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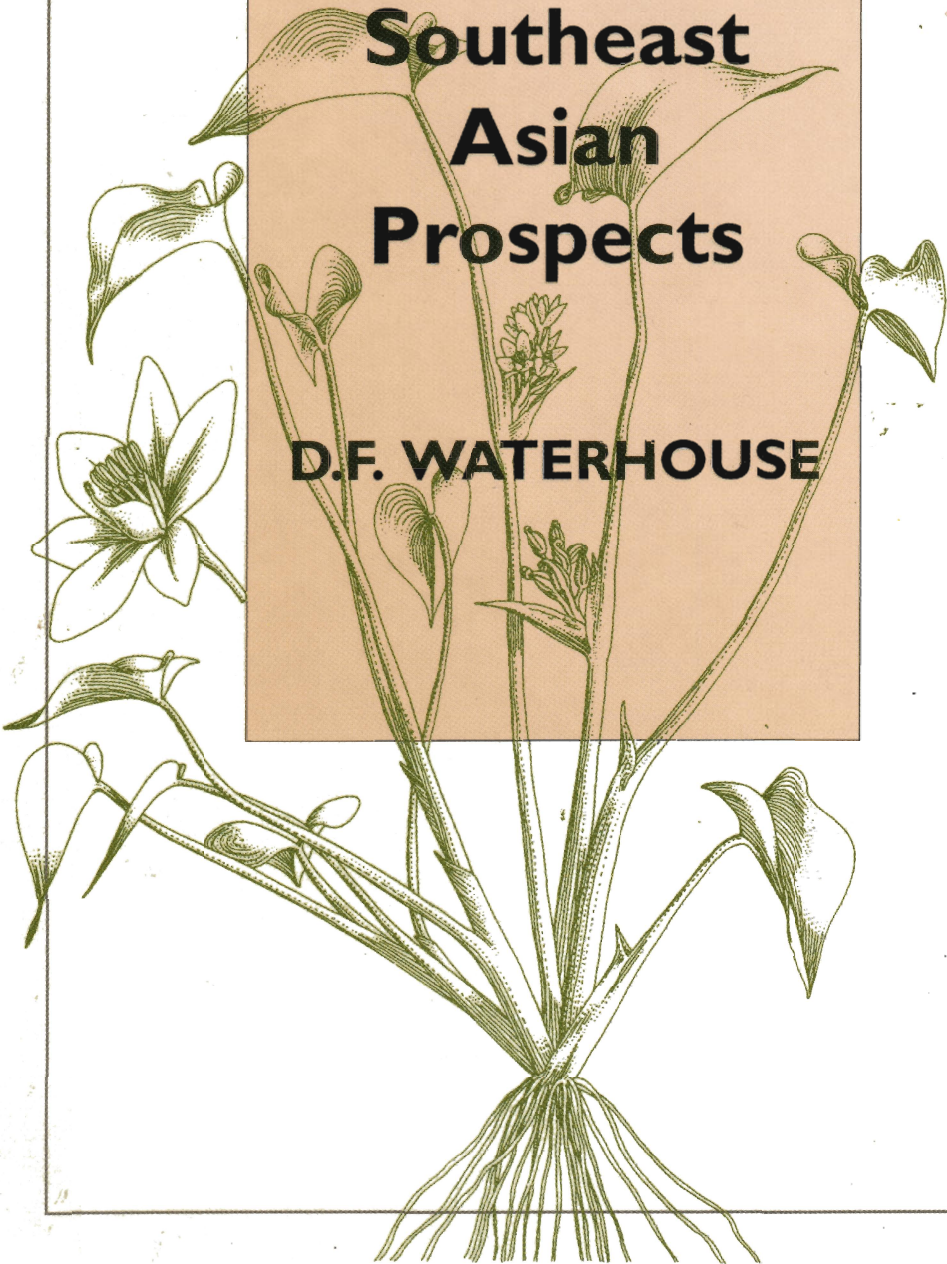
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**Biological
Control of
Weeds:
Southeast
Asian
Prospects**

D.F. WATERHOUSE



Biological Control of Weeds: Southeast Asian Prospects

D.F. Waterhouse

(ACIAR Consultant in Plant Protection)

ACIAR

(Australian Centre for International Agricultural Research)

Canberra
AUSTRALIA
1994

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GPO Box 1571, Canberra, ACT 2601.

Waterhouse, D.F. 1994. Biological Control of Weeds: Southeast Asian Prospects
ACIAR Monograph No. 26, vi + 302pp., 27 figs., 28 maps

ISBN 1 86320 099 1

Typeset in 11/13 Times using a Macintosh IIvx running Quark XPress by K & B Publications

Printed by Brown Prior Anderson Pty. Ltd.

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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.

Valuable advice on taxonomic problems has been received from a number of colleagues in the Division of Entomology, CSIRO, Canberra, including Dr M. Carver (Hemiptera), Dr P. Cranston (Diptera), E.D. Edwards (Lepidoptera), Dr I.D. Naumann, Dr K.H.L. Key (Orthoptera), T. Weir (Coleoptera) and Dr E.C. Zimmerman (Curculionidae).

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

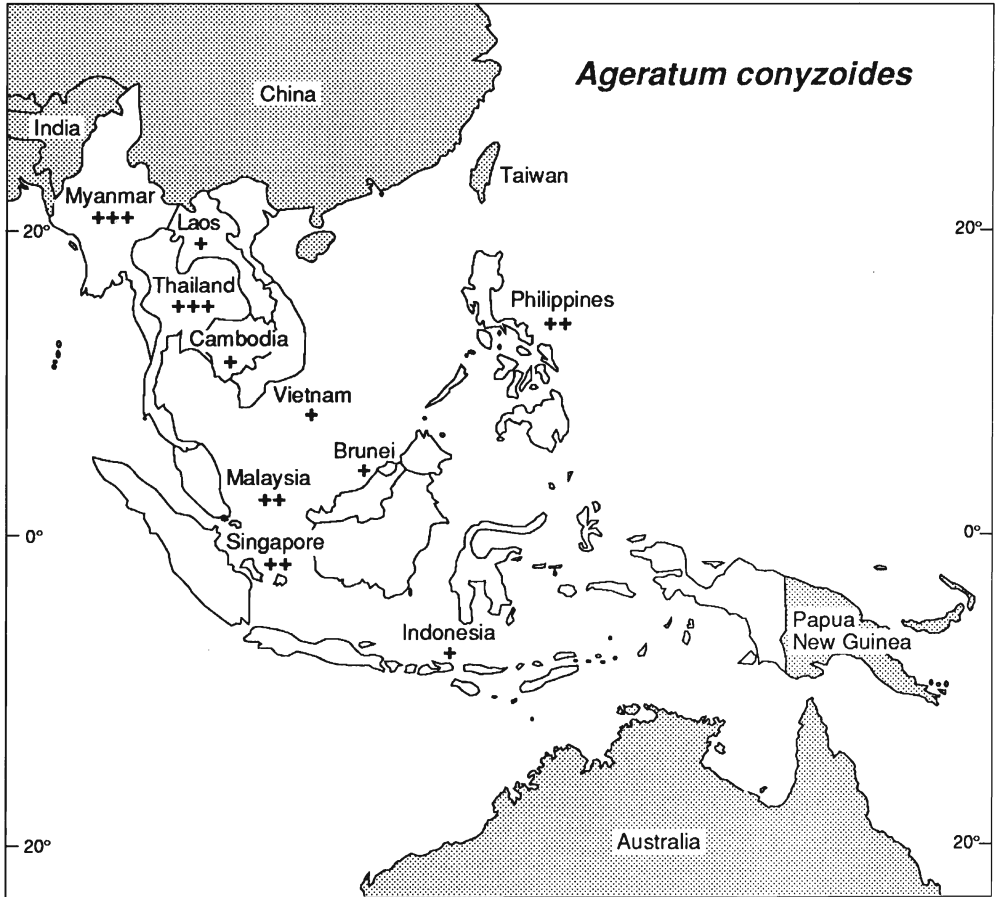
4 Target weeds

1. *Ageratum conyzoides*
2. *Amaranthus spinosus*
3. *Bidens pilosa*
4. *Chromolaena odorata*
5. *Commelina benghalensis*
6. *Echinochloa crus-galli*
7. *Eichhornia crassipes*
8. *Eleusine indica*
9. *Euphorbia heterophylla*
10. *Euphorbia hirta*
11. *Fimbristylis miliacea*
12. *Marsilea minuta*
13. *Melastoma malabathricum*
14. *Mikania micrantha*
15. *Mimosa invisa*
16. *Mimosa pigra*
17. *Mimosa pudica*
18. *Monochoria vaginalis*
19. *Nephrolepis biserrata*
20. *Panicum repens*
21. *Paspalum conjugatum*
22. *Passiflora foetida*
23. *Pennisetum polystachion*
24. *Pistia stratiotes*
25. *Portulaca oleracea*
26. *Rottboellia cochinchinensis*
27. *Sphenoclea zeylanica*



Ageratum conyzoides

(after Holm *et al.* 1977)



Map 4.1 *Ageratum conyzoides*

As a member of the Asteraceae, it would be expected that *Ageratum conyzoides* would have many natural enemies attacking it in its area of origin in Tropical America. However, no study has been made and virtually nothing is known of the situation there. Elsewhere it is attacked by a range of insects, nematodes, fungi and viruses, but almost all have a very wide host range and are not suitable as biological control agents.

Surveys in Tropical America would be necessary to provide data on which prospects for its biological control could be evaluated.

4.1 *Ageratum conyzoides* L.

Asteraceae

goatweed, ageratum; bandotan (Indonesia), rumput tahi ayam (Malaysia), bulak manok, kolokong kabayo (Philippines), ya tabsua, ya sap raeng (Thailand), cò cút heo, bò xít (Vietnam)

Rating

	+++	Myan, Thai
17	++	Msia, Sing, Phil
	+	Laos, Camb, Viet, Brun, Indo

Origin

Tropical America.

Distribution

Pantropical; also in the subtropics and extending into temperate areas from latitude 30°N to 30°S. Widespread in SE Asia. Present in Java prior to 1860.

Characteristics

Ageratum conyzoides is a self pollinated, C3, annual herb. It is erect, often branched, sometimes decumbent and ranges up to 1.2 m at flowering. Its flowers are light blue, white or violet and its leaves and stems are hairy.

Importance

A. conyzoides occurs in both light and heavy soils in moister areas in agricultural land, waste land, roadsides, plantations, pastures and upland rice fields. It may produce 40 000 or more seeds per plant and these are mainly spread by wind and water. They germinate readily and the life cycle can be completed in less than 2 months. *A. conyzoides* is one of about 300 species in the genus, all of which originated in the Americas. Goatweed is important in 46 countries in 36 crops and is troublesome in plantations after grasses have been suppressed (Holm et al. 1977). It is a rapidly colonising, vigorously growing weed in a wide variety of arable crops in which thick carpets of *A. conyzoides* compete strongly for nutrients and moisture. When a stand is destroyed another rapidly takes its place. It is suspected of poisoning cattle, but this is not confirmed from Australia. It was rated 19th of the World's Worst Weeds by Holm et al. (1977), as equal 15th in Southeast Asia (Waterhouse 1993a) and 15th in the Oceanic Pacific (Waterhouse unpub.).

Its crushed leaves smell strongly of coumarin and are used as a styptic for wounds, also for sores, skin diseases, eye inflammation and lung problems (Gonzalez et al. 1991). It is sometimes used as cut flowers in the home.

Natural enemies

Although *A. conyzoides* is listed by Holm et al. (1977) as a weed in some crops in Central and South America, it is significant that nowhere in that region (unlike the rest of the tropical world) is it regarded as a serious or a principal weed. From this it might be inferred that natural enemies might be controlling its abundance. However, so little information on natural enemies (Tables 4.1.1 to 4.1.3) was obtained from the databases searched that it is not possible to substantiate this claim. Almost all of the records are from outside its area of origin and one (the agromyzid fly, *Melanagromyza metallica*) is known to have a narrow host range. However, *M. metallica* is already widespread. In addition to India, it is known also from many places including Taiwan, Philippines, Vietnam, Thailand, Indonesia, Melanesia, Papua New Guinea, Solomon Is, Micronesia, Australia and Africa. It lays its eggs on the apical part of the stem. The larva bores into the pith region, gradually extending towards the root and the final instar larva cuts an exit hole at the base of the stem. Mines may extend into the roots and pupae are often present at about ground level in the mines (Singh and Beri 1973).

If *A. conyzoides* is considered to be an important target it will be necessary to survey for organisms attacking it in Central America and northern South America.

Table 4.1.1 Natural enemies of *Ageratum conyzoides*: insects and mites.

Species	Location	Other hosts	References
INSECTS			
Orthoptera			
ACRIDIDAE			
<i>Zonocerus variegatus</i>	Nigeria	<i>Chromolaena odorata</i> , <i>Lantana camara</i>	Toye 1974
Hemiptera			
APHIDIDAE			
<i>Aphis craccivora</i>		many	Raychaudhuri 1983
<i>Aphis gossypii</i>		many	Raychaudhuri 1983
<i>Aphis spiraeicola</i> (= <i>A. nigricauda</i>)	Java	many	Patch 1939, Raychaudhuri 1983
<i>Aulacorthum solani</i>		many	Raychaudhuri 1983
<i>Brachycaudus helichrysi</i>		many	Raychaudhuri 1983
<i>Capitophorus hippophaes</i>		<i>Eupatorium</i> , <i>Mirabilis</i> , <i>Polygonum</i>	Ghosh et al. 1971
<i>Hyperomyzus carduellinus</i>			Patch 1939
<i>Myzus ornatus</i>		many	Raychaudhuri 1983
<i>Myzus persicae</i>		many	Raychaudhuri 1983
<i>Neomasonaphis</i> (= <i>Masonaphis</i>) <i>anaphalidis</i>		many	Raychaudhuri 1983
<i>Uroleucon</i> (= <i>Macrosiphum</i>) <i>solidaginis</i>			Patch 1939
<i>Vesiculaphis pieridis</i>	India	<i>Lyonia ovalifolia</i> , <i>Pieris ovalifolia</i>	Patch 1939

(continued on next page)

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Table 4.1.1 (continued)

Species	Location	Other hosts	References
ALEYRODIDAE			
<i>Bemisia tabaci</i>	India, Malaysia, Turkey	a very wide range	Ang et al. 1977, Sastry 1984, Shreni et al. 1979
DIASPIDIDAE			
<i>Mycetaspis personata</i>	Brazil	polyphagous	d'Araujo e Silva et al. 1968a
LYGAEIDAE			
<i>Nysius inconspicuus</i>	India	sesame and many others	Thangavelu 1978
Thysanoptera			
PHLAEOTHRIPIIDAE			
<i>Haplothrips gowdei</i>	Hawaii	vector of pineapple yellow spot virus	Sakimura 1937
THRIPIIDAE			
<i>Caliphrips ipomoeae</i>	Brazil	polyphagous	d'Araujo e Silva et al. 1968a
<i>Microcephalothrips abdominalis</i>	India	polyphagous	Gopinathan et al. 1981
<i>Thrips tabaci</i>	Hawaii	vector of pineapple yellow spot virus	Sakimura 1937
Diptera			
AGROMYZIDAE			
<i>Calycomyza</i> sp.	USA		Spencer & Steyskal 1986
<i>Melanagromyza metallica</i>	India, etc	no other host mentioned	Singh & Beri 1973
CHLOROPIDAE			
<i>Ocella pleuralis</i>	Trinidad	<i>C. odorata</i> , <i>C. ivaefolia</i> , <i>C. iresinoides</i> , <i>Fleischmannia microstemon</i> , <i>Wedelia caracasana</i> , <i>Wulffia baccata</i>	McFadyen 1988a
TEPHRITIDAE			
<i>Xanthaciura insecta</i>	Florida, Trinidad	<i>C. odorata</i> , <i>F. microstemon</i> <i>W. caracasana</i>	McFadyen 1988a, Needham 1946
Lepidoptera			
ARCTIIDAE			
<i>Pareuchaetes pseudoinsulata</i> (= <i>Ammalo insulata</i>)	Nigeria, Trinidad	<i>C. odorata</i>	Bennett & Cruttwell 1973, Olaoye 1974
GELECHIIDAE			
<i>Dichomeris</i> sp.	Trinidad	<i>C. odorata</i>	Bennett & Cruttwell 1973
NOCTUIDAE			
<i>Pseudoplusia includens</i> (= <i>Plusia oo</i>)	Brazil	polyphagous	d'Araujo e Silva et al. 1968a
<i>Spodoptera frugiperda</i>	Brazil	polyphagous	d'Araujo e Silva et al. 1968a

(continued on next page)

Species	Location	Other hosts	References
PYRALIDAE			
<i>Pionea upalusalis</i>	Trinidad, Puerto Rico, Venezuela	<i>C. odorata</i> , <i>C. ivaefolia</i> , <i>Austroeupatorium</i> <i>inulaefolium</i> , <i>Fleischmannia</i> <i>microstemon</i>	McFadyen 1988a
MITES			
<i>Brevipalpus obovatus</i>	India	cotton, <i>Solanum nigrum</i> , <i>Sonchus asper</i> , <i>Phaseolus vulgaris</i> , <i>Euphorbia hirta</i> , <i>Xanthium sp.</i> , <i>Cichorium intybus</i>	Sadana et al. 1983
<i>Tetranychus urticae</i>	China	a very wide range	Dong et al. 1986

Table 4.1.2 Natural enemies of *Ageratum conyzoides*: nematodes.

Species	Location	Other hosts	References
<i>Aphelenchoides fragariae</i>	Hawaii	strawberry, <i>Vanda</i> orchids, <i>Impatiens</i> , <i>Nephrolepis biserrata</i>	Sher 1954
<i>Helicotylenchus multicinctus</i>	Brazil	banana, <i>Portulaca</i> <i>oleracea</i> and several weeds	Zem & Lordello 1983
<i>Meloidogyne</i> sp.	Cuba	<i>Eleusine indica</i> , <i>Croton lobatus</i> , <i>Cynodon dactylon</i>	Acosta et al. 1986 Holm et al. 1977
<i>Meloidogyne arenaria</i>	Philippines		Valdez 1968
<i>Meloidogyne arenaria</i> <i>thamesis</i>	Philippines		Valdez 1968
<i>Meloidogyne incognita</i>	Philippines	many vegetables and weeds	Mamaril & Alberto 1989
<i>Meloidogyne javanica</i>	Philippines, Nigeria	many vegetables and weeds	Mamaril & Alberto 1989, Salawu et al. 1991 Valdez 1968
<i>Pratylenchus pratensis</i>	Hawaii		Holm et al. 1977
<i>Rotylenchulus reniformis</i>	Hawaii, India	many weeds	Linford & Yap 1940, Lal et al. 1978

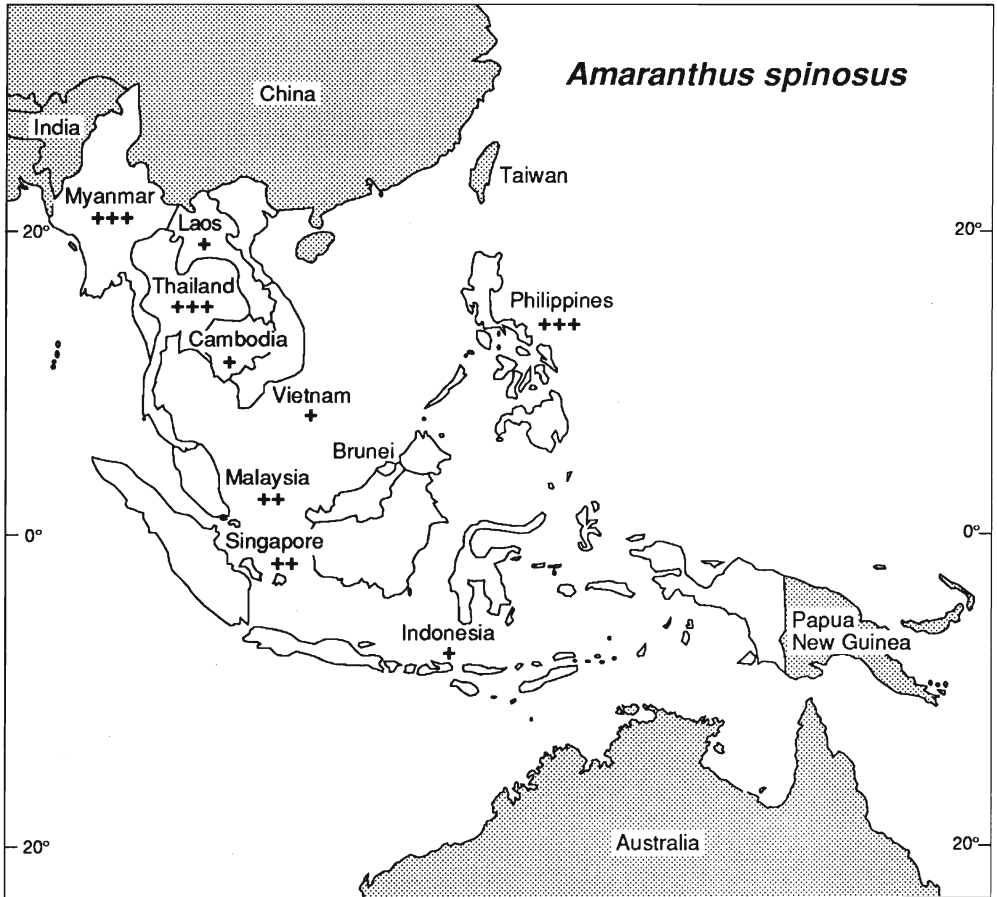
Table 4.1.3 Natural enemies of *Ageratum conyzoides*: fungi, bacteria and viruses.

