies with an overall perspective of the region's major exotic weed problems and prospects for their amelioration; and thus to aid in the selection of projects for support that are best suited to their terms of reference.

It is hoped that it may be possible in the near future to produce a companion volume dealing with major arthropod pests exotic to Southeast Asia.

*G.H.L. Rothschild*

Director

Australian Centre for International  
Agricultural Research, Canberra

# 1 Abstract

Biological control programs have already been mounted in some region of the world against 6 of the 28 major weeds that are exotic to Southeast Asia. Substantial or partial success has been achieved in one or more countries for all of these except *Mikania micrantha*, which is still under investigation. A substantial amount of information on their natural enemies in the region where the weeds evolved is available on all 6. This is in stark contrast with the situation for most of the remaining 22 weed species. Indeed, for more than half of these, so little relevant information is available that it is not possible to evaluate the chances of mounting a successful program. For this group of weeds the first step would be a survey in the centre of origin of the weed. It is probable that surveys could be mounted simultaneously of several candidate weeds in the same region of the world (e.g. Central America or Tropical Africa). The very minimum period for a preliminary survey would be several weeks in both spring and late summer. When the organisms collected had been identified by taxonomists a decision would be facilitated on possible follow-up surveys.

On the basis of available information there are good to excellent prospects for reducing, in at least some parts of the region, the weediness of the following:

*Chromolaena odorata*  
*Eichhornia crassipes*  
*Mimosa invisa*  
*Mimosa pigra*  
*Pistia stratiotes*  
*Portulaca oleracea*

There are also good reasons for believing that there will prove to be valuable natural enemies for the following:

*Ageratum conyzoides*  
*Amaranthus spinosus*  
*Bidens pilosa*  
*Eleusine indica*  
*Melastoma malabathricum*  
*Mikania micrantha*

There is insufficient information yet available on the remaining 15 weeds to attempt to evaluate their prospects for classical biological control.

## 2 Estimation of biological control prospects

Weed	Rating	Family	Any biological control successes?	Attractiveness as a target in SE Asia
<i>Ageratum conyzoides</i>	17	Asteraceae	–	++
<i>Amaranthus spinosus</i>	17	Amaranthaceae	–	++
<i>Bidens pilosa</i>	10	Asteraceae	–	++
<i>Chromolaena odorata</i>	18	Asteraceae	yes	++++
<i>Commelina benghalensis</i>	10	Commelinaceae	–	
<i>Cynodon dactylon</i>	18	Poaceae	–	unsuitable
<i>Echinochloa crus-galli</i>	21	Poaceae	–	
<i>Eichhornia crassipes</i>	20	Pontederiaceae	yes	+++++
<i>Eleusine indica</i>	24	Poaceae	–	++
<i>Euphorbia heterophylla</i>	10	Euphorbiaceae	–	
<i>Euphorbia hirta</i>	10	Euphorbiaceae	–	
<i>Fimbristylis miliacea</i>	23	Cyperaceae	–	
<i>Marsilea minuta</i>	12	Marsileaceae	–	
<i>Melastoma malabathricum</i>	13	Melastomataceae	–	++
<i>Mikania micrantha</i>	13	Asteraceae	–	++
<i>Mimosa invisa</i>	18	Mimosaceae	yes	++++
<i>Mimosa pigra</i>	15	Mimosaceae	yes	++++
<i>Mimosa pudica</i>	17	Mimosaceae	–	
<i>Monochoria vaginalis</i>	26	Pontederiaceae	–	
<i>Nephrolepis biserrata</i>	10	Nephrolepidaceae	–	
<i>Panicum repens</i>	16	Poaceae	–	
<i>Paspalum conjugatum</i>	15	Poaceae	–	
<i>Passiflora foetida</i>	11	Passifloraceae	–	
<i>Pennisetum polystachion</i>	11	Poaceae	–	
<i>Pistia stratiotes</i>	14	Araceae	yes	++++
<i>Portulaca oleracea</i>	10	Portulacaceae	–	+++
<i>Rottboellia cochinchinensis</i>	12	Poaceae	–	
<i>Sphenoclea zeylanica</i>	14	Sphenocleaceae	–	