Species	Location	Other hosts	References
FUNGI			
<i>Cercospora agerati</i>			Stevens 1925
<i>Colletotrichum</i> sp.	India		Kulkarni & Sharma 1976
<i>Cylindrocladium quinqueseptatum</i>	India	many commercial hosts	Sulochana et al. 1982
<i>Mycovellosiella perfoliata</i>	India		Srivastava 1981
<i>Puccinia conoclinii</i>			Stevens 1925
<i>Sclerotium rolfsii</i>	India	many	Desai et al. 1980
BACTERIA			
<i>Pseudomonas solanacearum</i>	India	potato, <i>Ranunculus sceleratus</i>	Sathiarajan & Sasikumar 1977, Sunaina et al. 1989
VIRUSES			
<i>Ageratum</i> vein yellowing	India, Malaysia	(transmitted by <i>Bemisia tabaci</i>)	Ang et al. 1977, Shreni et al. 1979
anemone mosaic			Holm et al. 1977
<i>Bidens</i> mottle		several, including <i>Zinnia</i> , <i>petunia</i> & <i>Verbena</i>	Logan & Zettler 1984
hibiscus yellow vein mosaic	India	(transmitted by <i>B. tabaci</i>)	Jeyarajan et al. 1988
pineapple yellow spot	Hawaii		Sakimura 1937
potato virus Y	India	potato	Joshi & Prakash 1977
tapioca mosaic	India	(transmitted by <i>B. tabaci</i>)	Jeyarajan et al. 1988
tobacco leaf curl	India	tomato	Holm et al. 1977, Reddy et al. 1981
tomato leaf curl	Turkey, India	many weeds (transmitted by <i>B. tabaci</i>)	Sastry 1984, Jeyarajan et al. 1988
urd bean yellow mosaic	India	(transmitted by <i>B. tabaci</i>)	Jeyarajan et al. 1988
<i>Zinnia</i> yellow net	India	(transmitted by <i>B. tabaci</i>)	Srivastava et al. 1977



Amaranthus spinosus

(after Holm *et al.* 1977)



Map 4.2 *Amaranthus spinosus*

Mass rearing and release, as required, of the weevil *Hypolixus trunculatus* is reported to provide good control of *Amaranthus spinosus* in Thailand but, of course, this is augmentative rather than classical biological control.

Three other insects (a weevil, a leaf mining fly and a caterpillar) are known which may prove to be adequately specific for classical biological control.

However, almost nothing is known about the natural enemies of *A. spinosus* in tropical America where it evolved and it would thus be necessary to carry out a survey there in order to evaluate what potential biological control agents are available.

4.2 *Amaranthus spinosus* L.

Amaranthaceae

spiny amaranth, spiny pigweed, needle burr; hin nu nive tsu bauk (Myanmar), phak khom nam (Thailand), phti banla (Cambodia), bayam duri (Malaysia and Indonesia), orai (Philippines), dên gai (Vietnam)

Rating

	+++	Myan, Thai, Phil
17	++	Msia, Sing
	+	Laos, Camb, Viet, Indo

Origin

Tropical America.

Distribution

A. spinosus is mainly tropical and subtropical in distribution, but also extends into the temperate zone from latitude 30°N to 30°S.

Characteristics

A. spinosus is an erect, much branched, annual, growing to 1.2 m. Its stems are angled in cross section, fleshy, often reddish and bear many spines. Its leaves are alternate, with a pair of straight spines up to 1 cm long at the base. The inflorescence is long, slender and terminal or arises from leaf axils. The flowers are small, greenish and unisex. It is propagated by reddish brown seeds.

Importance

Spiny amaranth prospers in warm sunny situations, but not where it is cool or shady. It is not reported as a problem in the Mediterranean or Middle East. It is a weed in 44 countries in 28 crops, mainly in the Caribbean, in the west and south of Africa, in India and in Southeast Asia. Up to 235 000 seeds per plant have been recorded. Seeds are spread by wind and water. Some germinate soon, others over several months and still others remain viable in the soil for many years. *A. spinosus* is abundant in cultivated and abandoned fields, along roadsides and in waste places. It is a weed of varying degrees of aggressiveness in many crops, including upland rice, cotton, cowpeas, groundnuts, maize, mangos, millet, pineapples, sugarcane and vegetables. The rigid needle-like spines break off in the hands of workers in sugarcane, cotton and other crops.

A. spinosus may contain high nitrate levels and has been implicated in livestock poisoning. It is avoided by most animals because of its spines. Leaves are sometimes used by humans as a green vegetable. Other *Amaranthus* species are valuable as a grain crop in some South American countries and the family Amaranthaceae contains a number of widely grown ornamental garden species (Purseglove 1968).

Natural enemies

A. spinosus is attacked by a number of natural enemies (Tables 4.2.1 and 4.2.2), but most of the reports come from outside its native range and are of non-specific organisms. The agromyzid fly *Haplopeodes minutus*, known in USA from species of *Amaranthus* and *Chenopodium* (Spencer and Steyskal 1986) and both the beetle *Cassida nigriventris* and the moth *Coleophora versurella*, known in Pakistan from these same plant genera (Khan et al. 1978), may prove to be sufficiently specific to be candidate biological control agents.

The weevil *Hypolixus trunculatus*, whose larvae tunnel in the stems and form galls, is known from Pakistan, India and Thailand and attacks *Amaranthus spinosus*, *A. viridis* and *Digera arvensis*. Although it has a relatively long life cycle and low reproductive capacity, mass rearing and augmentative releases have resulted in a satisfactory level of control and replaced the use of herbicides in Thailand (Julien 1992, Napompeth 1982, 1989, 1992a). Females deposit eggs singly in cavities scooped out of the shoots. Larvae tunnel down inside the stem to its base, where a gall develops. Breeding continues throughout the year but is at its height in late summer. At this time the life cycle is 44 to 50 days. Pupation occurs within the gall. Larvae and pupae are parasitised by larvae of the pteromalid wasp *Oxysychnus* sp. (Agarwal 1985).

Evans (1987) records five fungi from *A. spinosus* but, except for one which is unsuitable because it has a wide host range, too little is known about their host specificity to assess the prospects for their use in classical biological control.

Comment

Almost nothing is known about the natural enemies of *A. spinosus* in tropical America where it evolved. A survey in this region would be necessary to document the organisms attacking it. There are good general grounds for believing that there are some natural enemies that are specific to the family Amaranthaceae. In most countries, members of this family have little value as crop plants, so the chances are that some safe natural enemies will be found that are of value as classical biological control agents.

Table 4.2.1 Natural enemies of *Amaranthus spinosus*: insects and mites.

Species	Location	Other hosts	References
INSECTS			
Hemiptera			
APHIDIDAE			
<i>Myzus persicae</i>	Malawi, Thailand	highly polyphagous	Chapola 1980, Napompeth 1982
COREIDAE			
<i>Cletus fuscescens</i>	Nigeria	<i>Amaranthus dubius</i> , <i>A. cruentus</i> , <i>A. hypochondriachus</i>	Ukwela & Ewete 1989
LYGAEIDAE			
<i>Germalus unipunctatus</i>	Vanuatu		Cock 1984b
<i>Nysius</i> sp.	Vanuatu		Cock 1984b

(continued on next page)

Table 4.2.1 continued

Species	Location	Other hosts	References
MIRIDAE			
<i>Horcias nobilellus</i>	Brazil	polyphagous	d'Araujo e Silva et al. 1968a
PIESMATIDAE			
<i>Piesma cinereum</i>	Brazil	polyphagous	d'Araujo e Silva et al. 1968a
Thysanoptera			
PHLAEOTHRIPIIDAE			
<i>Haplothrips longisetosus</i>	India	<i>Amaranthus viridis</i> , <i>A. oleosa</i> , <i>Chenopodium anthelminthicum</i>	Dhiman 1986
Coleoptera			
CHRYSOMELIDAE			
<i>Cassida exilis</i>	Pakistan	<i>Amaranthus viridis</i> , <i>Chenopodium album</i>	Baloch et al. 1976
<i>Cassida nigriventris</i>	Pakistan	<i>Amaranthus viridis</i> , <i>Chenopodium album</i> , <i>Spinacia oleracea</i>	Baloch et al. 1976 Khan et al. 1978
CURCULIONIDAE			
<i>Ceutorhynchus asperulus</i>	India	red gram, <i>Amaranthus viridis</i> , <i>A. tricolor</i> , <i>Basella alba</i>	Puttaswamy & Channabasavanna 1981, Puttaswamy et al. 1981
<i>Hypolixus trunculatus</i>	Pakistan, India, Thailand	<i>Amaranthus viridis</i> , <i>Chromolaena odorata</i> , <i>Digera arvensis</i>	Agarwal 1985, Baloch et al. 1976, 1977, Ghani 1965, Julien 1992 Napompeth 1982, 1990b, 1992a
MELYRIDAE			
<i>Astylus lineatus</i>	Brazil	citrus	d'Araujo e Silva et al. 1968a
Diptera			
AGROMYZIDAE			
<i>Haplopeodes minutus</i>	USA	<i>Amaranthus</i> , <i>Chenopodium</i>	Spencer & Steyskal 1986
Lepidoptera			
COLEOPHORIDAE			
<i>Coleophora versurella</i>	Pakistan	<i>Chenopodium botrys</i>	Khan et al. 1978
CURCULIONIDAE			
<i>Hypolixus ritsemæ</i>	Vanuatu		Cock 1984b
LYCAENIDAE			
<i>Zizeeria knysna</i>	Pakistan		Baloch et al. 1976
<i>Zizeeria krupta</i>	Pakistan		Baloch et al. 1977, Ghani 1965
NOCTUIDAE			
<i>Neogalea</i> (= <i>Spodoptera</i>) <i>sunia</i>	Nicaragua	polyphagous	Savoie 1988
<i>Spodoptera eridania</i>	Nicaragua	polyphagous	Savoie 1988
<i>Spodoptera exigua</i>	Nicaragua	polyphagous	Savoie 1988
<i>Spodoptera litura</i>	Philippines	highly polyphagous	Moody et al. 1987

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Species	Location	Other hosts	References
PYRALIDAE			
<i>Loxostege</i> sp.	Argentina	seed heads of <i>Amaranthus</i> sp. (the genus <i>Loxostege</i> contains pests)	C.J. Deloach pers. comm.1980
<i>Spoladea</i> (=Hymenia) <i>recurvalis</i>	India, Pakistan Vanuatu	polyphagous	Baloch et al. 1976 Chaudhury & Kapil 1977, Lock 1984b, Ghani 1965
SCYTHRIDIDAE			
<i>Eremocera</i> <i>impactella</i>	Pakistan	<i>Amaranthus viridis</i> , <i>Chenopodium album</i>	Baloch et al. 1977
TORTRICIDAE			
<i>Archips</i> sp.	Pakistan		Ghani 1965
YPONOMEUTIDAE			
<i>Plutella xylostella</i>	Pakistan		Ghani 1965
MITE			
TETRANYCHIDAE			
<i>Tetranychus</i> <i>novocaledonicus</i>	India	<i>Amaranthus tricolor</i> , <i>A. viridis</i>	Puttaswamy & Channabasavanna 1981

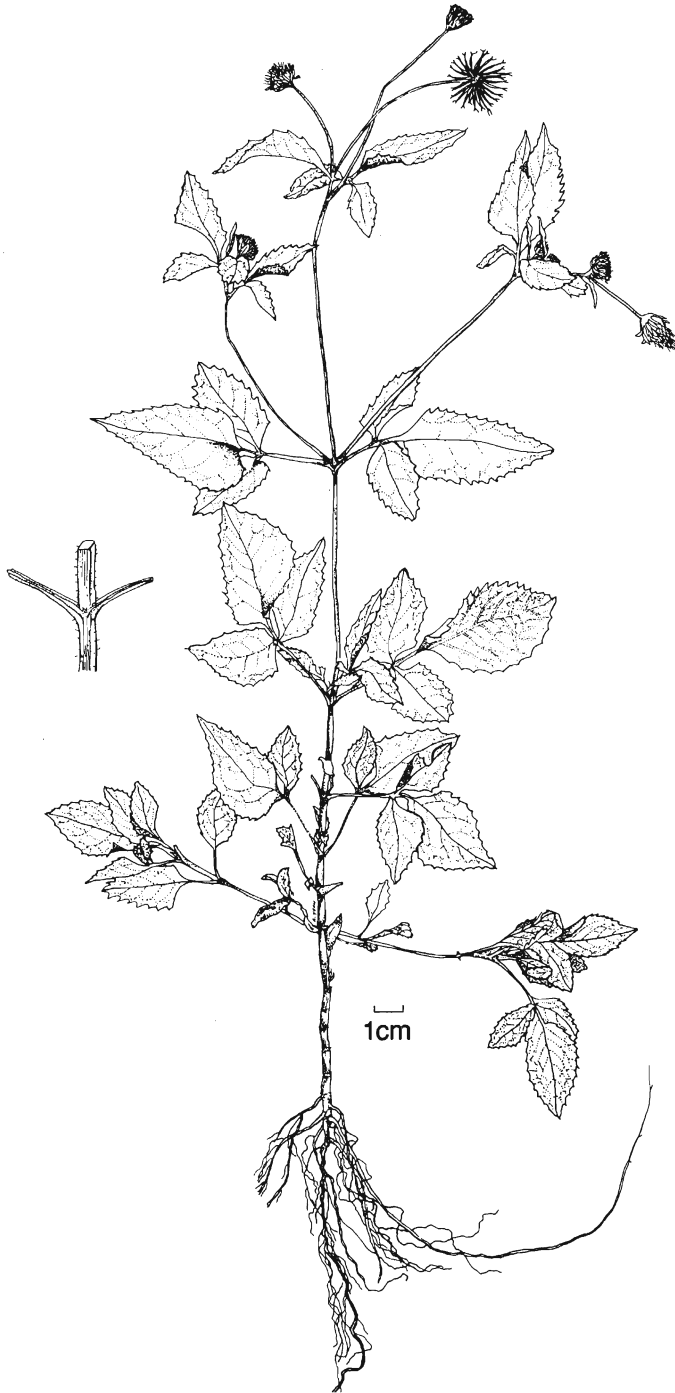
Table 4.2.2 Natural enemies of *Amaranthus spinosus*: nematodes, fungi, viruses.

Species	Location	Other hosts	References
NEMATODES			
<i>Cactodera amaranthi</i>	Cuba	spinach, other species of <i>Amaranthus</i>	Stoyanov 1972
<i>Meloidogyne incognita</i>	Philippines		Valdez 1968
<i>Pratylenchus zeae</i>		rice, many weeds	Fortuner 1976
<i>Pseudocephalobus indicus</i>	India	only recorded on <i>A. spinosus</i>	Joshi 1972
<i>Rotylenchulus reniformis</i>	India, USA	many weed hosts	Inserra et al. 1989, Lal et al. 1978
FUNGI			
<i>Albugo blitii</i>	Dominica, Jamaica, India, Pakistan, Sudan	many Amaranthaceae	Baloch et al. 1977, Evans 1987
<i>Alternaria compacta</i>	India		Kar & Ashok-Das 1988
<i>Aposphaeria amaranthi</i>	USA	potential bioherbicide for <i>A. albus</i> ; effect on <i>A. spinosus</i> not known	Mintz & Weidemann 1992
<i>Bipolaris indica</i> (as <i>Drechslera indica</i>)		many, including <i>Helianthus</i> , <i>Pennisetum</i> , <i>Portulaca</i>	Evans 1987, Kenfield et al. 1989

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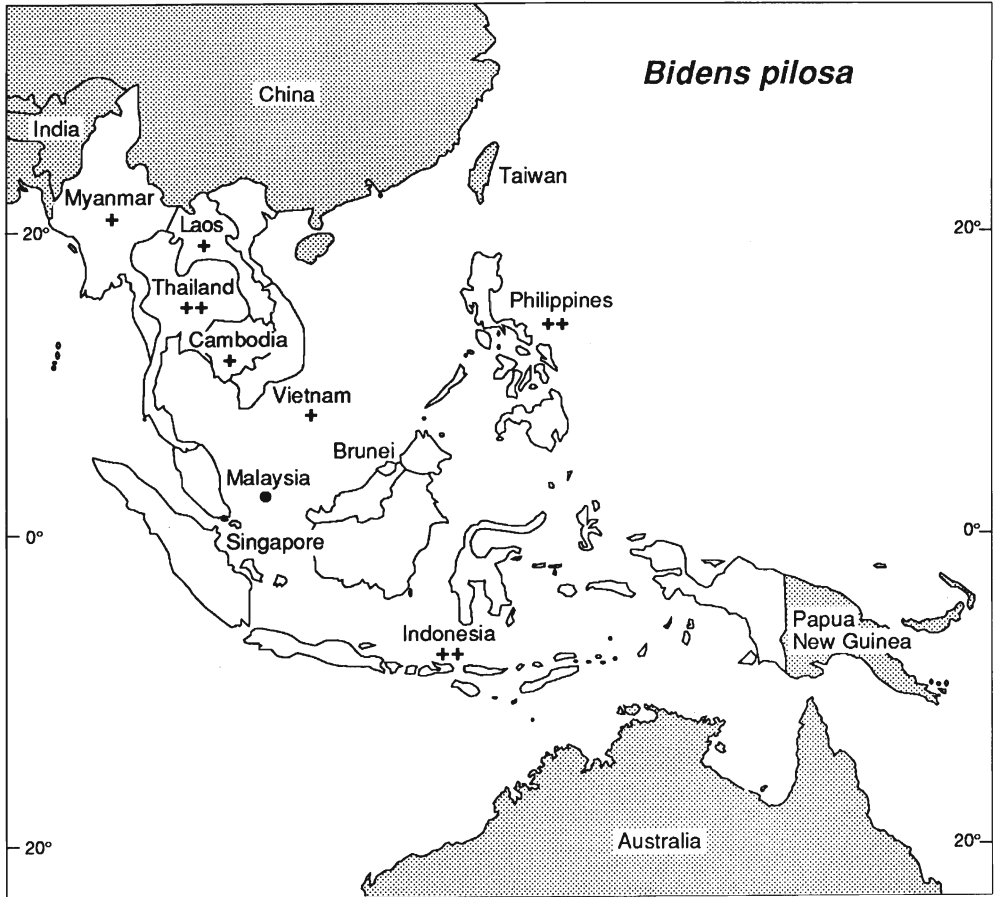
Table 4.2.2 continued

Species	Location	Other hosts	References
<i>Cercospora brachiata</i> (= <i>C. amaranthi</i>)	India, Nigeria, Uganda, Trinidad, USA, Japan, China, USSR	many Amaranthaceae	Evans 1987
<i>Fusarium oxysporum</i> f.sp. <i>elaeidis</i>	Nigeria	oil palm, <i>Chromolaena</i> <i>odorata</i> , <i>Imperata</i> <i>cylindrica</i> , <i>Mariscus</i> <i>alternifolius</i>	Oritsejafor 1986
<i>Phoma tropica</i>	India		Evans 1987
<i>Puccinia</i> sp.	Hong Kong		Evans 1987
VIRUSES			
cucumber mosaic	India	cucumber, <i>Solanum</i> , <i>nigrum</i> , <i>Tagetes</i> <i>erecta</i> , etc	Suteri et al. 1980
<i>Digera</i> mosaic	India	several weeds	Singh et al. 1975
groundnut rosette			Adams 1967
tobacco bunchy top	Malawi	(<i>Myzus persicae</i> is a vector)	Chapola 1980
tobacco mosaic	Philippines		Eugenio & del Rosario 1962



Bidens pilosa

(after Holm *et al.* 1977)



Map 4.3 *Bidens pilosa*

Bidens pilosa is native to tropical America. Preliminary studies, based mainly on Trinidad, indicate that it is attacked by a number of natural enemies, mainly insects, and that several of these may be sufficiently host specific to be considered as biological control agents. Further host specificity studies are required and additional, wider-ranging searches, particularly in South America.

4.3 *Bidens pilosa* L.

Asteraceae

cobbler's pegs, Spanish needle; djaringan ketul (Indonesia), pisau pisau (Philippines) yah koen jam khao (Thailand)

Rating

	++	Thai, Indo, Phil
10	+	Myan, Laos, Camb, Viet
	•	Msia

Origin

Tropical America

Distribution

Pantropical. Known from Java before 1835, but apparently not present in Kalimantan or the Moluccas (Soerjani et al. 1987).

Characteristics

Bidens pilosa is an erect, slender, branching, annual herb growing up to 1.5 m. Its stems are four-angled in cross section and its leaves opposite and sparsely hairy. The abundant yellow flowers are borne in heads on long stalks and produce black, barbed seeds characteristically radiating in all directions from a common base. The recurved, 2-toothed barbs enable the seeds to stick readily to hair and clothing and they are also distributed by wind and water. Cobbler's pegs prefers moister soils and flowers all year round.

Importance

A very common weed of 31 crops in more than 40 countries, *B. pilosa* occurs in gardens, cultivated land, open waste places and along roadsides. It is an important weed of pastures, maize, sorghum, vegetables, cotton, tea, coffee, cassava, coconut, oil palm, citrus, papaya, rice, rubber and tobacco. Single plants produce up to 6000 seeds, many of which germinate readily, permitting three or four generations a year in some regions.

Some seeds remain viable in the soil for at least 5 years. When herbicides have eradicated perennial grasses this weed often becomes dominant.

In South Africa the early spring growth is sometimes eaten by humans, but has low nutritive value. It has a pungent essential oil that may taint milk.

Natural enemies

These are also dealt with in 'Biological Control: Pacific Prospects' (Waterhouse and Norris 1987) which did not assess *B. pilosa* a particularly promising target for biological control. However, more information has since become available (Table 4.3.1 and 4.3.2),

particularly concerning leaf miners and seed head feeders of the fly family Agromyzidae. This suggests that there may be good prospects for some of these natural enemies.

Few details are available of the natural enemies of *B. pilosa* in Brazil. The pupal stage of the chrysomelid beetle *Phaedon pertinax* (= *P. consimilis*) lasts 6 to 8 days and the pentatomid bug *Stiretrus erythrocephalus* passes through 4 instars in 30 days (Ribeiro 1953). Thrips killed 22.25% of *B. pilosa* plants (particularly seedlings) and Diptera infested 97.8% of flower heads. Parasitisation of these Diptera by wasps and flies, varied from 40.96% to 58.91% according to the size of the population (Esposito et al. 1985).

About half of the 2500 species of the family Agromyzidae have known hosts and almost all of this group are restricted in their feeding to a single family or genus. Only 16 of the species (0.6% of the total) are truly polyphagous, feeding on a number of unrelated families (Spencer 1990). Agromyzid flies are, therefore, worth serious consideration as classical biological control agents. In this context, plants of the genus *Bidens* appear to be particularly attractive to agromyzid flies for they support 19 species (Table 4.3.3).

In the tribe Coreopsidae (of the family Asteraceae) only two (*Bidens* and *Coreopsis*) of its 26 genera support Agromyzidae (Table 4.3.4). *Coreopsis* is native in North America, but no agromyzids are known on it there, although three polyphagous species are known to attack it in Europe, India or Australia (Spencer 1990).

Eleven of the above 19 species are known from *Bidens pilosa* (Table 4.3.1). Of these, three are restricted to the genus *Bidens* (perhaps even to *B. pilosa*), two are polyphagous, and the remaining six have one or more additional hosts in other genera of the Asteraceae. Ten of the eleven species are restricted to the Americas and further host specificity tests may well indicate that many are valuable biological control agents. Four of the ten form blotch mines (*Amauromyza maculosa*, *Calycomyza allecta*, *C. platyptera* and *Liriomyza archboldi*), one makes long, linear irregular mines (*Liriomyza venegasiae*), and three feed in the seed heads (*Liriomyza insignis*, *Melanagromyza bidentis* and *M. floris*) (Spencer 1990, Spencer and Steyskal 1986).

The flower heads of *B. pilosa* are also attacked by three species of Tephritidae in Central America and by one of these in India. Adult weevils of the genera *Baris*, *Centrinaspis* and *Promecops* feed in the flowers of *B. pilosa* and other Asteraceae, but are thought not to breed there. Several other insects (at least three other beetles and a pierid butterfly) have also been recorded from *B. pilosa* and sometimes from other Asteraceae as well.

Table 4.3.4 shows the position of the genus *Bidens* as a member of the tribe Coreopsidae, within the family Asteraceae. There may well be natural enemies that attack it, but not any species of agricultural or special environmental significance.

Attempts at biological control

There have been none.

Table 4.3.1 Natural enemies of *Bidens pilosa*: insects.

Species	Location	Other hosts	References
Hemiptera			
ALEYRODIDAE			
<i>Dialeurodes vulgaris</i>	India	coffee, <i>Erythrina lithosperma</i>	Venkataramaiah 1974
APHIDIDAE			
<i>Aphis coreopsidis</i>	Brazil	soybean	Almeida 1979, d'Araujo e Silva et al. 1968a
<i>Aphis illinoisensis</i>	Brazil		d'Araujo e Silva et al. 1968a
<i>Uroleucon</i> (= <i>Dactynotus</i>) sp.	Brazil, USA	tobacco, lettuce	Christie et al. 1974, d'Araujo e Silva et al. 1968a
MIRIDAE			
<i>Garcanus gracilentus</i>	Brazil	sweet potato, polyphagous	d'Araujo e Silva et al. 1968a
<i>Horcias nobilellus</i>	Brazil	polyphagous <i>Amaranthus spinosus</i>	d'Araujo e Silva et al. 1968a
PENTATOMIDAE			
<i>Stiretrus erythrocephalus</i>	Brazil		Ribeiro 1953
<i>Thyanta perditor</i>	Brazil	soybean	Grazia et al. 1982
Coleoptera			
APIONIDAE			
<i>Apion luteirostre</i>	South America	<i>Mikania micrantha</i>	Cock 1980
CHRYSOMELIDAE			
<i>Chalcophana viridipennis</i>	Brazil		d'Araujo e Silva et al. 1968a
<i>Chlamisus insularis</i>	Trinidad	<i>Chromolaena odorata</i> , <i>C. ivaefolia</i>	McFadyen 1988a
<i>Phaedon pertinax</i> (= <i>P. consimilis</i>)	Brazil, (not in Trinidad)	<i>Mikania micrantha</i>	Cock 1980, d'Araujo e Silva et al. 1968a, Ribeiro 1953
<i>Physimerus pygmaeus</i>	South America	<i>Mikania micrantha</i>	Cock 1980
CURCULIONIDAE			
<i>Baris</i> sp.	Trinidad	(feed in <i>B. pilosa</i> flowers)	Cruttwell 1971a
<i>Centrinaspis</i> sp.	Trinidad	(feed in <i>B. pilosa</i> flowers)	Cruttwell 1971a
<i>Promecops</i> sp.	Trinidad	(feed in <i>B. pilosa</i> flowers)	Cruttwell 1971a
<i>Rhodoabaenus cariniventris</i>	Trinidad	adults feed on stems, and petioles of <i>B. pilosa</i> , <i>Chromolaena odorata</i> , <i>C. ivaefolia</i> , <i>Austro eupatorium inulaefolium</i>	McFadyen 1988a
<i>Rhodoabaenus tredecimpunctatus</i>	Trinidad	feed in <i>B. pilosa</i> stems: and in several other Asteraceae	McFadyen 1988a
Diptera			
AGROMYZIDAE			
<i>Amauromyza maculosa</i>	Trinidad (also N&S America, Hawaii)	polyphagous, but favours Asteraceae	Cruttwell 1971a, Spencer 1990, Spencer & Steyskal 1986

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Species	Location	Other hosts	References
<i>Calycomyza allecta</i>	Trinidad (also Brazil, Guadeloupe, Venezuela)	<i>Helianthus</i> , <i>Rudbeckia</i> and garden Asteraceae	Cruttwell 1971b, Frick 1956, Spencer 1990, Spencer & Steyskal 1986
<i>Calycomyza platyptera</i>	USA (Florida, California)	Asteraceae, including <i>Aster</i> , <i>Helianthus</i> , <i>Zinnia</i>	Spencer 1990 Spencer & Steyskal 1986
<i>Liriomyza archboldi</i>	Florida (Bahamas, Costa Rica)	restricted to <i>Bidens</i>	Spencer 1990, Spencer & Steyskal 1986
<i>Liriomyza insignis</i> <i>Liriomyza trifolii</i>	Costa Rica cosmopolitan	restricted to <i>Bidens</i> polyphagous, including <i>Chrysanthemum</i>	Spencer 1990
<i>Liriomyza venegasiae</i>	Southern California	<i>Venegasia carpesioides</i>	Spencer 1990, Spencer & Steyskal 1986
<i>Liriomyza</i> sp. <i>Melanagromyza bidentis</i>	Argentina Florida, Caribbean	restricted to <i>Bidens</i> <i>Verbesina</i> sp.	Spencer 1990 Spencer 1990
<i>Melanagromyza floris</i>	Costa Rica, Mexico, Trinidad (also Florida, Neotropics)	<i>Calendula</i> sp	Cruttwell 1971a, Spencer 1990, Spencer & Steyskal 1986
<i>Melanagromyza splendida</i>	USA, Hawaii	Asteraceae including <i>Helianthus</i> , <i>Lactuca</i> polyphagous, including <i>Cineraria</i>	Spencer 1990, Spencer & Steyskal 1986 Kleinschmidt 1970
<i>Phytomyza atricornis</i>	Australia		
CECIDOMYIIDAE			
<i>Asphondylia bidens</i>	Florida		Steyskal 1972
DROSOPHILIDAE			
<i>Cladochaeta nebulosa</i>	Florida		Steyskal 1972
TEPHRITIDAE			
<i>Dioxyna sororcula</i> (= <i>D. picciola</i>)	Florida, Trinidad, widespread	attacks several Asteraceae in India	Cruttwell 1971a, 1972a,b, Steyskal 1972
<i>Xanthaciura insecta</i>	Florida, Trinidad	<i>Ageratum conyzoides</i> , <i>Chromolaena odorata</i> <i>Fleischmannia caracasana</i>	McFadyen 1988a, Steyskal 1972
Lepidoptera			
ARCTIIDAE			
<i>Hypercompe</i> (= <i>Ecpantheria</i>) <i>hambletoni</i>	Brazil		d'Araujo e Silva et al. 1968a
NOCTUIDAE			
<i>Cropia</i> (= <i>Dyops</i>) <i>minthe</i> <i>Mocis latipes</i>	Brazil Brazil		d'Araujo e Silva et al. 1968a Lourencao et al. 1982
<i>Thysanoplusia</i> (= <i>Diachrysia</i>) <i>orichalcea</i>	Kenya	<i>Panicum maximum</i> , <i>Paspalum notatum</i> , <i>Hyparrhenia rufa</i> coffee and other crops	Bardner & Mathenge 1974
PIERIDAE			
<i>Perrhybris phaloe</i> (= <i>Ascia buniae phaloe</i>)	Trinidad		Cruttwell 1971a

Table 4.3.2 Natural enemies of *Bidens pilosa*: nematodes, fungi, mycoplasmas, viruses.

Species	Location	References
NEMATODES		
<i>Meloidogyne</i> sp.	Hawaii	Linford et al. 1949
<i>Meloidogyne hapla</i>	India	Singh et al. 1979
<i>Pratylenchus minutus</i>	Hawaii	Linford et al. 1949
<i>Rotylenchulus reniformis</i>	USA	Inserra et al. 1989, McSorley et al. 1981
FUNGI		
<i>Cercospora bidentis</i>	Mauritius	Rochecouste & Vaughan 1959
<i>Cercospora megalopotamica</i>	Hawaii	Stevens 1925
<i>Entyloma guaraniticum</i>	Mauritius	Rochecouste & Vaughan 1959
<i>Uromyces bidenticola</i>	Hawaii, Mauritius	Anon 1960, Rochecouste & Vaughan 1959
MYCOPLASMAS		
aster yellows	Hawaii	Holm et al. 1977
<i>Bidens</i> witches broom	Brazil	Vega et al. 1981
VIRUSES		
<i>Bidens</i> mosaic	Brazil	Kuhn et al. 1982
groundnut rosette	Hawaii	Adams 1967
<i>Sonchus</i> yellow net	Florida	Christie et al. 1974
soybean mosaic	Brazil	Almeida 1979
tomato spotted wilt	Hawaii	Sakimura 1937
PARASITIC PLANT		
<i>Cassytha filiformis</i>	Hawaii	Raabe 1965

Table 4.3.3 Species in Agromyzid genera attacking *Bidens*.

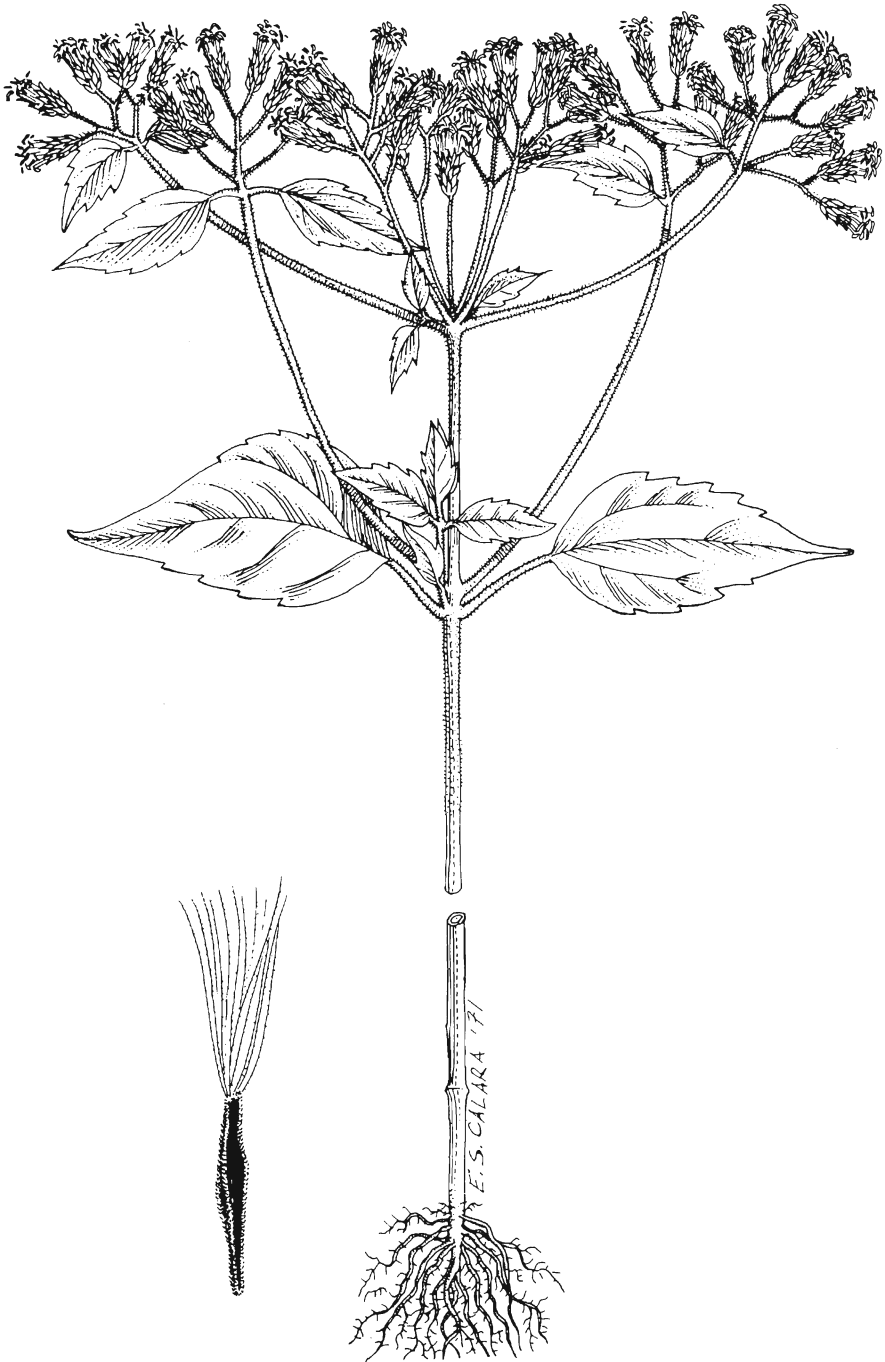
Genus	Specific to <i>Bidens</i>	Specific to Coreopsidae	Polyphagous
<i>Melanagromyza</i>		7	
<i>Amauromyza</i>		1	
<i>Liriomyza</i>	3	3	1
<i>Calycomyza</i>		3	
<i>Chromatomyia</i>			1
Total	3	14	2

Table 4.3.4 Relationship of four major Southeast Asian weeds and some economically important genera within the family Asteraceae.

Family Asteraceae: 21 000 species (Mabberley 1987)

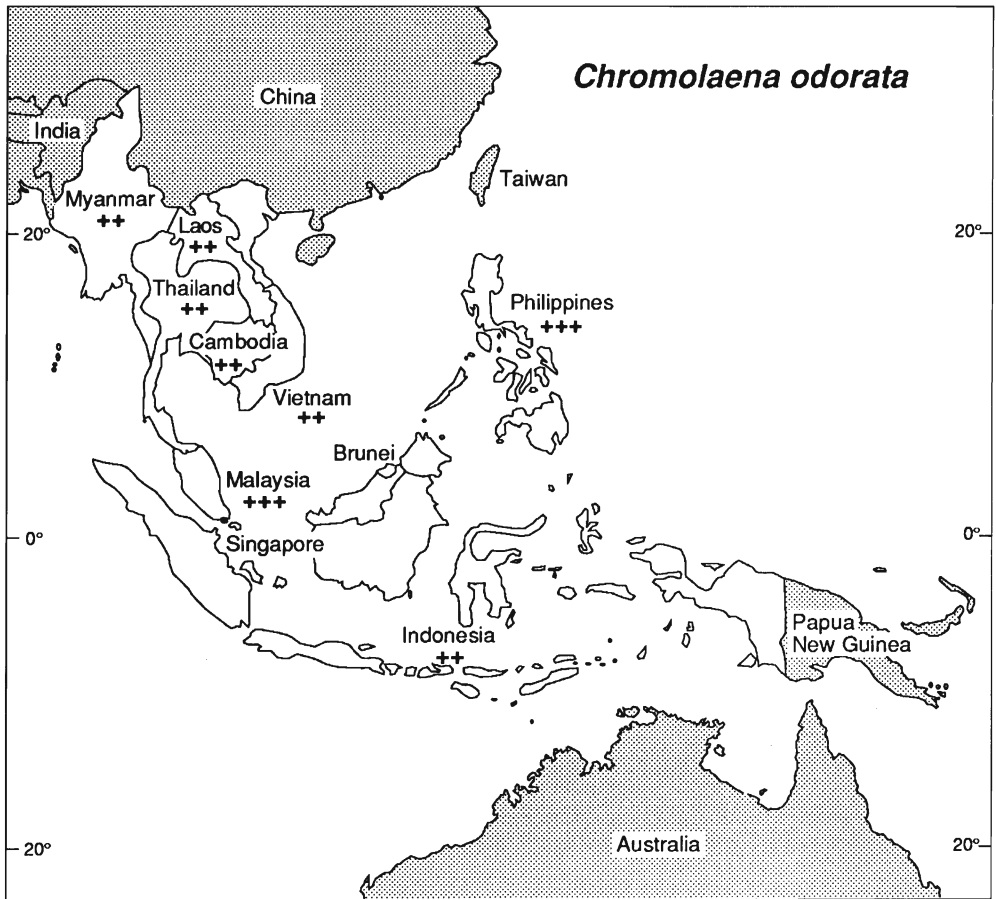
Tribe	Some economically important genera	Weed species
Arctoteae		
Carlineae		
Echinopsidae		
Cardueae	<i>Carthamnus, Cynara</i>	
Mutisieae		
Lactuceae	<i>Cichorium, Lactuca</i>	
Vernonieae		
Inuleae		
Astereae	<i>Aster</i>	
Eupatorieae		<i>Ageratum conyzoides, Chromolaena odorata, Mikania micrantha</i>
Calenduleae		
Senecioneae	<i>Cineraria</i>	
Anthemideae	<i>Chrysanthemum</i>	
Heleniae	<i>Dahlia</i>	
Madieae		
Heliantheae	<i>Cosmos, Helianthus, Zinnia</i>	
Tageteae		
Coreopsideae	<i>Coreopsis</i>	<i>Bidens pilosa</i>

The family Asteraceae, by far the largest in the dicotyledons, has been subdivided into 18 tribes, some 1300 genera and about 21 000 species (Mabberley 1987). It contains surprisingly few economically important crop plants, of which lettuce (*Lactuca sativa*), sunflower (*Helianthus annuus*) and globe artichoke (*Cynara scolymus*) are the major species. However, there are a number of commercially important garden plants, especially in the genus *Chrysanthemum*.



Chromolaena odorata

(after Holm *et al.* 1977)



Map 4.4 *Chromolaena odorata*

Chromolaena odorata is not a problem weed in the tropical Americas where it evolved. It is attacked there by more than 200 insects, at least a quarter of which are probably sufficiently host specific to be considered as classical biological control agents. The aggressiveness of *C. odorata* in countries to which it has spread is probably due to the absence of most of these natural enemies.