### 3 Introduction

Waterhouse (1993a) published information, collated from agricultural and weed experts in the 10 countries of Southeast Asia, on the distribution and importance of their major weeds in agriculture. Ratings were supplied on the basis of a very simple system:

- +++ very widespread and very important
- ++ not widespread but of great importance where it occurs
- + important only locally
- present, but not an important pest

The advantages and limitations of this system are discussed by Waterhouse (1993a). Of 232 weeds nominated, 140 were rated as highly important, and a subset of 40 particularly so.

The focus of the present work is on the possibilities for classical biological control of those of this subset of 40 that evolved outside Southeast Asia. The assumption is that many of these have been introduced without some of the organisms that help to control them where they evolved. The chances are very remote indeed, for weeds that evolved in Southeast Asia, of introducing sufficiently host-specific organisms from outside the region. Nevertheless, it is possible that useful organisms present in, say, Thailand or Myanmar may not be present in all of the islands constituting the Philippines or Indonesia (or vice versa) and this possibility should be borne in mind.

The origin of 12 of the subset of 40 major weeds is believed to be Southeast Asia, or close by, and these have been excluded from consideration at this stage. The remaining 28 species, 27 of which are treated here, are either known to have evolved in the Americas or Africa or are postulated to have evolved in both Asia and Africa. This latter group is considered because the possibility exists that useful organisms at the African end of the range may not yet have extended their distribution into all of Southeast Asia.

The 28th species, couch grass, *Cynodon dactylon*, has not been dealt with because, in many situations, such as lawns and some pastures, it is regarded as a highly desirable species. Biological control agents would not distinguish between these situations and the many others where it is a serious weed, so other control measures must be employed in the latter instances.

Of course, it is not to be expected that all of any one country's top 20 or even top 10 exotic weeds will necessarily be included in this regional priority list. Indeed, at least some of those omitted might well merit the production of additional dossiers if they are of such importance locally that resources for a program would be likely to achieve a very high priority for a particular country. ACIAR would be interested to hear of weeds that might be considered in this category.

It is not so long ago that Wilson (1964) pointed out that no insects had yet been used for the biological control of aquatic weeds and that it was not clear "whether in the aquatic environment there exists a sufficient development of that monophagy in phytophagous insects that has been the main foundation for the biological control of weeds on land". He

referred to the opinion of Brues (1946) that aquatic insects show little host specificity, but warned that this view might be the result of lack of information and recommended an extension of research in this general field. In the intervening 30 years, research on four major water weeds of South American origin has yielded success and even spectacular success with the following: *Salvinia molesta*, *Eichhornia crassipes*, *Alternanthera philoxeroides* and *Pistia stratiotes* (Room 1993).

It is very probable that a parallel can be drawn between the situation with water weeds in 1964 and the “conventional wisdom” of today that grassy weeds are unsuitable targets for classical biological control because of the danger to many major world crops that also belong to the family Poaceae e.g. rice, wheat, maize, sorghum, millet, sugarcane. However, it would be very strange indeed if host specialisation occurred widely in insects attacking all other plant families, but not amongst those attacking the very large number of grasses. In view of the fact that 10 of the 18 world’s worst weeds are grasses (Holm et al. 1977) and eight of the 28 major exotic weeds in Southeast Asia are also grasses (Waterhouse 1992, 1993a), it is evident that the time is long overdue for a detailed study of the natural enemies of these grasses in the regions where they evolved. This theme is mentioned further below, in particular in the discussion on *Eleusine indica*.