The arctiid moth *Pareuchaetes pseudoinsulata* has been established in India, Sri Lanka, Philippines, Sabah (Malaysia), the Mariana Is (Guam, Rota, Saipan, Tinian, Aguijan) and Federated States of Micronesia (Yap, Pohnpei, Kosrae), but only in the two latter island groups has it had spectacular success in controlling the weed. The mite *Acalitus adoratus* has spread naturally to Southeast Asia and Micronesia but, as yet, is having minor impact.

It is probable that a group of natural enemies will be necessary to bring about effective biological control of *C. odorata* in Southeast Asia, but there are a number of species that are well worthy of attention and longer term prospects for control appear promising.

4.4 *Chromolaena odorata* (L.) R.M. King and H. Robinson (Formerly *Eupatorium odoratum*)

Asteraceae

Siam weed, devil weed; bizat, tawbizat (Myanmar), tontrem khet (Cambodia), French weed (Laos), pokok tjerman (Malaysia), kirinyu, kumpai jepang, rumput gol kar (Indonesia), hagonoy (Philippines) saab sua, yah sua mop (Thailand), cò hoi (Vietnam)

Rating

	+++	Msia, Phil
18	++	Myan, Thai, Laos, Camb, Viet, Indo

Origin

Central America and tropical South America (from Florida to northern Argentina).

Distribution

C. odorata is a weed throughout Southeast Asia, Irian Jaya, Papua New Guinea, New Britain, Mariana and Caroline Is, southern China, Taiwan, Sri Lanka, Bangladesh, India, West, Central and South Africa.

Characteristics

C. odorata is an upright or scrambling, thicket-forming, perennial shrub, growing from 1.5 to 3 m high. Its roots are fibrous with a few well formed anchor roots and many laterals, the stems round, yellowish, hairy or almost smooth and profusely branched. Its leaves are opposite, with toothed margins and are conspicuously three veined. The flowers are at the tips of all stems, in clusters of 20 to 60, white or pale lilac. The achenes consist of 5 mm-long seeds with hooks on their angles, together with a pappus of 5 mm-long white bristles. The leaves have a pungent odour when damaged. Seed production is prolific (as many as 2 million per plant) and seeds provide the main mode of reproduction. The achenes float long distances in the air and the seed hooks cling to hair and clothing. Germination occurs as soon as there is adequate moisture, although some 66% of seeds are not viable. Buried seeds lose up to 50% of their viability after 2 years (Yadav and Tripathi 1982).

Importance

C. odorata is not a serious weed in the Americas and no specific control methods are necessary (McFadyen 1991a). This is in stark contrast to its serious weed status in the countries to which it has spread and has been attributed to the many natural enemies that attack it in the Americas (McFadyen 1989, 1991c). It was introduced to Calcutta in the 1840s, had spread into Sri Lanka, Southeast Asia and Nigeria by the 1940s and into Irian Jaya, New Britain and Micronesia by the 1980s. It is forecast to spread widely and

aggressively in equatorial Africa, northern and eastern Australia and the Pacific (McFadyen 1988b, 1989).

C. odorata grows in many soil types, but prefers well drained conditions and an annual rainfall above 1000 mm. Although it is not a problem in continuously cultivated land, it is most common and causes most losses in plantation crops, including coconut, rubber, oil palm, tea, coffee, cocoa, teak and cashew. It also thrives in areas newly cleared for planting, in abandoned or neglected fields, wastelands and along roadsides. It is sometimes a weed in pastures. Its rapid growth enables it to smother most competitors and it inhibits many with its allelopathic properties. It dies back after flowering in areas with a pronounced dry season and then becomes a fire hazard. After burning or cutting, the plants shoot freely from the crown. They are capable of forming dense tangled bushes two to three metres high, occasionally reaching six metres as climbers on other plants. The stems branch freely, with 20 or more laterals developing from axillary buds and often bent over under their own weight. Impenetrable stands of the weed cut off access to pastures and provide hiding places for rats, pigs and other undesirable animals. *C. odorata* is intolerant of shade, so that it dies out when the canopy closes in plantations (Ambika and Jayachandra 1990, McFadyen 1988b, 1991a). The shoots and young leaves contain nitrate at levels 5 to 6 times those toxic to stock and also pyrrolizidine alkaloids and cattle deaths occur following grazing. Hand weeding of *Chromolaena* is reported to cause skin allergy and scratches to result in infections (Ambika and Jayachandra 1990).

It is interesting that the spread of *C. odorata* in West Africa has led to a polyphagous grasshopper *Zonocerus variegatus* becoming a pest. Although they are unable to mature on the weed as the only diet, hoppers are strongly attracted to the plant and especially to its flowers; and thickets are preferred night roosting sites. Boppré (1991) hypothesises that the pyrrolizidine alkaloids accumulated from feeding on *C. odorata* protect the grasshoppers and their eggs from predators and parasitoids, leading to increased fitness and population density. However, this only occurs during the dry season, but not in the wet season when *C. odorata* does not bloom.

Claims have been made (e.g. Field 1991, Herren-Gemmill 1991) that, under some circumstances, *C. odorata* may be beneficial to resource-poor farmers. One potential advantage, is its ability to outcompete another serious weed, alang-alang (*Imperata cylindrica*). However, McFadyen (1992) pointed out that a suitable perennial legume would be even more beneficial than *C. odorata*, and she also refuted a number of other claims. In Sri Lanka the indigenous legume *Tephrosia purpurea* has been successfully used to suppress weeds including *C. odorata* under coconut (Salgado 1972). Whatever potential benefits there may be in the presence of *C. odorata* there is an enormous body of fact to demonstrate that *C. odorata* has serious adverse effects on agricultural productivity in countries to which it has been introduced.

Natural enemies

A good deal is known about the insects attacking *Chromolaena odorata*, mainly as a result of studies aimed at biological control which started in the late sixties at the Commonwealth Institute of Biological Control Station in Trinidad. A number of scientists

were involved, but principally R.E. McFadyen (née Cruttwell) (Bennett and Cruttwell 1973, Bennett and Rao 1968, Bennett and Yaseen 1975, Cock 1984a, Cock and Holloway 1982, Cruttwell 1973a,b, 1974, 1977a,b, Cruttwell and Bennett 1969, McFadyen 1988a,b, 1991a,b, Yaseen and Bennett 1977).

An extensive bibliography dealing with all aspects of *C. odorata*, including its natural enemies and biological control, was compiled by Muniappan et al. (1988a), later supplemented in *Chromolaena odorata* Newsletters 3 (1990) and 6 (1992). The proceedings of three International Workshops on Biological Control of *Chromolaena odorata*, held in 1988, 1991 and 1993 also contain a wealth of up-to-date information.

In the Americas *C. odorata* is attacked by at least 207 insect and 2 mite species (McFadyen 1988a). Of these, about half are probably polyphagous, a quarter are restricted to the Asteraceae and a quarter specific to *Chromolaena*. All stages of growth of the above ground parts of the plants are attacked, but the roots have not been examined (McFadyen 1991a) and not all regions where *C. odorata* occurs naturally were visited. For other regions of the world McFadyen (1988a) quotes records of 42 insect and 9 mite species, the vast majority of which are, or are likely to prove, polyphagous. Since then a few additional species have been recorded, all but one of which (an eriophyid mite, see India below) are likely to be polyphagous.

In Trinidad, the cumulative effect of the natural enemies is great, between 25 and 50% of all growing tips being destroyed. Seed germination is as low as 17% and many flowerheads fail to produce seed. Seedlings often succumb to the attack of stem and tip feeding insects and competitiveness and growth of established plants is greatly reduced by insect attack. At different sites and in different seasons damage is caused by different insects and, in general, is heaviest in shaded sites. Some of the insects are heavily attacked by parasitoids and if introduced without these to another country might prove to be even more effective.

In addition to an arctiid moth (*Pareuchaetes pseudoinsulata*) and a weevil (*Apion brunneonigrum*), which have already had considerable attention paid to them (see next section), McFadyen (1991c) has nominated an additional 11 insects for priority evaluation (Table 4.4.1). Furthermore, others (Cruttwell 1974, Cock 1984a, Cock and Holloway 1982, McFadyen 1988c, Muniappan and Viraktamath 1986) have suggested an additional 22 species (Table 4.4.2) which were evidently considered less important by McFadyen (1991c). It is clear therefore that, if required, there are many promising candidates for detailed consideration. The additional species of *Pareuchaetes* suggested by Cock and Holloway (1982) have not been investigated in detail, but all are believed to breed on *C. odorata* or related species and several may be better adapted climatically and biologically than *P. pseudoinsulata* to conditions in many overseas countries.

Although no special search has been carried out except in Trinidad and Tobago a number of fungal pathogens occurring on *C. odorata* are shown in table 4.4.3. Half of the records come from outside its area of origin and must, therefore, be suspected of having a wider than desirable host range. Possibly *Cionothrix praelonga* is of greatest interest, since preliminary tests indicate that it may be host specific (Ooi et al. 1991). It is autoecious (i.e. it does not have an alternate host), occurs in the Caribbean and Venezuela and

Table 4.4.1 Potential biological control agents for *C. odorata*: insects (after McFadyen 1991c).

Species	Part attacked	Damage	Problem	Country found
Coleoptera				
CHRYSOMELIDAE				
<i>Aulacochlamys</i> sp.	stem	moderate		Trinidad
<i>Chlamisus insularis</i>	stem	minor		all Americas
<i>Pentispa explanata</i>	leaf miner	moderate	prefers shade	Trinidad
CURCULIONIDAE				
<i>Rhodoabaenus cariniventris</i>	stem	great		Trinidad
Diptera				
AGROMYZIDAE				
<i>Melanagromyza eupatoriella</i>	shoot borer	great	cage mating	West Indies, S. America
CECIDOMYIIDAE				
<i>Clinodiplois</i> sp.	shoot galls	great	rearing	Trinidad
<i>Perasphondylia reticulata</i>	bud galls	great	cage rearing	all Americas
TEPHRITIDAE				
<i>Procecidochares</i> sp.	stem galls	moderate	parasites	Americas
Lepidoptera				
BUCCULATRICIDAE				
<i>Bucculatrix</i> sp.	leaf miner	minor		Mexico
NYMPHALIDAE				
<i>Actinote anteas</i>	leaf	great	cage mating	Trinidad, Costa Rica
PYRALIDAE				
<i>Mescinia parvula</i>	shoot borer	great	cage mating	all Americas

causes conspicuous leaf lesions. *Pseudocercospora eupatorii-formosani* is reported to be common and damaging on *C. odorata* in Brunei, but is widespread already in South and Southeast Asia (Chacko 1988, Evans 1987, Peregrine and Ahmad 1982).

Attempts at biological control

Four insects have been released for biological control, the weevil *Apion brunneogrimum*, the fly *Melanagromyza eupatoriella* and two moths *Mescinia parvula* and *Pareuchaetes pseudoinsulata* (Table 4.4.4). Of these, only the last has become established, fairly readily in Sri Lanka, Guam and other Micronesian islands, but with some difficulty in India and Sabah (Malaysia) and it has since spread unaided to the Philippines and Brunei. It failed to become established in Thailand, Ghana, Nigeria and South Africa. It has produced spectacular defoliation and death of many plants in Guam

Table 4.4.2 Additional potential biological control agents for *C. odorata*: arthropods.

Species	Part attacked	Country found
Coleoptera		
CERAMBYCIDAE		
<i>Aerenica hirticornis</i>	stem borer	Trinidad, Bolivia, Brazil, Argentina
CURCULIONIDAE		
<i>Baris</i> sp.	flowers, leaf buds	Trinidad
<i>Centrinaspis</i> sp.	flowers, leaf buds	Trinidad, Costa Rica
Diptera		
CECIDOMYIIDAE		
<i>Asphondylia corbulae</i>	flower galls	El Salvador, Trinidad
<i>Clinodiplosis eupatorii</i>	leaf galls	Central America, Brazil, West Indies
<i>Clinodiplosis</i> sp.	bud galls	Trinidad
<i>Contarinia</i> sp.	flowers (achenes)	Trinidad
<i>Neolasioptera brickelliae</i>	flowers (achenes)	Trinidad
<i>Neolasioptera cruttwellae</i>	stem galls	Trinidad
<i>Neolasioptera eupatorii</i>	stem galls	USA, Trinidad, Bolivia
<i>Neolasioptera frugivora</i>	flowers (achenes)	Trinidad
TEPHRITIDAE		
<i>Cecidochoares fluminensis</i>	flowers	Trinidad, SE Brazil
<i>Procecidochoares connexa</i>	stem galls	Mexico, Brazil, Bolivia
Lepidoptera		
ARCTIIDAE		
<i>Pareuchaetes aurata aurata</i>	leaves, buds	Paraguay, Argentina, SE Brazil, Bolivia
<i>Pareuchaetes aurata aurantior</i>	leaves, buds	Amazon River
<i>Pareuchaetes arravaca</i>	leaves, buds	Surinam and French Guiana
<i>Pareuchaetes insulata</i>	leaves, buds	Southern USA, Mexico, Caribbean, Colombia
<i>Pareuchaetes misantlensis</i>	leaves, buds	Mexico
<i>Pareuchaetes</i> sp.	leaves, buds	Mexico
GELECHIIDAE		
<i>Dichomeris</i> (= <i>Trichotaphe</i>) sp.	leaf roller (see Cruttwell 1973b)	Trinidad
LYCAENIDAE		
<i>Calephelis laverna</i>	leaves	Brazil, Trinidad, Venezuela, Central America
Acarina		
ERIOPHYIDAE		
<i>Calacarus</i> sp.	shoots	India

Table 4.4.3 Natural enemies of *C. odorata*: fungi.

Species	Country found	References
<i>Anhellia niger</i>	Trinidad, Tobago	Ooi et al. 1991
<i>Cercospora</i> sp.	Peninsular Malaysia, Sabah	Singh 1980
<i>Cercospora eupatorii</i>	North America, Cuba, Nepal, India, Ivory Coast	Chacko 1988, Evans 1987
<i>Cercospora eupatoriicola</i>	India, Bangladesh	Chacko 1988, Evans 1987
<i>Cercospora eupatorii-odoratii</i>	Malaysia	Chacko 1988, Evans 1987
<i>Cionothrix praelonga</i>	Dominica, Tobago, Venezuela	Chacko 1988, Evans 1987
<i>Fusarium oxysporum</i> f. sp. <i>elaeidis</i>	Trinidad, Tobago	Oritsejafor 1986
<i>Guignardia eupatorii</i>	Sri Lanka	Chacko 1988, Evans 1987
<i>Mycovellosiella perfoliata</i>	Trinidad, Tobago	Ooi et al. 1991
<i>Phoma</i> sp.	Trinidad, Tobago	Ooi et al. 1991
<i>Phomopsis eupatoriicola</i>	not recorded	Chacko 1988, Evans 1987
<i>Phyllosticta eupatoriicola</i>	not recorded	Chacko 1988, Evans 1987
<i>Pseudocercospora eupatorii-formosani</i>	India, Myanmar, Thailand, Malaysia, Borneo, Brunei,	Chacko 1988, Evans 1987
<i>Septoria</i> sp.	Guam	Russo 1985
<i>Septoria ekmaniana</i>	Trinidad, Tobago	Ooi et al. 1991

and striking but sporadic defoliation in Sri Lanka. In India, populations have built up but damage has seldom been great. Where established, it is heavily attacked by a range of predators and these are believed to have prevented successful establishment in several countries.

The eriophyid mite *Acalitus adoratus* causes abnormal growth of the epidermal hairs on young leaves and stems of *C. odorata*. Although it was never purposely introduced, it was observed in Thailand in 1984 and the Philippines in 1987, but had probably been present for some years. It is also widespread in Java and Sumatra, but there is no information from other Indonesian islands. It is present in Yap and Palau in the Caroline Islands and was observed on Guam in November 1993 (R. Muniappan pers. comm.). It is not present in India and it is not known whether it is present in Sri Lanka (Cruttwell 1977b, McFadyen 1991b, 1993, Muniappan et al. 1988a).

Further details follow of the situation in individual countries and of the biology of some of the more promising natural enemies.

Asia

INDIA

In one study, 11 insects and 3 mites were found attacking *C. odorata*. All except *Calacarus* sp. (Eriophyidae) are polyphagous (Muniappan and Viraktamath 1986, Viraktamath and Muniappan 1992). Most eriophyid mites have a highly restricted host range, so it is not clear whether it may even have accompanied the weed from the

4.4.4 Introductions for the biological control of *Chromolaena odorata*.

Species	Country	Liberated	Result	References
Coleoptera				
BRENTHIDAE				
<i>Apion brunneonigrum</i>	Ghana	1975	–	Cock 1984a, 1985,
	Guam	1984	–	Nafus & Schreiner 1989
	India	1972–83	–	Chacko & Narasimham 1988, Cock 1984a, 1985
	Malaysia (Sabah)	1970	–	Ooi et al. 1988a,b
	Nigeria	1970–75	–	Cock 1984a, 1985
	Sri Lanka	1974–76	–	Cock 1984a, 1985
Lepidoptera				
ARCTIIDAE				
<i>Pareuchaetes aurata</i>	South Africa	1990	?	Julien 1992, Kluge & Caldwell 1993
	Pohnpei	1988–92	+	Esguerra et al. 1991, Esguerra et al. 1994 Muniappan et al. 1988b
<i>Pareuchaetes pseudoinsulata</i>	Ghana	1973	–	Cock 1985, Cock & Holloway 1982
		1989	?	Julien 1992
	Guam	1984	+	Nafus & Schreiner 1989, Seibert 1989
	India	1973	–	Chacko & Narasimham 1988, Cock & Holloway 1982
		1984	+	Chacko & Narasimham 1988, Julien 1992, Muniappan et al. 1989, Satheesan et al. 1987
	Indonesia	1991, 1993	?	McFadyen pers. comm.
	Kosrae	1992	+	Esguerra et al. 1994
	Malaysia (Sabah)	1970	+	Cock & Holloway 1982, Ooi et al. 1988a,b, Syed 1979a
	Northern Marianas	1986–87	+	Nafus & Schreiner 1989, Seibert 1989
	Nigeria	1973–78	–	Cock & Holloway 1982
	South Africa	1989	–	Julien 1992, Kluge 1991, Kluge & Caldwell 1991
	Sri Lanka	1973	+	Dharmadhikari et al. 1977
Thailand	1987	–	Napompeth et al. 1988	
Yap	1988–91	+	Marutani & Muniappan 1991a, Muniappan et al. 1988b	
PYRALIDAE				
<i>Mescinia parvula</i>	Guam	1984	–	Nafus & Schreiner 1989

Americas. In another study 21 polyphagous insects were recorded from *C. odorata*, of which the most widespread and numerous were *Aphis fabae* and *A. spiraecola* (Lyla and Joy 1992, Lyla et al. 1987). Some of these same species are included amongst the 31 insects and 9 mites recorded on *Chromolaena* by Chacko and Narasimham (1988).

Pareuchaetes pseudoinsulata from Trinidad was cleared of a nuclear polyhedral virus and mass reared. It was first released in 1973 at several sites in Karnataka, but no establishment occurred. Observations suggested that two ants, *Myrmicaria brunnea* and *Oecophylla smaragdina*, were major predators (Cock and Holloway 1972). *P. pseudoinsulata* from Sri Lanka (where it had been sent and had already become established) was next released and appeared to be doing well until unexpectedly wiped out by virus (Cock 1985). However, further material from Sri Lanka was laboratory reared and 36000 larvae and 1000 adults released from 1984 onwards, this time in Kerala. This procedure resulted in field establishment (Chacko and Narasimham 1988, Joy et al. 1993, Muniappan et al. 1989, Satheesan et al. 1987). Most recently, the establishment of *P. pseudoinsulata* at Sullia Taluk in Karnataka State and defoliation of *Chromolaena* thickets over about 1000 km² was reported in December 1992 (R. Muniappan pers. comm. 1993). However the overall performance of the moth has been unsatisfactory (Joy et al. 1993).

Small releases of the weevil *Apion brunneonigrum* have been made since 1972, but establishment has not resulted (Cock 1985, Ooi et al. 1991).

SRI LANKA

P. pseudoinsulata was received from India in 1973 and about 2000 larvae released in a coconut estate in the North Western Province. Six months after release spectacular defoliation was observed of a hectare of previously impenetrable growth of *C. odorata*. In addition to leaves, terminal buds and tender stems were being consumed. Further releases were made and two years later it was estimated that some 800 ha of *C. odorata* had been defoliated (Dharmadhikari et al. 1977). Since then sporadic, heavy defoliation has mainly occurred at the beginning of the dry season at the time of flowering. This has caused great damage and, at times, death of the weed. However *P. pseudoinsulata* populations fluctuate considerably, due in no small measure to natural enemies. Young larvae are taken by birds and predatory *Sycanus* bugs. They are also parasitised by the braconid *Apanteles creatonoti* and the tachinid *Exorista* sp. (Kanagaratnam 1976). In one series of experiments from 63 to 100% of pupae were consumed by ants, termites and lizards (Mahindapala et al. (1980). Perera (1981) fed *P. pseudoinsulata* larvae on *C. odorata* leaves dipped in 32P labelled sodium orthophosphate, transferred them to *C. odorata* in the field and collected predators from pitfall traps. Several carabids and a histerid showed no radioactivity, nor did the ants *Odontomachus simillimus* and *Diacamma rugosum* which were observed carrying away treated larvae to their nests, indicating that they do not feed on the larvae soon after capture. There was no unusual preponderance of predatory wasps, but birds were observed picking up larvae so it is likely that they were the cause of the sudden decline in larval population (P.A.C.R. Perera pers. comm. 1993).

How effective the moth is as a control agent is yet to be determined. However, Perera (1981) calculated that a *P. pseudoinsulata* larva from hatching to pupation consumes an average of 184.6 cm² of leaf. Based on measurements of a heavy growth of *C. odorata*, there are 22.42 × 10⁸ cm² of leaf area per ha requiring about 12 million larvae to produce defoliation. Assuming an average egg production of 200 per female moth and a 1:1 sex ratio, 12 million larvae could be produced in two generations (3 months) with a release of 600 to 700 females. Cock and Holloway (1982) have suggested that there is a better climate match between Sri Lanka and Trinidad than for most of the other countries where the moth has been released.

Apion brunneonigrum were released between 1974 and 1976 and, two months after release, were seen on flower heads but have not been recovered since (Cock 1985, Kanagaratnam 1976, Ooi et al. 1991).

Southeast Asia

BRUNEI

Although no releases of *P. pseudoinsulata* have been made, two females were trapped in the early 1980s, presumably having resulted from the colonies established in neighbouring Sabah (Malaysia) (Cock 1985).

INDONESIA

An aphid has been observed to attack young shoots and cause leaf curl of *C. odorata*. Work on biological control of the weed was initiated in 1991 with the introduction of *P. pseudoinsulata* to Sumatra, but there is no information on the outcome. There is a current project (1993) under R.E. McFadyen to study the host specificity of the tephritid fly *Procecidochares connexa* and either the moth *Mescinia parvula*, the stem boring *Melanagromyza eupatoriella* or the butterfly *Actinote antea*s with a view, if judged safe to do so, to liberation in Indonesia and the Philippines (R.E. McFadyen pers. comm., Tjitrosoedirdjo 1991, Tjitrosoedirdjo et al. 1991).

MALAYSIA (SABAH)

Aphis spiraecola attacks young shoots of *C. odorata* and causes leaf fall (Bennett and Rao 1968).

P. pseudoinsulata was introduced from India to Sabah in 1970 and releases made between 1970 and 1974 of over 4000 eggs, 40 000 larvae and 700 adults. Temporary establishment occurred in two areas in 1973 and 1974, but both colonies then appeared to die out over the next couple of years. This was considered to be due to general predators, such as ants (Cock and Holloway 1982). However, in 1983 and 1987, pockets of larvae appeared scattered over Sabah and often distant from the sites of original release (Ooi et al. 1988a,b). There is a good climate match between Sabah and Trinidad, which may explain the establishment (Cock and Holloway 1982).

Small releases of *A. brunneonigrum* were made in 1970 and recoveries were reported a year later, but there is no indication that the weevil has survived (Ooi et al. 1988a,b, Syed 1973, 1975, 1979a,b).

PHILIPPINES

Aphis gossypii, *A. spiraecola* (= *A. citricola*) and the tortricid *Homona coffearia* were found attacking *C. odorata* (Torres 1986) and the total of natural enemies increased to 11 by 8 additional (unspecified) insects (Torres 1988). Although it had not been intentionally introduced, numerous larvae of *P. pseudoinsulata* were discovered in 1985 in a limited area near the coast of Palawan. They were feeding on the leaves and stems of *C. odorata* under coconut trees and along roads, but surveys elsewhere at the time revealed no evidence of *P. pseudoinsulata* larvae (Aterrado 1986a,b, Torres and Paller 1989). However *P. pseudoinsulata* was discovered later in Zamboanga City, Bohol and northern Leyte provinces in the Visayas islands (Aterrado and Talatala-Sanico 1988).

The eriophyid mite *Acalitus adoratus* was discovered in the Philippines in 1987 (McFadyen 1991b).

THAILAND

A number of insects were found attacking *C. odorata*: the aphids *Aphis craccivora*, *A. gossypii* and *A. spiraecola*, the weevil *Hypolixus trunculatus*, a stem boring cicindelid larva and the arctiid moth *Amsacta lactinea*. They were causing little damage (Napompeth 1990a,b, Napompeth et al. 1988, Napompeth and Winotai 1991).

P. pseudoinsulata was introduced from Guam from 1986 to 1988 but, despite repeated field releases in 1987 and 1988, did not become established. The shoot miner *Melanagromyza eupatoriella* was introduced from Trinidad in 1978, but could not be reared and was not released.

The mite *Acalitus adoratus*, detected in 1984, has since spread to all *C. odorata* infested areas, but is not having a significant effect on the weed.

VIETNAM

Infestations of *Aphis craccivora* and *A. gossypii* have been recorded on *C. odorata*, but no releases of biological control agents have been made (Napompeth and Hai 1988).

Pacific

GUAM

P. pseudoinsulata was introduced from India and Trinidad, mass reared and first released in Guam in 1984 and later in the Northern Marianas. Initially late instar larvae were released in batches of up to 800, but were heavily attacked by ants, spiders, toads and other general predators and failed to become established. Next, groups of 500 or more adult moths were released at a number of sites, resulting in establishment in all release areas. Populations built up rapidly, defoliation of *Chromolaena* soon followed and almost all plants were stripped. Shoots arising from the crowns were also attacked as they appeared and, within a year, over 90% of the plants were killed. The moth spread rapidly and by 1987 had reached almost all infested areas of Guam. Eventually more than 25000 ha of the weed had been defoliated (Muniappan 1988c, Nafus and Schreiner 1989, Seibert 1989). A parasitoid *Exorista xanthaspa* (= *E. civiloides*) caused up to 30% mortality and predation by ants, spiders, toads and lizards occurred (Seibert 1989).

It was observed that the feeding of *P. pseudoinsulata* larvae caused the leaves of *C. odorata* to turn yellow, an effect that could not be produced by simply applying larval excreta to the plant. Yellow leaves were tougher and had a higher level of nitrate and, when larvae were forced, much against their preference, to feed on yellow leaves, they exhibited slow growth and high mortality. Furthermore, larvae continued to feed on yellow plants both by day and night (exposing them to daytime predators), whereas on green plants they fed at night and hid at ground level by day (Marutani and Muniappan 1991b). Interestingly, the yellow plants appear to lose their allelopathic properties and hence this major aid to dominance over other vegetation. The yellowing is reversible if the insects are removed (McConnell et al. 1992, Muniappan and Marutani 1992).

Three additional insects were released to aid in the control of *Chromolaena*, but there is no evidence of establishment. *Apion brunneonigrum* was released early in 1984 at the beginning of the dry season when the above ground growth of *Chromolaena* dies back. Because of the unsuitable condition of the host plants the beetle was not expected to become established. Small numbers of *Mescinia parvula* were released late in 1984 and again late in 1986 (Seibert 1989). The mite *Acalitus adoratus* appeared in Guam in 1993 (R. Muniappan pers. comm.).

Larvae of the pyralid moth *Eucampyla etherella* were observed attacking young flower buds and mature flowers and causing extensive damage. Larvae were parasitised by the eulophid *Elachertus* sp. and the elasmid *Elasmus* sp. (Marutani and Muniappan 1990).

NORTHERN MARIANAS (ROTA, TINIAN, SAIPAN, AGUIJAN)

P. pseudoinsulata has been established from liberations in 1986 and 1987 on all of these islands (Muniappan et al. 1989, Nafus and Schreiner 1989).

Federated States of Micronesia

KOSRAE

Monthly releases of *P. pseudoinsulata* larvae in batches of 1000 to 4000 were made from early 1992 in sunny areas and defoliation of *C. odorata* was observed six months later. Predators were less active in sunny than in shady locations (Esguerra et al. 1994).

PALAU

Although no releases of biological control agents have been made, the mite *Acalitus adoratus* was found to be present (Muniappan et al. 1988b).

POHNPEI

P. pseudoinsulata larvae were introduced from Guam in 1988, some liberated and others mass reared during which both larvae and adults were released until 1992. In four release sites extensive feeding injury and heavy defoliation of *C. odorata* was observed in 1991 and populations persisted in 1992 in burnt areas where Siam weed was regenerating from root stocks (Esguerra et al. 1994). Heavy predation, especially in shaded conditions, was observed on all stages by ants, spiders, birds and lizards (Esguerra et al. 1991, 1994).

YAP

C. odorata was first reported in 1987. *P. pseudoinsulata* was released in 1988 at 14 different sites, but failed to become established except at one location where only 100 larvae and 104 adults had been released (Muniappan et al. 1988b). It eventually disappeared at this site. However releases of 500 larvae in September and October and several hundred in December 1990 to June 1991 resulted in establishment (Marutani and Muniappan 1991a). As on Guam and Rota, larvae of *Eucampyla etheiella* were found causing extensive damage to buds and mature flowers (Marutani and Muniappan 1990). The eriophyid mite *Acalitus adoratus* was found attacking *C. odorata* late in 1988, although it was not observed during a survey of the weed in May of that year (Muniappan et al. 1988b).

Africa

GHANA

P. pseudoinsulata from India was used to establish a culture and releases were made between 1973 and 1978 in a variety of habitats including oil palm plantations. Although small amounts of leaf damage were observed shortly after release, no recoveries were made. Failure to establish was ascribed to predators, in particular to ants (Cock and Holloway 1982).

One small release of *Apion brunneonigrum* was made in 1975, but it failed to become established (Cock 1985).

NIGERIA

P. pseudoinsulata shipped from Ghana between 1973 and 1978 were released, but no establishment occurred (Cock and Holloway 1982).

A. brunneonigrum was sent from Trinidad from 1970 to 1975, but there is no record of establishment (Cock 1985).

SOUTH AFRICA

Disease-free adults of *P. pseudoinsulata* originating from Guam were released in batches of 500 to 1000 at 10 sites in Natal in 1989, but there are no signs of establishment. Very heavy egg predation (up to 82%) by ants and chrysopids was observed (Kluge 1991, Kluge and Caldwell 1991). *P. pseudoinsulata* has been obtained from Florida where the climate is similar to that in Natal and where there is a rich ant fauna. It is (as of 1991) to be released as soon as laboratory cultures of larvae have been cleared of microsporidia.

The larvae of another arctiid moth, *Pareuchaetes aurata aurata*, from *Chromolaena jujuensis* in Argentina were found to feed voraciously and complete their development on *C. odorata*. Females scatter their eggs around the base of the host plant and it is hoped that this will help to overcome the problem of ant predation. After specificity testing it has been released in Natal, but no further information is available (Kluge and Caldwell 1993).

A laboratory culture of the butterfly *Actinote anteus* has been established with material collected in Costa Rica and host testing is to commence (Kluge and Caldwell 1991).

Work is also in progress on the host specificity of the weevil *Rhodoabaenus*

cariniventris and a leaf spot disease caused by *Septoria* sp. (Kluge and Morris 1992).

Major natural enemies

Acalitus adoratus Acarina: Eriophyidae

Recorded originally from Trinidad, Florida, Brazil and Bolivia, it appeared without special assistance in Thailand, Philippines, Indonesia (Java and Sumatra), Caroline Is (Yap, Palau) Guam and southern China. It was not present in India in the mid 1980s nor in Sri Lanka or West Africa (McFadyen 1993).

These tiny mites (0.14 to 0.18 mm long) usually live on the lower surface of leaves. Their feeding induces abnormal growth of the epidermal hairs, resulting in the formation of erineum patches, the term given to areas covered with dense twisted hairs amongst which the mites live. These appear as white patches on the leaves, usually 0.5 to 3 mm in diameter, and the whole leaf surface may be affected. The patches often turn yellow on older leaves. The nymphs and adults feed, and the eggs are laid, between the epidermal hairs. Particularly heavy infestations develop in dry and exposed situations and, although the damage is not spectacular, heavy attack stunts, distorts and slows growth, thereby reducing competitiveness. Tests indicated that, as with many other eriophyid mites, *A. adoratus* is host specific.

When infested leaves senesce, *A. adoratus* leave the erineum patches and are preyed upon by other mites and by the larvae of a cecidomyiid fly, *Arthrocnodax meridionalis* (Cruttwell 1977b, McFadyen 1991b, Muniappan et al. 1988a,b).

It is suggested that *A. adoratus* was accidentally introduced to Sabah when field-collected adults of the weevil *Apion brunneonigrum* in Trinidad were released directly in the 1970s; and that it has since spread naturally and on leaves of *C. odorata* used as packing material around fruit and other produce (McFadyen 1993).

Actinote anteus Lepidoptera: Nymphalidae

Recorded from Costa Rica and Trinidad. The host specificity of this acraeinine defoliator is being examined in South Africa (Kluge and Caldwell 1991).

Apion brunneonigrum Coleoptera: Apionidae

This weevil has been recorded from Trinidad, Venezuela and Argentina. Small releases were made in West Africa, India, Sri Lanka, Sabah and the Marianas, but the weevil persisted only in Sabah and then apparently only briefly. The reasons for these failures have not been investigated.

Cruttwell (1973a) studied its biology and host specificity and found that it would feed and develop only on *C. odorata* and *C. ivaefolia*. It has never been recorded damaging economic plants either in Trinidad or South America. The life history is closely linked with the development of its host, the adults becoming reproductively mature at the time that the plant produces young flower buds which provide food for egg maturation. Eggs are deposited in the developing flower heads and larvae feed within the flower heads, destroying the seeds. Pupation occurs in the flowerheads and, until the next flowering, adults feed on tender growth, usually in shaded situations, and may do considerable dam-

age (Cock 1984a). An individual larva destroys 30 to 60 seeds during development and the ovipositing female many young flowers. *A. brunneonigrum* thus has potential for causing considerable damage, particularly in lightly shaded conditions.

***Aulacochlamys* sp. Coleoptera: Chrysomelidae**

Widespread and occasionally abundant in Trinidad, where it causes moderate damage. Eggs are laid singly in a cylindrical ribbed case formed from faeces. These cases form the apex of a conical larval case which is enlarged as the larva grows. Larvae feed on the surface of stems and leaf petioles. Mature larvae attach the 3.5 to 3.7 mm long case to a stem and pupate inside. Adults emerge one to two weeks later. The small black adults (1.8 to 2.5 mm long) feed on the surface of stems and petioles. No parasitoids are known (McFadyen 1988a).

***Bucculatrix* sp. Lepidoptera: Bucculatricidae**

Recorded from *C. odorata* in Mexico and *Chromolaena jujuensis* (= *Eupatorium hookerianum*) in Argentina. Larvae are solitary leaf miners and pupate in the mines (McFadyen 1988a).

***Chlamisus insularis* Coleoptera: Chrysomelidae**

Recorded from Mexico, Panama and Trinidad. The life history is similar to that of *Aulacochlamys* sp., but this species is somewhat larger. The mature larval case is conical with a rough surface and 6 to 7 mm long. The adults are black with golden markings and 3.3 to 4.3 mm long. Adults are known to feed on *C. odorata*, *C. ivaefolia* and *Bidens pilosa*. A black, solitary eulophid egg parasitoid is known (McFadyen 1988a).

***Clinodiplosis* sp. Diptera: Cecidomyiidae**

Recorded from *C. odorata* and *C. ivaefolia* in Trinidad. Up to three larvae at a time live between the bud leaves of stem tips or axillary buds, destroying tissue and preventing growth. A gall is formed by the slight swelling of the bud leaves which become red and densely covered with hairs. Mature larvae drop to the ground and pupate just below the soil surface. Adults emerge 11 to 18 days later. This gall midge is abundant and widespread in Trinidad, breeds throughout the year and causes considerable damage to *C. odorata* (McFadyen 1988a).

***Mescinia parvula* Lepidoptera: Pyralidae**

Recorded from Trinidad; similar larvae were found on *C. odorata* in Mexico and Brazil and on *C. jujuensis* in Argentina. A few individuals were released on Guam in 1984, but there has been no evidence of establishment.

Ovipositing females select leaves with dense hairs (in effect young leaves) with the result that developing buds are nearby. Eggs are laid individually amongst the epidermal hairs on the underside of the young leaves and hatch in 5 to 6 days. Young larvae move to a terminal or axillary bud and several may enter the same bud. They bore down the stem destroying meristematic tissue and preventing growth. Larvae may leave a stem and enter a new bud. After 13 or so days larvae leave the stem to spin a flimsy cocoon, either attached to the plant or among ground litter, in which they pupate. Adults emerge 10 to

11 days later and live up to 6 days. Attempts to induce mating in cages in Trinidad were unsuccessful. In specificity tests larvae fed on only a few Asteraceae other than *C. odorata* and *C. ivaefolia* but, with the exception of 1 out of 30 larvae placed on *Dahlia*, no development was ever completed. Over a three year period in Trinidad, no oviposition or attack was observed on *Dahlia* plants growing near *C. odorata* which was frequently attacked by *M. parvula*. Furthermore, since *Dahlia* leaves are not hairy, it is most unlikely that *M. parvula* would ever oviposit on them. Larvae in Trinidad are attacked by eight hymenopterous and one tachinid parasitoid and, if freed from these, might do considerably more damage to *C. odorata* (Cruttwell 1977a).

***Pareuchaetes aurata aurata* Lepidoptera: Arctiidae**

This subspecies occurs in south-eastern Brazil, Paraguay and northern Argentina at latitudes (26° to 30°S) similar to those of Natal, South Africa. It has an average life cycle of 30 days at 26° to 29°C and 58 days at 22° to 25°C. Its larvae are nocturnal feeders and shelter at the base of plants during the day. In the laboratory, pupation occurred in a flimsy cocoon spun between leaves on the plant. Mating may occur on the night of emergence and an average of 242 eggs are laid over the next eight days. These are laid singly on the ground and, in the laboratory, newly-hatched first instar larvae were able to walk up about 2m of stem to commence feeding. In the field *P. aurata aurata* is found in shaded habitats near surface water.

In Argentina, larvae and pupae are infected with a microsporidan disease (*Nosema* sp.), up to 20% of larvae are parasitised by a complex of braconid, chalcidid and tachinid parasitoids and all stages are subject to attack by predatory ants.

The usual host plant of *P. aurata aurata* is *Chromolaena jujuensis*, but it has been successfully reared for more than 10 generations on *C. odorata*. In the field it has never been recorded as a pest on any of the many commercially important crops grown in its natural area of distribution. It was liberated in Natal (South Africa) in 1990 (Kluge and Caldwell 1993).

***Pareuchaetes pseudoinsulata* Lepidoptera: Arctiidae**

This moth is native to Trinidad, Tobago and the north-eastern coast of Venezuela. It has become established in Brunei, Guam, India, Philippines, Sabah, Sri Lanka, the Northern Marianas and Yap, but has failed to do so in Ghana, Nigeria, South Africa and Thailand. It was previously misidentified first as *Ammalo arravaca* and then as *A. insulata*, which is a closely related but distinct species (Cock and Holloway 1982).

The moth, which lives up to about 10 days, lays 150 to 250 eggs (maximum 580) in groups attached to the lower surface of the leaves of *C. odorata*. Larvae feed on the leaves and are gregarious until the 3rd instar, but then disperse. From the 4th instar on they feed at night, hiding by day amongst debris at the base of the plant, where they later pupate. The life cycle varies from 40 to 60 days and breeding occurs throughout the year. Host specificity studies in Trinidad showed that development occurred only on *Chromolaena ivaefolium*, *C. microstemon* and *C. odoratum*. In addition larvae developed, but only as far as the 3rd instar, on *Ageratum conyzoides* (Bennett and Cruttwell 1973), although in Sri Lanka, adults were produced on this weed. However their eggs had a somewhat lower

hatchability than those from adults bred on *C. odorata* (Mahindapala et al. 1980). A high degree of host specificity has since been confirmed by others (e.g. Ahmad and Thakur 1991, Sankaran and Sugathan 1974, Syed 1979a) and no damage to plants other than to *C. odorata* has been reported either in the Americas or in the overseas countries where it has become established.

In Trinidad the eggs are parasitised by a scelionid wasp and the larvae by five species of tachinid fly. A nuclear polyhedrosis virus also affects the larvae (Bennett and Cruttwell 1973) and may have been responsible for breeding difficulties in some overseas countries, although other countries have experienced no problems in establishing cultures.

***Pentispa explanata* Coleoptera: Chrysomelidae**

This hispine beetle is recorded on *C. odoratum* from Mexico to Colombia and from Venezuela on *Pithecoctenium* sp. (Bignoniaceae). In Trinidad adults are widespread on *C. odorata* and *C. ivaefolia*, but would not feed on *Pithecoctenium echinatum*.

Eggs are inserted singly under the leaf epidermis and covered with a faecal plug. Larvae hatch after about 12 days and form irregular blotch mines which expand to 2 to 3 cm in diameter 20 to 25 days later when larvae are mature. Pupation occurs in the mine and adults emerge 5 to 8 days later. Adults disperse and feed on the underside of the leaves producing characteristic scars. There is one generation a year. Larvae are parasitised by a solitary ectoparasitic elasmid *Austelasmus* sp. and are taken by predatory wasps (McFadyen 1988a).