For any biological control organisms to be approved for introduction into Southeast Asia against weedy grasses they would need to be sufficiently specific that they would not cause economic damage to the crop grasses listed in table 3.1. This list refers to Thailand, but is believed to be much the same as that for other Southeast Asian countries. It does not, however, include pasture species. A number of useful grasses are also harvested from the wild and some may have to be considered also, although there are important weeds (e.g. *Imperata cylindrica*) amongst them. There are, of course, many additional crop grasses of importance outside the region, but of little or no importance in most or all of Southeast Asia. They would certainly have to be taken into consideration in other regions of the world.

The successful biological control of a weed presents a special problem, seldom shared by the control of an insect pest, namely that some other plant, perhaps even a weed that is more difficult to control by other means, will spread to occupy the space vacated. Reduction to the greatest possible extent of the density of a weed is desirable in situations such as pastures or national parks. In many other situations, however, all that may be required is a significant reduction in seeding (for annuals) or in competitiveness (for annuals and perennials) so that the weed no longer has an opportunity of becoming dominant and thus, when necessary, is more readily controlled by cultural or other measures. Thus, even partial biological control (leading to the weed becoming less aggressive) provides desirable plant species with the opportunity to compete more successfully for sunlight and nutrients and may be of significant value.

Another problem is that many weeds display a good deal of variability throughout their distribution, resulting in part from polyploidy, hybridisation with closely related species and other genetic modifications. The taxa thus produced may not be equally susceptible to natural enemies, so it is desirable, where possible, to match them with taxa encountered in the surveys in the area of origin of the weed. It may also be necessary to

seek expert taxonomic advice at an early stage, perhaps involving electrophoretic, DNA and other studies, particularly when commencing a project on a weed that has not yet been the target of a biological control investigation.

The summary accounts presented are designed to enable a rapid review to be made of (i) the main characteristics of the major weeds of agriculture that are believed to be exotic to part or all of Southeast Asia, (ii) what is known of their natural enemies and (iii) prospects for reducing their weediness by classical biological control.

The material on weed characteristics draws heavily on the publications by Barnes and Chan (1990), Holm et al. (1977), Noda et al. (1985) and Soerjani et al. (1987). Additional information is available from these sources, including detailed botanical descriptions, vernacular names, biology, agricultural importance and herbicidal control.

I am particularly grateful to the University of Hawaii Press for permission to draw on 21 of the illustrations in its publication 'The World's Worst Weeds' by Holm et al. (1977) to Ancom Berhad, Malaysia (Barnes and Chan 1990) and the Director of BIOTROP Indonesia (Soerjani et al. 1987) to draw on 2 and 3 illustrations respectively from their publications and to the Division of Entomology CSIRO for permission to use illustration 4.16. The figures have been slightly amended by the omission of inserts that are mainly of taxonomic interest. Acknowledgement appears on each of the illustrations used.

In most instances four databases were searched for relevant information:

AGRICOLA (Bibliography of Agriculture) 1970+  
 BIOSIS (Biological Abstracts) 1989+  
 CAB (Commonwealth Agricultural Bureaux) 1984+  
 DIALOG (Biological Abstracts) 1959+

In many cases abstracting journals and other sources published prior to the above commencement dates were also searched. Useful information was also obtained by serendipity from these and other references and from unpublished records. Nevertheless, in many cases the search cannot be described as exhaustive. Even more relevant, however, than attempting an exhaustive search would be a fresh, detailed field survey targeted on the known (or presumed) area of origin of the weed. In any event, in most instances a preliminary investigation would be highly desirable in the area of origin of a weed before deciding whether or not to embark upon a major project. Several such surveys might well be carried out simultaneously where more than one weed occurs in the same general region. Indeed, it is strongly recommended that a pre-project activity be funded to carry out such surveys, with special reference to selected weeds of major importance in Southeast Asia.