***Perasphondylia reticulata* Diptera: Cecidomyiidae**

This gall fly is recorded from *C. odorata* and *C. ivaefolia* in Trinidad, Brazil and Bolivia and from *C. odorata* and *Eupatorium* sp. in El Salvador.

Larvae occur singly in a hollow pear-shaped gall, 7 to 9 mm long, in stem tips and axillary buds. *P. reticulata* causes considerable damage but is generally uncommon and confined to the cooler valleys in Trinidad. However it is commoner in Brazil and Bolivia. It is attacked by several parasitoids in Trinidad and Bolivia (McFadyen 1988a).

***Procecidochores connexa* Diptera: Tephritidae**

This gall fly is recorded from Mexico, Brazil and Bolivia.

Eggs are inserted in the tip of the stem and abnormal growth commences even before they hatch. One to seven larvae feed in separate curved tunnels in the developing gall. Mature larvae pupate in the tunnel behind an epidermal window through which the adult emerges later. The galls slow and distort growth and cause moderate damage.

Larvae are parasitised by a number of wasps throughout their range (McFadyen 1988a).

***Rhodoaenus cariniventris* Coleoptera, Curculionidae**

This weevil is recorded from Trinidad and USA. Eggs are deposited in a slit between two rows of punctures encircling the stem, which result in wilting of the stem tip. On hatching, larvae feed for a few days in the wilted portion then tunnel into the sound tissue below the punctures. Bennett (1955) reports that, after a month, they pupate in the stem at the base of the plant and adults emerge 10 days later. However, McFadyen (1988a)

states that, when mature, the larva cuts off from the hollow tip of the stem a piece about 2cm long containing it. This falls to the ground, where the open ends are plugged with frass, and pupation occurs. Adults feed on stems and petioles of *Bidens pilosa*, *Chromolaena inulaefolium*, *C. ivaefolia* and *C. odorata* (all Asteraceae). Larvae tunnel in the stems of all these except *B. pilosa* (McFadyen 1988a). Cruttwell (1974) suggested that the feeding of adults might be insufficiently restricted, but the situation merits further investigation.

R. cariniventris is parasitised in Trinidad by an external egg parasitoid *Euderus* sp. (Eulophidae) (Bennett 1955).

Comments

The genus *Chromolaena* belongs to the tribe Eupatorieae (Table 4.3.4), which is mainly of American origin. There are no crop plants or important ornamentals in this tribe. However, it does contain the major weeds *Ageratum conyzoides* (4.1) and *Mikania micrantha* (4.14) and several less important species: *Ageratina altissima* in eastern USA, *A. adenophora* and *A. riparia* in India to southern China, Australia, Hawaii and South Africa and *Austroeupatorium inulaefolium* in Indomalaysia and Sri Lanka. There are 129 species of *Chromolaena*, all from Central and South America. *Chromolaena ivaefolia* and *C. laevigata* are widespread and occasionally weedy in the Americas, but only *C. odorata* has spread elsewhere (McFadyen 1991a). These relationships suggest that many of the insects that attack *C. odorata* and its close allies are likely to be sufficiently host specific to be considered for classical biological control.

There has been discussion concerning the possible reasons for *Pareuchaetes pseudoinsulata* establishing fairly readily in Sri Lanka and Guam, with difficulty in India and Sabah and not at all in Africa (e.g. Cock 1984a, Cock and Holloway 1982, Seibert 1989). The desirability is rightly emphasised of matching, where possible, the climate of the area from which it (or any other biological control agent) is collected with that of the area in which it is to be released. Since *P. pseudoinsulata* has no diapause and breeds all year round, it will at least experience great difficulty in bridging (or find it impossible to bridge) the gap created by almost complete leaf loss of *C. odorata* in areas where there is a severe and long dry season. However, if this were the only problem, the moth should be able to establish itself at least briefly before being eliminated by starvation: this sequence has not, however, been documented. What, however, has been widely reported is the very high level of predation on eggs, larvae and pupae, in particular by ants and spiders, but also by other invertebrate and vertebrate predators (e.g. Kluge 1991, Kluge and Caldwell 1991). It seems probable that massive predation has been the cause of rapid demise of many releases. Thus, release sites should be chosen (or treated) so as to minimise predation. Although significant predation was also observed on Guam, the lower diversity of predators (and other organisms) on islands may well have contributed to the comparatively ready establishment of *P. pseudoinsulata* there and on other Pacific islands. Furthermore, the release of significant numbers (500 or more) of adults rather than of eggs or larvae may have assisted in avoiding rapid elimination of the released material.

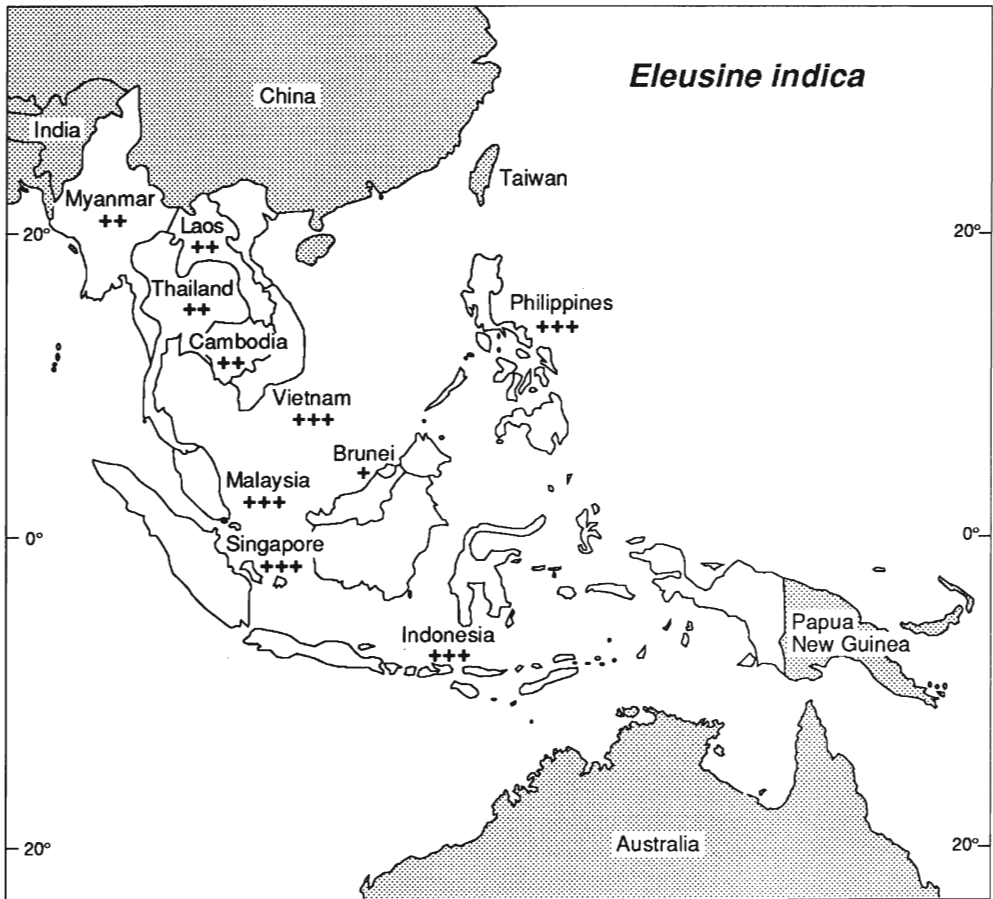
The general vigour of the released insects and the presence or absence of microsporida or viruses would also play a crucial role in successful establishment and it is probable that these factors have not always been adequately considered.

It is possible that the high level of predation and of parasitisation of the biological control agents will, in many areas, so lessen the potential each has to cause damage to *C. odorata* that the combined effects of several will be required to bring about an adequate and sustained reduction in its weediness. Fortunately, many potentially suitable insects are available for study.



Eleusine indica

(after Holm *et al.* 1977)



Map 4.8.1 *Eleusine indica*

Eleusine indica is of African origin and, except for finger millet, *E. coracana*, is not closely related to graminaceous crop plants. Finger millet is a staple crop in India and some parts of Africa, but relatively unimportant or not grown elsewhere. Little is known about the insect or other enemies of *E. indica* in Africa and, elsewhere, almost all records are of pests with a wide host range. Because it is a major weed (5th) in Southeast Asia and is only distantly related to crop plants a search for specific natural enemies in Africa must be regarded as an attractive proposition.

4.8 *Eleusine indica* (L.) Gaertn.

Poaceae

crowsfoot grass, goose grass; sin ngo let kya, sin ngo myet (Myanmar), yah teenka (Thailand), smao choeung tukke (Cambodia) cô mân trầu (Vietnam), rumput sambou (Malaysia), rumput belulång (Indonesia), sabung sabungan (Philippines)

Rating

	+++	Viet, Msia, Sing, Indo, Phil
24	++	Myan, Thai, Laos, Camb
	+	Brun

Origin

Africa (Phillips 1972), replacing an alternative view that it was India (Holm et al. 1977, Waterhouse 1993a).

Distribution

Throughout the tropics, sub-tropics and temperate regions of the world, including Africa, Asia, SE Asia, Australia, the Pacific and the Americas.

Characteristics

E. indica is a tufted, annual, C4 grass attaining a height of 0.6 m. Its flower spikes mostly have 2 to 7 spikelets, producing a characteristic windmill-like appearance.

Importance

The genus *Eleusine*, contains nine annual or perennial grasses all native to Africa except for the South American *E. tristachya* (Hilu and Johnson 1992, Phillips 1972). It belongs to the subfamily Chloridoideae, which is but distantly related to all except one of the principal grain crops. That exception is finger millet, or ragi, *E. coracana* ($2n = 36$), which is believed to have arisen from *E. indica* ($2n = 18$) (Hilu and de Wet 1976, Hilu and Johnson 1992, Hiremath and Salimath 1992) and is an important staple cereal in India and some regions of eastern Africa (Rachie and Peters 1977). However, it is worth noting that *E. coracana* is regarded as a minor weed in some Southeast Asian countries (Thailand, Vietnam) (Waterhouse 1993a) and that it is nowhere important in this region. The genera *Eleusine* and *Dactyloctenium* are closely related.

E. indica is an important weed in more than 60 countries in at least 46 crops and, in these, has the status of a serious weed in 30 countries and 27 crops. It was evaluated as the fifth worst weed in the world (Holm et al. 1977) and also rated fifth in a recent survey in Southeast Asia (Waterhouse 1993a). It was rated 15th in 1992 in the oceanic Pacific (Waterhouse, unpublished). It grows well in sunny or somewhat shaded places, in marshlands, wastelands, roadsides, along borders of irrigated fields and canals, in lawns and in pastures, and prospers and is particularly troublesome on arable land. It ranges from near

the seashore to an altitude of at least 2000 m and is a major problem in almost all forms of agriculture between the tropics of Capricorn and Cancer.

E. indica grows and flowers well in all seasons and a single plant may produce more than 50 000 small seeds, which move readily by wind, in mud on the feet of animals and in the tread of machinery. The seeds are eaten by wild and domestic animals and are occasionally grown for grain in Africa and India, but *Eleusine coracana*, finger millet, with somewhat larger seeds is far better for this purpose. Although sometimes claimed to be palatable to grazing animals, crowsfoot grass becomes fibrous too early in the season to be a satisfactory pasture grass. The seed heads may contain high levels of cyanogenic glycosides and are believed to be responsible for occasional cases of stock poisoning (Everist 1974).

Natural enemies

Natural enemies restricted to the genus *Eleusine* and its close relatives might well be considered for biological control of *E. indica* except in India or other regions where finger millet is an important cereal.

E. indica is reported in the literature to be attacked by more than 50 insects, nematodes, fungi, bacteria and viruses, all except 6 in continents other than Africa (Tables 4.8.1 to 4.8.4). Further, with few exceptions, all of these organisms are known to have wide host ranges and to attack important agricultural crops. Indeed, of those recorded, only one cecidomyiid gall fly and possibly one or two fungi could be considered further for classical biological control. Figliola et al. (1988) consider that, where they already occur, two fungi, *Bipolaris setariae* and *Magnaporthe* (= *Pyricularia*) *grisea* hold promise as bioherbicides for *E. indica*, although their host range is a little too wide for classical biological control.

It is not surprising that the organisms attacking an economic crop, finger millet, *E. coracana*, have been investigated in greater detail than those of a weedy relative. Finger millet is believed to have been domesticated in the East African highlands by 3000 BC or earlier and archaeological data suggests that it may have been introduced to India as early as 2000 BC (Hilu et al. 1979). Since *E. coracana* and *E. indica* are closely related, Wapshere (1990b) argues, probably correctly, that most or all of the more specific organisms infesting finger millet are also likely to attack *E. indica*. It is very disappointing, therefore, that almost all of the natural enemies of finger millet so far recorded (again mostly from outside Africa) have wide to very wide host ranges and are not potential biological control agents. The very few species that may prove to have a limited host range are shown in table 4.8.5. Wapshere (1990b) has listed 40 insects that attack *E. coracana* and at the same time belong to groups known to have species restricted to a single grass genus (and there are also many other insects from groups with a wider host range that attack *E. coracana*). In addition to the undescribed *Orseolia* gall midge attacking *E. indica* in India, only three insects (two cecidomyiid gall midges, one from Uganda and one from Nigeria and an aphid from India), a nematode (*Heterodera delvii*) from India and a smut fungus (*Melanopsichium* (= *Ustilago*) *eleusinis*) may, if shown to attack *E. indica* also, prove to be sufficiently host specific to be considered for classical biological control. It is relevant that cecidomyiid gall flies are believed to have a high degree of specificity to their host grass genera (Barnes 1946, K.M. Harris pers. comm. 1993, Wapshere 1990a).

Comment

It has been pointed out above that the majority of records for natural enemies of both *E. indica* and *E. coracana* come from outside Africa and that almost all of these organisms have a wide host range. Indeed, this is to be expected if both *Eleusine* species are of African origin. Except for any specific enemies that may have accompanied them, it is inevitable that they will be attacked in new countries by non-specific natural enemies that, hitherto, were attacking other plants. Of course, the possibility exists that natural enemy species in the new country may have evolved a degree of specificity in the four or five thousand years that the *Eleusine* species have existed outside Africa.

It is significant that there has not so far been any detailed search in Africa for natural enemies of *E. indica* to establish whether or not adequately specific species occur there. A two year (or longer) survey of *E. indica* in several regions of Africa would probably be required, together with observations on whether the organisms found attacking *E. indica* also attack *E. coracana*, nearby grasses or other plants. The relevant regions for study in Africa and Madagascar are indicated in map 4.8.2 based on the distribution data of Phillips (1972).

If (i) the African cecidomyiid gall midges (*Contarinia* (= *Stenodiplosis*) spp.) (Tables 4.8.1, 4.8.5) do not already occur in Southeast Asia (they are not known in Australia), (ii) they prove to be adequately host specific and (iii) the Ugandan species attacks *E. indica* in addition to *E. coracana*, they would appear to be the most promising of known species for introduction elsewhere. The undescribed species from northern Nigeria (Table 4.8.1) was collected from *E. indica* at Zaria in July 1959 and July 1960 (K.M. Harris, pers. comm. 1993). Larvae of the Indian *Orseolia* sp. nr. *fluviatilis* probably induce galls on young shoots of *E. indica*, so would affect vegetative growth rather than having a direct impact on seed production. It is as yet known only from India.

To sum up, for an attempt at classical biological control of a grass weed, *E. indica* would appear to be the one with most positive factors combined except that, so far, few adequately specific, natural enemies are known. However, almost nothing is known about the natural enemies in Africa, not only its centre of origin but also that of the genus *Eleusine*. It would, indeed, be most surprising if several natural enemies having a restricted host range were not discovered during a thorough survey there.

Table 4.8.1 Natural enemies of *Eleusine indica*: insects.

Species	Country	Portion attacked	Comments: other hosts	References
Hemiptera				
APHIDIDAE				
<i>Chaetogeoica graminiphaga</i>	India		beans and a number of grasses	Raychaudhuri 1983
<i>Geoica lucifuga</i>	India		also on rice, <i>Eleusine coracana</i> and many weeds including <i>Cynodon dactylon</i> , <i>Cyperus rotundus</i>	Raychaudhuri et al. 1978

(continued on next page)

Species	Country	Portion attacked	Comments: other hosts	References
<i>Hysteroneura setariae</i>	Hawaii		rice, maize, wheat	Beardsley 1962
<i>Schizaphis</i> (= <i>Toxoptera</i>) <i>graminum</i>			sorghum, sugar cane rice, sorghum, maize and a very wide host range	Patch 1939
<i>Sitobion avenae</i> (= <i>Macrosiphum</i> <i>granarium</i>)			rice, wheat, a very wide host range	Patch 1939
<i>Sitobion</i> (= <i>Macrosiphum</i>) <i>miscanthi</i>	India		on a very wide range of crop plants and weeds	Raychaudhuri 1983
<i>Stegophylla</i> (= <i>Anoecia</i>) <i>querci</i>			maize and several weeds	Patch 1939
<i>Tetraneura basui</i>	India		on rice, <i>Echinochloa</i> <i>colona</i> , <i>Paspalum</i> <i>conjugatum</i> and other weeds	Raychaudhuri 1983
<i>Tetraneura</i> <i>nigriabdominalis</i> (= <i>T. hirsuta</i>)	India		rice, maize, sugarcane <i>Eleusine coracana</i> and a very wide range of weeds	Patch 1939, Raychaudhuri 1983
CERCOPIDAE				
<i>Prosapia</i> (= <i>Monecphora</i>) <i>bicincta fraterna</i>	Cuba		also on <i>Paspalum</i> <i>notatum</i> , <i>Brachiaria</i> <i>subquadripara</i> , <i>Andropogon annulatus</i> , <i>Cynodon dactylon</i>	Plana et al. 1986
CICADELLIDAE				
<i>Nephotettix malayanus</i>	Philippines		rice, many weeds	Khan et al. 1991
<i>Nephotettix</i> <i>nigromaculatus</i> (= <i>N. nigropictus</i>)	Philippines		rice, many weeds	Khan et al. 1991
<i>Nephotettix virescens</i>	Philippines		rice, many weeds	Khan et al. 1991
<i>Recilia dorsalis</i>	Philippines		rice, many weeds	Khan et al. 1991
DELPHACIDAE				
<i>Laodelphax striatellus</i>	China		wheat, barley, oats, sorghum etc	Zhang et al. 1981
<i>Peregrinus maidis</i>	India		transmitter of <i>Eleusine</i> mosaic virus (see table 4.8.4); very wide host range	Cherian and Kylasam 1937, Patch 1939, Rao et al. 1965
<i>Sogatella furcifera</i>	China		can complete development also on 17 other species of crops and weeds including rice, barley, wheat, <i>Echinochloa</i> <i>crus-galli</i>	Huang et al. 1985

(continued on next page)

Table 4.8.1 (continued)

Species	Country	Portion attacked	Comments: other hosts	References
LYGAEIDAE				
<i>Blissus leucopterus</i>	USA	lower stem	damages sorghum and many grasses including <i>Cynodon dactylon</i> and <i>Dactyloctenium aegyptium</i> , but particularly damaging to <i>E. indica</i>	Ahmad et al. 1984, Lynch et al. 1987
Thysanoptera				
PHLAEOTHRIPIIDAE				
<i>Haplothrips ganglbaueri</i>	India		rice, wheat, sorghum	Ananthakrishnan & Thangavelu 1976
Diptera				
AGROMYZIDAE				
<i>Liriomyza marginalis</i>	N&S America		<i>Panicum miliaceum</i> , <i>Digitaria</i> , <i>Paspalum</i> (primary host), <i>Euchlaena</i>	Spencer 1990, Spencer & Steyskal 1986
<i>Pseudonapomyza spicata</i>	Australia	leaf	maize, sugarcane, grasses	Kleinschmidt 1970
CECIDOMYIIDAE				
<i>Orseolia</i> sp. nr <i>fluviatilis</i>	India	stem	undescribed gall midge resembling (but not) the rice stem gall midge <i>Orseolia</i> (= <i>Pachydiplosis</i>) <i>oryzae</i> ; no host other than <i>E. indica</i> known	Barnes 1954a,b, 1956, Gagné 1985, Hegdekatti 1927, Rachie and Peters, 1977
<i>Stenodiplosis</i> sp.	Nigeria	seed heads	undescribed species	K.M. Harris pers. comm. 1993
Lepidoptera				
ARCTIIDAE				
<i>Cnaphalocrocis medinalis</i>	Philippines	leaf folder	rice, many weeds	Abenes & Khan 1990
<i>Cnaphalocrocis</i> (= <i>Marasmia</i>) <i>patnalis</i>	Philippines	leaf folder	rice, many weeds	Abenes & Khan 1990
<i>Cretonotos</i> (= <i>Amsacta</i>) <i>gangis</i>	Philippines	leaves	rice, many weeds	Catindig et al. 1993
NOCTUIDAE				
<i>Spodoptera frugiperda</i>	USA		wide range of crops and weeds	Pencoe and Martin 1982
PYRALIDAE				
<i>Ostrinia furnacalis</i>	Guam		wide range of crops and weeds	Schreiner et al. 1990

Table 4.8.2 Natural enemies of *Eleusine indica*: nematodes.

Species	Country	Comments	References
<i>Ditylenchus destructor</i>	South Africa	groundnut, several weeds	De Waele et al. 1990
<i>Hirschmaniella spinicaudata</i>	Cuba	has other weed hosts including <i>Cyperus iria</i>	Fernandez and Ortega 1982
<i>Meloidogyne</i> sp.	China	rice root knot nematode (damage up to 50%); also attacks wheat, and <i>Echinochloa colona</i>	Guo et al. 1984, Holm et al. 1977
<i>Meloidogyne arenaria</i>	Cuba, Philippines, USA	<i>Echinochloa crus-galli</i> , <i>Portulaca oleracea</i> , tobacco	Tedford and Fortnum 1988, Valdez 1968
<i>Meloidogyne graminicola</i>	India	wheat, <i>Panicum</i> spp, tomato, capsicum, etc	Rao et al. 1970
<i>Meloidogyne incognita</i>	Cuba, USA	<i>Ageratum conyzoides</i> , <i>Croton lobatus</i> , <i>Cynodon dactylon</i> , tobacco	Acosta et al. 1986
<i>Meloidogyne javanica</i>	Brazil	attacks tomato and weeds including <i>Bidens pilosa</i> , <i>Euphorbia heterophylla</i> , <i>Galinsoga parviflora</i>	Lordello et al. 1988
<i>Pratylenchus pratensis</i>	Hawaii	also attacks <i>Cynodon dactylon</i>	Holm et al. 1977
<i>Pratylenchus zaeae</i>	S. Africa, Cuba	<i>E. indica</i> is a moderately good host of the maize nematode; has other weed hosts, including <i>Cyperus iria</i>	Fernandez and Ortega 1982, Jordaan et al. 1988
<i>Rotylenchulus reniformis</i>	Hawaii		Linford and Yap 1940

Table 4.8.3 Natural enemies of *Eleusine indica*: fungi and bacteria.

Species	Country	Comments	References
FUNGI			
<i>Bipolaris setariae</i> (as <i>Drechslera setariae</i>)	USA (not recorded in Australia)	heavy attack on <i>E. indica</i> , light on maize, sorghum, none on dicotyledons	Figliola et al. 1988 Hiremath and Sulladmath 1985
<i>Corticium sasakii</i>	India	rice, many weeds including <i>Commelina benghalensis</i> , <i>Cynodon dactylon</i> , <i>Fimbristylis miliacea</i>	Roy 1973
<i>Drechslera gigantea</i>	Brazil	no hosts other than <i>E. indica</i> mentioned	Muchovej 1987
<i>Helminthosporium</i> sp.	Thailand		Chandrasrikul 1962
<i>Helminthosporium holmii</i>	India	also on <i>Echinochloa colona</i> , <i>Chloris gayana</i>	Singh and Misra 1978
<i>Helminthosporium maydis</i>	China	attacks 21 other weeds including <i>Imperata cylindrica</i> , <i>Digitaria ciliaris</i> and <i>Echinochloa crus-galli</i>	Wu and Liang 1984

(continued on next page)

Table 4.8.3 (continued)

Species	Country	Comments	References
<i>Helminthosporium nodulosum</i> (as <i>Bipolaris nodulosa</i> or <i>Cochliobolus nodulosus</i>)	Africa, Australia, India, Japan, Philippines, USA	also infests maize, <i>Eleusine coracana</i> , wheat, barley, oats and weeds including <i>Dactyloctenium aegyptium</i> ; causes seedling blight leaf stripe and sooty heads in <i>E. indica</i>	Rachie and Peters 1977, Wapshere 1990b
<i>Magnaporthe</i> (= <i>Pyricularia</i>) <i>grisea</i>	Africa, Australia, India, USA, Georgia	heavy attack on <i>E. coracana</i> , <i>Rotboellia cochinchinensis</i> , light attack on maize	Chauhan & Verma 1981, Figliola et al. 1988, Heath et al. 1990, 1992, Shetty et al. 1985, Valent et al. 1986, Vodianaia et al. 1986, Wapshere 1990b,c
<i>Pellicularia rolfsii</i>	Australia, India	causes wilt disease of <i>E. coracana</i> and infests many grasses and dicotyledonous plants	Wapshere 1990b
<i>Phyllachora eleusines</i>	Africa, Australia	only recorded on <i>Eleusine</i> and <i>Eragrostis</i> in Africa; in Australia only on <i>Eragrostis</i>	Parbery 1967, Ramakrishnan 1963
<i>Pyricularia oryzae</i>	Brazil, China	attacks rice	Prabhu et al. 1992, Teng 1932, Valent et al. 1986
<i>Sclerophthora macrospora</i>	India	attacks maize, wheat, oats, rice: attacks <i>E. coracana</i> and many grasses, but not <i>E. indica</i> in Australia; there may be host specific strains	Rachie and Peters 1977, Ullstrup 1955, Wapshere 1990b
<i>Sclerotium rolfsii</i>	Australia, India	attacks many dicotyledonous crop plants and a wide range of grasses	Reddy 1983, Safeeulla 1976
<i>Ustilago</i> sp. <i>Ustilago eleusinis</i> (as <i>Melanopsichium eleusinis</i>)	China Africa, Asia	smut fungus of <i>Eleusine</i> and <i>Dactyloctenium</i> , but only on <i>D. radulans</i> in Australia	Mundkur 1939 Simmonds 1966, Zundel 1953
BACTERIA			
<i>Pseudomonas glumae</i>	Japan	an important rice pathogen: attacks a wide range of weeds	Miyagawa et al. 1988
<i>Pseudomonas plantarii</i>	Japan	attacks rice, wheat, sorghum, maize and many weeds	Miyagawa et al. 1988

Table 4.8.4 Natural enemies of *Eleusine indica*: viruses.

Virus	Country	Other hosts	References
cereal chlorotic mottle	Australia	oats, barley, wheat, maize, <i>E. coracana</i> , <i>Digitaria ciliaris</i> , <i>Echinochloa colona</i> ; transmitted by <i>Nesoclutha pallida</i>	Greber 1979
corn leaf gall	Philippines	maize	Agati and Calica 1950
corn stunt	USA	several other weeds	Pitre and Boyd 1970
<i>Eleusine</i> mosaic	India	maize, sorghum, <i>E. coracana</i> and many other hosts	Rao et al. 1965
groundnut rosette	Malawi	groundnut	Adams 1967
maize dwarf mosaic	USA	maize	Lee 1964
maize streak	Nigeria	maize, but not all cultivars <i>Cicadulina triangula</i> is the vector	Ekukole et al. 1989, Rossel et al. 1984
rice leaf gall	Philippines	rice	Agati and Calica 1950
rice orange leaf	Philippines	rice	Watanakul 1964
rice ragged stunt	China	rice, <i>E. indica</i> and 4 other weeds	Xie et al. 1984
	Philippines	rice, <i>Echinochloa glabrescens</i> , <i>Monochoria vaginalis</i> , <i>Paspalum distichum</i>	Salamat et al. 1987
rice tungro bacilliform	Philippines	rice, many weeds	Khan et al. 1991
rice tungro spherical	Philippines	rice, many weeds	Khan et al. 1991
rice yellow mottle	Kenya	rice, two grasses	Okioma et al. 1983
sugarcane mosaic	India	sugarcane	Chona and Rafay 1950
sugarcane streak	Hawaii	sugarcane	Holm et al. 1977
tungro	Philippines	rice	Watanakul 1964
wheat rosette	China	oats, barley, sorghum, wheat etc. <i>Laodelphax striatellus</i> is the vector	Zhang et al. 1981

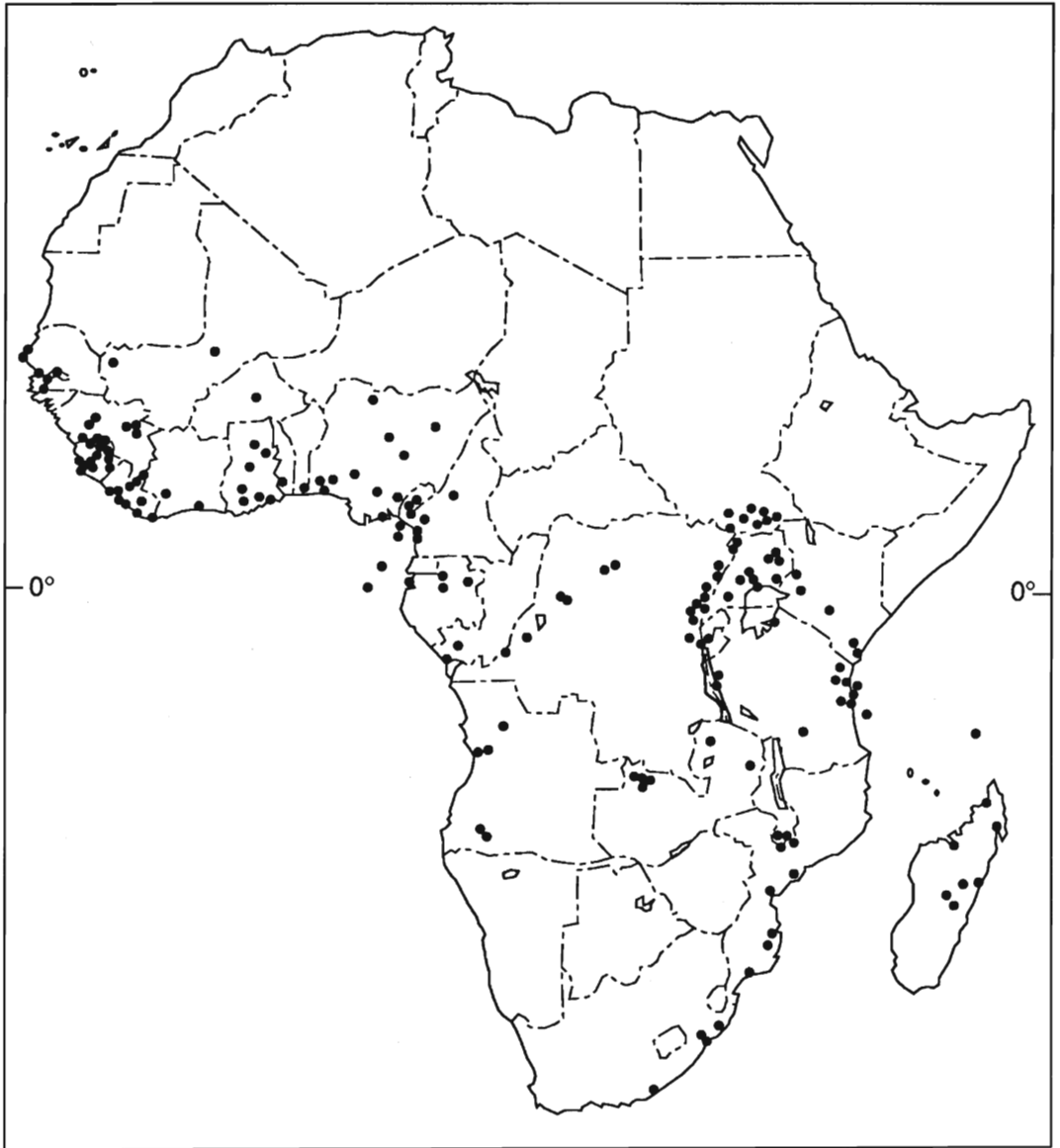
Table 4.8.5 Natural enemies of *Eleusine coracana* which may prove to have a limited host range.

Species	Country	Portion attacked	Comments	References
INSECTS				
Diptera				
CECIDOMYIIDAE				
<i>Contarinia</i> sp.	Uganda	inflorescence	not the same as the sorghum midge <i>Contarinia sorghicola</i> : the same or a similar species attacks the common fallow weed <i>Sorghum verticilliflorum</i>	Barnes 1946, 1954a,b, 1956, Geering 1953, Rachie & Peters 1977

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Table 4.8.5 (continued)

Species	Country	Portion attacked	Comments	References
Hemiptera				
APHIDIDAE				
<i>Sitobion</i> (= <i>Macrosiphum</i>) <i>leelamaniae</i>	India (not in Australia)		attacks several millets in India including pearl millet <i>Pennisetum</i> <i>glaucum</i> (= <i>P. typhoideum</i>), also <i>Andropogon vulgare</i>	Raychaudhuri 1983
NEMATODES				
<i>Heterodera delvii</i>	India	root cysts	no other hosts mentioned	Jairajpuri et al. 1979
FUNGI				
<i>Melanopsichium</i> <i>eleusinis</i> (= <i>Ustilago</i> <i>eleusinis</i>)	Asia, Africa		a smut fungus: only from <i>Eleusine</i> and <i>Dactyloctenium</i> : tentatively identified from <i>D. radulans</i> in Queensland, but not from <i>E. indica</i>	Simmonds, 1966, Wapshere 1990c, Zundel 1953

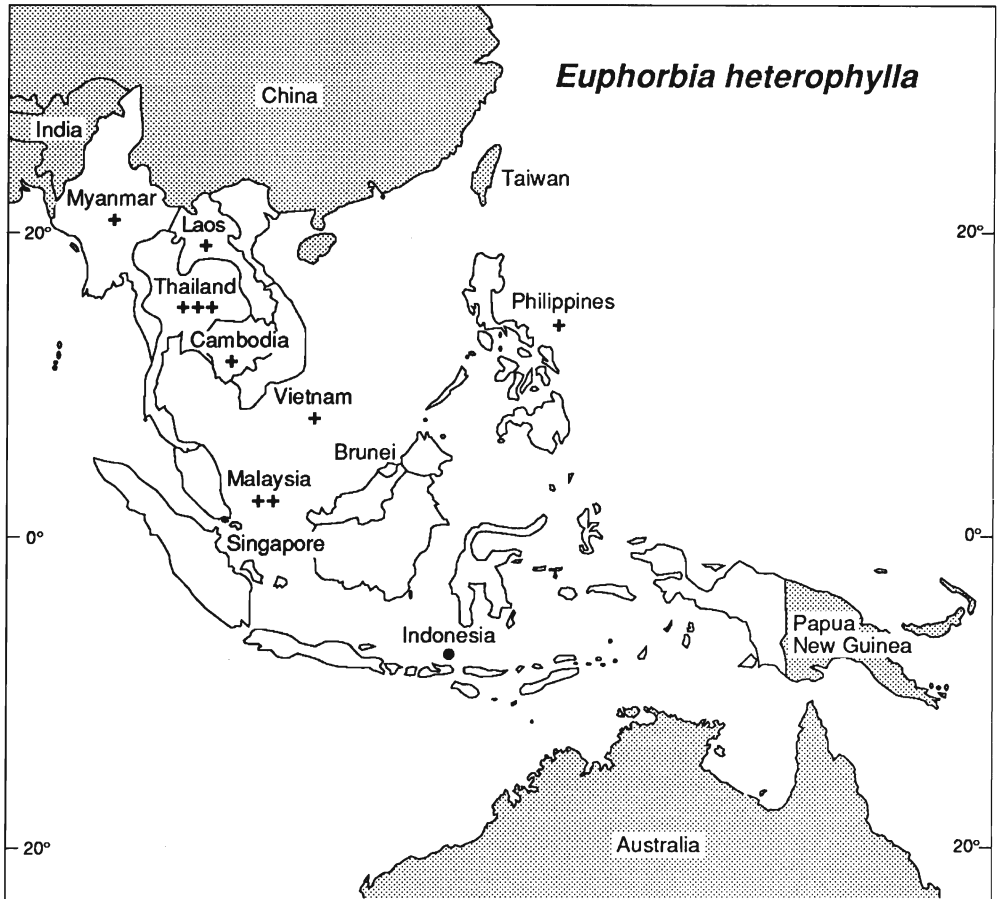


Map 4.8.2 Distribution of *Eleusine indica* in Africa (after Phillips 1972)



Euphorbia heterophylla

(after Barnes and Chan, 1990)



Map 4.9 *Euphorbia heterophylla*

There are very few records of natural enemies other than fungi attacking *Euphorbia heterophylla* and no study has been made in tropical America where it evolved. However, from the sparse records of insects attacking species of *Euphorbia* in Brazil it is likely that adequately host specific insects do occur. Nevertheless *E. heterophylla* is regarded as an important weed in southern Brazil.

4.9 *Euphorbia heterophylla* L.

(= *E. geniculata* = *E. prunifolia*)

Euphorbiaceae

painted spurge, Mexican fire plant; yaa yaang (Thailand)

Rating

	+++	Thai
10	++	Msia
	+	Myan, Laos, Camb, Viet, Phil
	•	Indo

Origin

Tropical and sub-tropical America.

Distribution

Widespread as a weed in the tropical and subtropical regions of the world, notably in Southeast Asia, but apparently not in Kalimantan or Sulawesi (Indonesia) (Soerjani et al. 1986).

Characteristics

An erect annual, up to about 1 m tall; stem cylindrical, hairy; lower leaves alternate; stems and leaves with milky latex. The simple or lobed leaves are crowded towards the top of the stem, with a flat, dichotomously-branched, terminal inflorescence of small yellow flowers and large leafy bracts, often with a bright red or cream patch at the base. The inflorescence consists of many small, short-stalked flowers lacking petals but with conspicuous glands (Wilson 1981). Reproduction is by seeds which are shed with an explosive mechanism.

Importance

A weed of increasing importance in upland fields of rice and many other crops; also in wastelands, roadsides, boundaries of coffee plantations; very abundant locally. Seeds persist in the soil until favourable conditions allow germination and rapid growth, giving rise to large populations of the weed. It is an important weed in 23 tropical countries and present in at least 37 others. Its rapid growth enables it to compete successfully with crops, quickly forming a dense canopy over young crop plants. Dense populations of the weed, with its white sticky latex, may make it impossible to harvest the crop.

The young leaves are sometimes used as a vegetable, but are laxative if too much is eaten. The plant is said to have caused poisoning in livestock (Wilson 1981).

Natural enemies

Except possibly for *Alternaria* sp. and *Helminthosporium* sp. which have not been shown to be pathogenic to crop plants (Yorinori 1985), there are no records of apparently host

specific organisms attacking *Euphorbia heterophylla* (Table 4.9.1). However, it is known that a number of insects do attack it in Brazil, but this observation was incidental to a study of fungi and none of the insects were identified (E.G. Fontes, pers. comm. 1992). Although periodic collections were made in Trinidad in the early 1970's, no promising insects were encountered (Yaseen 1972).

There are few records (19 only) of insects attacking members of the genus *Euphorbia* in Brazil (Table 4.9.2) (d'Araujo e Silva et al. 1968a,b), indicating that little attention has so far been paid to *Euphorbia* spp. in this region. Six of the insects are polyphagous and too little is known about the others to arrive at a conclusion. Even if some are restricted to the Euphorbiaceae, it remains to be determined whether any will attack either *Euphorbia heterophylla* or *E. hirta*.

E. heterophylla is resistant to most herbicides and, in recent years, has become progressively more important in Brazil, particularly in the southern, soybean-producing states (Yorinori 1985), which suggests that its insect enemies, if any, may be heavily parasitised.

A biological control program has been in progress in Canada since the late 1960's against *Euphorbia cyparissias* and *E. pseudovirgata*, involving the introduction of some twenty species of insects from Europe. Several species have become established, with rather localised effects (Julien 1992). It is said that insects are generally unable to attack *Euphorbia* species because of the latex that flows freely from any wound and clogs the mouthparts (Best et al. 1980), but clearly some insects are adapted to deal with this problem.

The best known economic plant in the Euphorbiaceae is cassava, *Manihot esculenta* of South American origin. The insects attacking it there are comparatively well known, a factor that will aid the evaluation of the specificity of insects attacking *Euphorbia* spp. Another species of horticultural importance is poinsettia, *Euphorbia pulcherrima*.

Table 4.9.1 Natural enemies of *Euphorbia heterophylla*.