Surveys of this nature are particularly important, since the amount of useful, published information on arthropods or other organisms attacking the target weeds is, in general, inadequate to serve as a basis for a sound decision. Although acceptable host specificity is required for classical biological control, it is possible that some of the less specific fungi listed might be developed for use as bioherbicides.

In addition to surveys in the region of origin of the weed(s) it will also be necessary to survey the weed(s) in the country or countries where biological control is to be

attempted. This is to indicate whether any of the organisms that might be considered for introduction are already present.

The species treated are drawn from tables 10 and 11 of 'The Major Arthropod Pests and Weeds of Agriculture in Southeast Asia: Distribution, Importance and Origin' (Waterhouse 1993a). It is quite possible that additional weeds rating highly in these tables will prove to be exotic to Southeast Asia (or significant parts of it) and, alternatively, that some considered to be exotic will, on further evidence, be shown to have evolved in the region.

The natural enemies most commonly involved in classical biological control of weeds have been arthropods, although there is a growing interest in, and a few striking successes with, fungi. Because there is a considerable lack of uniformity in the names of many of the insects involved, a separate index is included listing the preferred scientific names. These have been used in the text, replacing those used by the authors quoted. On the other hand, with few exceptions the names used for fungi, bacteria, nematodes and viruses are those of the authors quoted, although it is probable that some names have been changed since they were used. Where the name of a weed or an insect given in a publication is no longer preferred by taxonomists, the superseded name, *x*, is shown thus (= *x*), but this usage is not intended to convey any other taxonomic message. Indeed, the superseded name may still be valid, but simply not applicable to the particular species referred to by the author.

I am most grateful for assistance from many colleagues during the preparation of this book. It is not possible to name them all, but special thanks are due to Dr B. Napompeth (Thailand), Dr R. Muniappan (Guam), C.J. Davis (Hawaii) and, in Australia, Dr I.W. Forno, Dr K.L.S. Harley, M.H. Julien, Dr K.R. Norris, J. Prance, Dr D.P.A. Sands, Dr A.J. Wapshere and A.D. Wright of CSIRO and Dr R.E. McFadyen (Queensland Department of Lands). Many others who have contributed unpublished information are acknowledged at appropriate places in the text.

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Continuing warm support has been provided by Dr P. Ferrar, Research Program Coordinator, Crop Sciences, ACIAR, Canberra.

It is a pleasure to acknowledge the expert assistance of Mrs A. Johnstone (Ms A. Ankers) in converting my manuscripts into presentable form; and also of Mrs S. Smith and C. Hunt for assistance with the illustrations.

It would not have been possible to continue with these biological control activities in deep retirement without the support, forbearance and encouragement of my wife, to whom particular thanks are due.

**Table 3.1 Grasses (other than pasture species) that are important in Thailand.**

A. Crop Grasses	Importance	
<i>Bambusa</i> spp.	+++	bamboo, construction, furniture, paper
<i>Coix lacryma-jobi</i>	+	job's tears, cereal
<i>Cymbopogon</i> spp.	++	lemongrasses, flavourings
<i>Hordeum</i> spp.	++	barleys
<i>Oryza sativa</i>	+++++	rice
<i>Saccharum officinarum</i>	+++	sugar cane
<i>Setaria italica</i>	++	foxtail millet
<i>Sorghum bicolor</i>	++++	sorghum
<i>Triticum</i> spp.	++	wheats
<i>Zea mays</i>	++++	maize
<i>Zizania latifolia</i>	+	vegetable

**B. Grasses harvested from the wild**

<i>Arundo donax</i>		giant reed, cane
<i>Dendrocalamus</i> spp.		weaving, vegetables
<i>Gigantochloa</i> spp.		construction, furniture
<i>Imperata cylindrica</i>		paper, roof thatch
<i>Melocanna baccifera</i>		paper, furniture, food
<i>Phragmites</i> spp.		reeds, thatch, mats
<i>Phyllostachys</i> spp.		furniture, vegetable
<i>Schizostachyum dumetorum</i>		rope