Species	Location	Other hosts	References
INSECTS			
Orthoptera			
ACRIDIDAE			
<i>Poeciloceris hieroglyphicus</i>	Sudan	beans, melons	Ba-Angood 1977, Ba-Angood & Khidir 1975
Hemiptera			
ALEYRODIDAE			
<i>Bemisia tabaci</i>	Thailand, Venezuela	cotton, polyphagous	Debrot & Centeno 1985, Nachapong & Mabbett 1979
ALYDIDAE			
<i>Leptocoris acuta</i>	PNG		F. Dori pers. comm. 1993
<i>Leptocoris oratorius</i>	PNG		F. Dori pers. comm. 1993
<i>Leptocoris solomonensis</i>	PNG		F. Dori pers. comm. 1993

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Table 4.9.1 (continued)

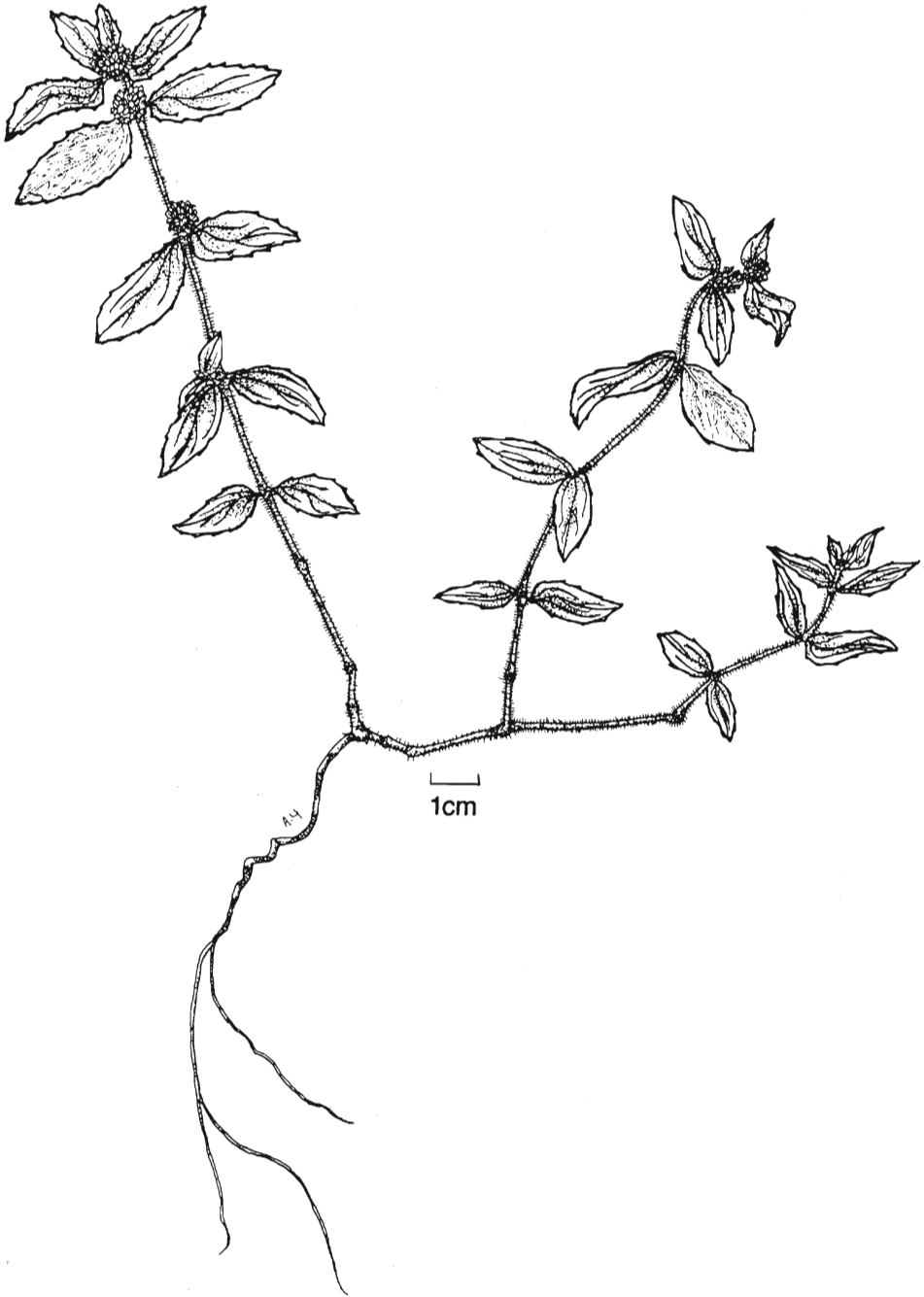
Species	Location	Other hosts	References
MITES			
TETRANYCHIDAE			
<i>Tetranychus urticae</i>	Cuba	polyphagous	Perez et al. 1987
FUNGI			
<i>Alternaria</i> sp.	Brazil		Yorinori 1985
<i>Amphobotrys ricini</i>	USA		Holcomb et al. 1989
<i>Elsinoe</i> sp.	Burundi	cassava	Zeigler & Lozano 1983
<i>Helminthosporium</i> sp.	Brazil		Fontes et al. 1992, Gazziero et al. 1988, Yorinori 1985
<i>Macrophomina phaseolina</i>	India		Saxena et al. 1981
<i>Phytophthora palmivora</i>	Sarawak	black pepper	Anon 1979
<i>Puccinia</i> sp.	Brazil		Fontes et al. 1992
<i>Rhizoctonia solani</i>	Brazil		Yorinori 1985
<i>Sclerotinia sclerotiorum</i>	Brazil		Yorinori 1985
<i>Sphaceloma</i> sp.	Brazil, Burundi	cassava	Yorinori 1985, Zeigler & Lozano 1983
<i>Uromyces euphorbiae</i>	Brazil		Yorinori 1985
NEMATODES			
<i>Meloidogyne exigua</i>	Brazil	coffee, many weeds	Luc et al. 1990
<i>Meloidogyne javanica</i>	Brazil		Lordello et al. 1988
<i>Rotylenchulus reniformis</i>	Florida		Inserra et al. 1989, MacGowan 1989
VIRUSES			
<i>Euphorbia</i> mosaic	Brazil, USA, Venezuela		Debrot & Centeno 1985, Kim & Flores 1979, Kim & Fulton 1984, Yorinori 1985

Table 4.9.2 Insects attacking species of *Euphorbia* in Brazil (d'Araujo e Silva et al. 1968a,b).

Insect	Hosts	Feeding habit
Hemiptera		
ALEYRODIDAE		
<i>Bemisia tabaci</i> (= <i>B. costa-limai</i>)	<i>Euphorbia hirtella</i> , tomato, <i>Mentha arvensis</i>	polyphagous
COCCIDAE		
<i>Coccus</i> spp.	Euphorbiaceae, <i>Acalypha</i> sp., <i>Aspidosperma ramiflorum</i> , <i>Cassia</i> sp., <i>Citrus</i> spp.	polyphagous

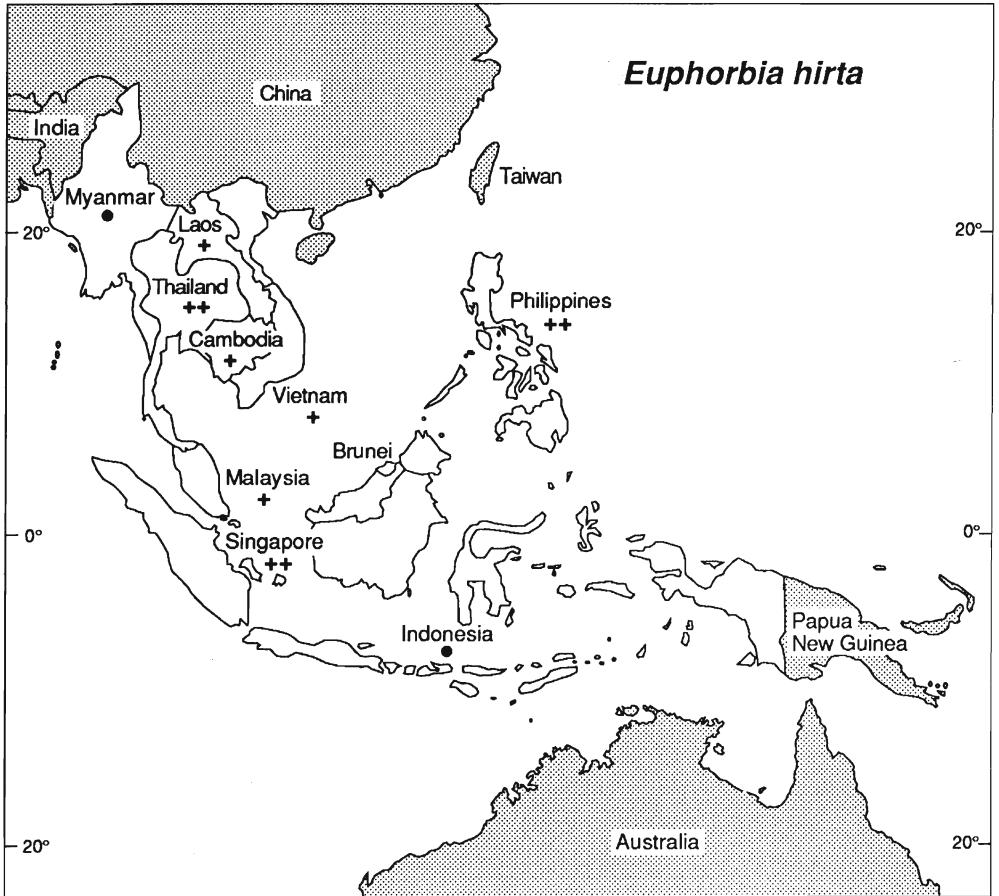
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Insect	Hosts	Feeding habit
<i>Eucalymnatus</i> spp.	<i>Euphorbia capansa</i> , <i>Nerium</i> sp., <i>Caryota</i> sp., <i>Phoenix</i> sp.	polyphagous
<i>Platinglisia noacki</i>	Euphorbiaceae, <i>Begonia</i> sp., <i>Eugenia</i> sp., <i>Grevillea robusta</i> , <i>Ilex</i> sp., <i>Laurus</i> sp., <i>Magnolia</i> <i>pumila</i> , etc.	polyphagous
COREIDAE		
<i>Chariesterus armatus</i>	<i>Euphorbia braziliensis</i>	possibly restricted
TINGIDAE		
<i>Corythuca pellucida</i>	Euphorbiaceae	possibly restricted
<i>Corythuca socia</i>	Euphorbiaceae	possibly restricted
Thysanoptera		
PHLAEOTHIRIPIDAE		
<i>Haplothrips gowdeyi</i>	<i>Euphorbia</i> sp., coffee, rice, <i>Crotolaria</i> sp., <i>Passiflora</i> sp., <i>Buddleia variabilis</i>	polyphagous
Coleoptera		
CHRYSOMELIDAE		
<i>Caryedes</i> (= <i>Gibbobruchus</i>) <i>pickeli</i>	Euphorbiaceae	possibly restricted
<i>Disonycha argentinensis</i>	<i>Euphorbia pulcherrima</i>	possibly restricted
<i>Gibbobruchus polycoccus</i>	Euphorbiaceae	possibly restricted
CURCULIONIDAE		
<i>Sternocoelus</i> sp.	Euphorbiaceae	?restricted to Euphorbiaceae
<i>Sternocoelus notaticeps</i>	Euphorbiaceae	?restricted to Euphorbiaceae
Lepidoptera		
LYMANTRIIDAE		
<i>Thagona tibialis</i>	<i>E. cespitosa</i> , <i>E. ovalifolia</i> , <i>E. pulcherrima</i>	?restricted to Euphorbiaceae
NOCTUIDAE		
<i>Spodoptera eridania</i>	Euphorbiaceae, many crops	polyphagous
NYMPHALIDAE		
<i>Didonis biblis</i>	Euphorbiaceae, <i>Tragia volubilis</i>	possibly restricted
<i>Dynamine artemisia</i>	Euphorbiaceae	?restricted to Euphorbiaceae
<i>Episcada pascua</i>	Euphorbiaceae	?restricted to Euphorbiaceae
SPHINGIDAE		
<i>Erinyis oenotrus</i>	<i>E. ovalifolia</i>	possibly restricted



Euphorbia hirta

(after Holm *et al.* 1977)



Map 4.10 *Euphorbia hirta*

There is only one record of a natural enemy attacking *Euphorbia hirta* in tropical America where it evolved and only a few of polyphagous species attacking it elsewhere. A survey in Central America would be necessary to determine what species attack it there that might be potential biological control agents.

4.10 *Euphorbia hirta* L.

(= *E. pilulifera*)

Euphorbiaceae

garden spurge, asthma plant; mayo (Myanmar), nam nom raatchasee (Thailand) tuk das khla thom (Cambodia), cò sua lông (Vietnam), ara tanah, hairy spurge (Malaysia) gelâng susu, gèndong âncok (Indonesia), gatas gatas (Philippines)

Rating

	++	Thai, Sing, Phil
10	+	Laos, Camb, Viet, Msia
	•	Myan, Indo

Origin

Tropical America.

Distribution

E. hirta is a weed of the tropics and subtropics.

Characteristics

A small, prostrate, hairy annual, 0.15 to 0.3 m tall, with a tap root; stems much branched from the base, often reddish, bearing brownish stiff hairs and having milky sap; leaves, hairy, opposite, sometimes purple-blotched and with toothed margins; flowers unisexual; reproduction by seeds 0.5 to 1 mm long.

Importance

E. hirta grows well in sunny to lightly shaded cultivated lands, gardens, lawns, waste areas and run down grasslands. It is an early coloniser of bare ground especially under damp or irrigated conditions. It flowers all year round in Southeast Asia producing up to 3000 seeds per plant. When the seed pods mature they explode to disperse the seeds. Its prostrate habit enables it to tolerate mowing and it can be important in lawns. It has been reported from 47 countries as a weed in many crops, including citrus, cotton, groundnuts, maize, pineapples, rice, sorghum, sugarcane, tea and vegetables. Moody (1989) records it as being more widespread in rice than *Euphorbia heterophylla*.

E. hirta is sometimes used in medicines in Fiji, Malaysia, Indonesia, the Philippines and Brazil—the leaves and latex against intestinal diseases, ulcers and bronchitis, and the latex for conjunctivitis. It may have slightly poisonous properties and is useless as fodder for livestock.

Natural enemies

In view of its common occurrence in the tropical and subtropical belt of the world, it is surprising that there are so few records of natural enemies attacking it, and those that do are highly polyphagous (Table 4.10.1). A survey in Central America would be necessary to learn more about its natural enemies that might have potential for biological control.

Table 4.10.1 Natural enemies of *Euphorbia hirta*.

Species	Location	Other hosts	References
INSECTS			
Orthoptera			
ACRIDIDAE			
<i>Chrotogonus trachypterus</i>	India	polyphagous	Chandra et al. 1983
Hemiptera			
APHIDIDAE			
<i>Aphis craccivora</i>	Nigeria, Uganda	polyphagous, a virus transmitter	Booker 1964, Davies 1972, Ofuya 1988
<i>Aphis gossypii</i>	India	polyphagous	Jeritta & David 1986
ALEYRODIDAE			
<i>Bemisia tabaci</i>	India	polyphagous, a virus transmitter	Jeyarajan et al. 1988
DELPHACIDAE			
<i>Tarophagus proserpina</i>	Philippines	polyphagous	Duatin & Pedro 1986
LYGAEIDAE			
<i>Nysius inconspicuus</i>	India	polyphagous	Thangavelu 1978
PSEUDOCOCCIDAE			
<i>Ferrisia virgata</i>	India	polyphagous	Jeritta & David 1986
Thysanoptera			
THRIPIDAE			
<i>Haplothrips euphorbiae</i>	India	possibly host restricted	Jeritta & David 1986
Diptera			
AGROMYZIDAE			
<i>Liriomyza bryoniae</i>	Europe	highly polyphagous	Spencer 1973, 1990
<i>Liriomyza strigata</i>	W. Europe, USSR	highly polyphagous	Spencer 1973, 1990
Lepidoptera			
NOCTUIDAE			
<i>Achaea janata</i>	Indonesia	polyphagous	Kalshoven 1981
FUNGI			
<i>Aecidium tithymali</i>	Thailand		Puckdeedindan 1966
<i>Amphobotrys ricini</i>	USA		Holcomb et al. 1989
<i>Cylindrocladium quinqueseptatum</i>	India		Sulochana et al. 1982
<i>Phytophthora palmivora</i>	Sarawak	black pepper	Anon 1979
PROTOZOA			
<i>Phytomonas</i> sp.	Venezuela		Barreto 1982
NEMATODES			
<i>Meloidogyne incognita</i>	Hawaii		Valdez 1968

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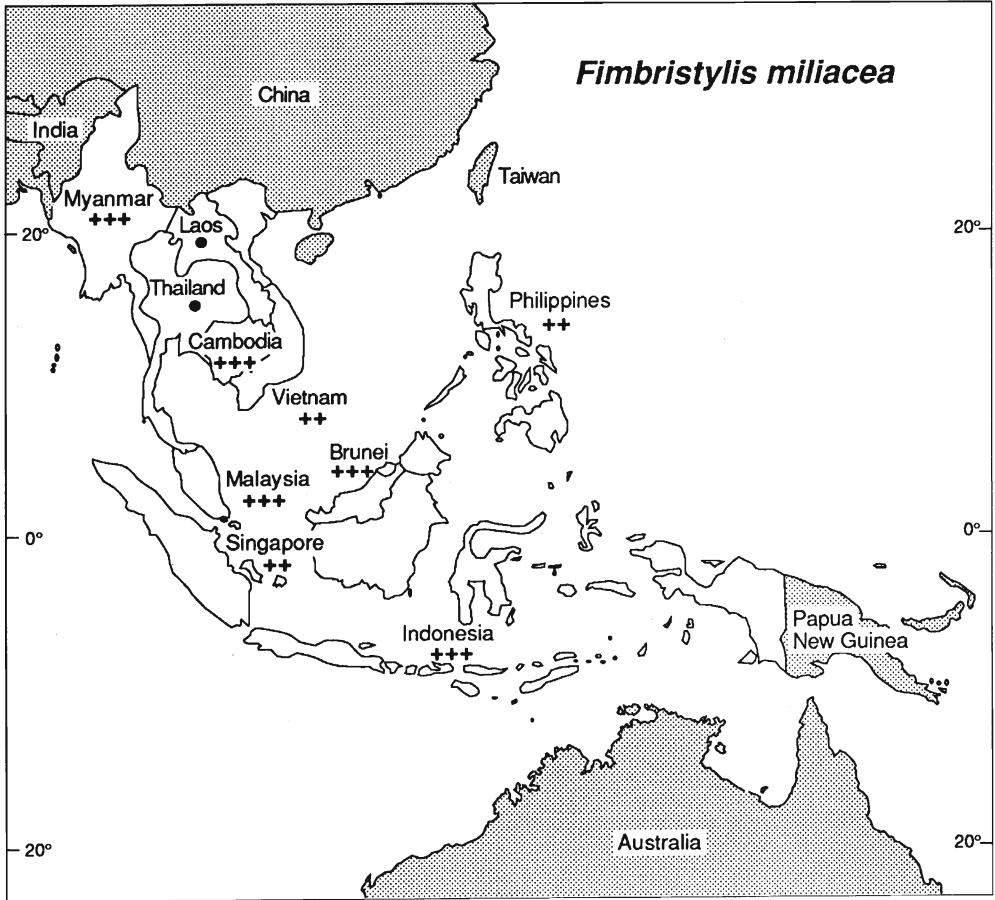
Table 4.10.1 (continued)

Species	Location	Other hosts	References
<i>Meloidogyne javanica</i>	India		Dahiya et al. 1988
<i>Radopholus similis</i>	Zimbabwe	polyphagous	Martin et al. 1969
<i>Rotylenchulus reniformis</i>		Hawaii, USA	Linford & Yap 1940, Inserra et al. 1989
VIRUSES			
groundnut rosette	Hawaii, Nigeria, Uganda		Adams 1967, Booker 1964, Davies 1972
hibiscus yellow vein mosaic	India		Jeyarajan et al. 1988
tapioca mosaic	India		Jeyarajan et al. 1988
tobacco leaf curl	Hawaii		Holm et al. 1977
tomato leaf curl	India		Jeyarajan et al. 1988
urd bean yellow mosaic	India		Jeyaragan et al. 1988



Fimbristylis miliacea

(after Holm *et al.* 1977)



Map 4.11 *Fimbristylis miliacea*

Very few natural enemies of *Fimbristylis miliacea* are known and it would be necessary to carry out a survey in tropical America before it would be possible to evaluate the prospects for its biological control.

4.11 *Fimbristylis miliacea* (L.) Vahl

(= *F. littoralis*)

Cyperaceae

lesser fimbristylis, grass-like fimbristylis; mônhnyin (Myanmar), kak phrèk kdam, smao (Cambodia), rumput bukit, rumput tahi berbau (Malaysia), agor (Thailand), ba bawagan (Indonesia)

Rating

	+++	Myan, Camb, Msia, Brun, Indo
23	++	Viet, Sing, Phil
	•	Thai, Laos

Origin

Tropical America.

Distribution

Central America, West Africa, Asia and Southeast Asia to northern Australia.

Characteristics

An erect annual or perennial sedge, growing up to 0.9 m; flower stems 4 or 5 angled, leaves two-ranked, threadlike, stiff and half as long as flower stems; inflorescence a diffuse compound umbel.

Importance

F. miliacea thrives in damp, open waste places, competing actively with other vegetation following germination during dry periods or shallow water conditions. A layer of water 15 cm deep suppresses germination. Seedlings emerge during the entire growing period of rice with which it competes actively. It is a troublesome weed in 21 countries. In Malaysia it is the first sedge to emerge after rice has been transplanted and the first to recover after ploughing. In the Philippines it flowers all year, plants each producing up to 10000 seeds. In many places there is no seed dormancy.

F. miliacea is one of the most serious and widespread weeds of rice and is also reported from taro (Hawaii), bananas (Taiwan), abaca (Philippines), maize, sugarcane (Indonesia, Taiwan) and sorghum (Malaysia).

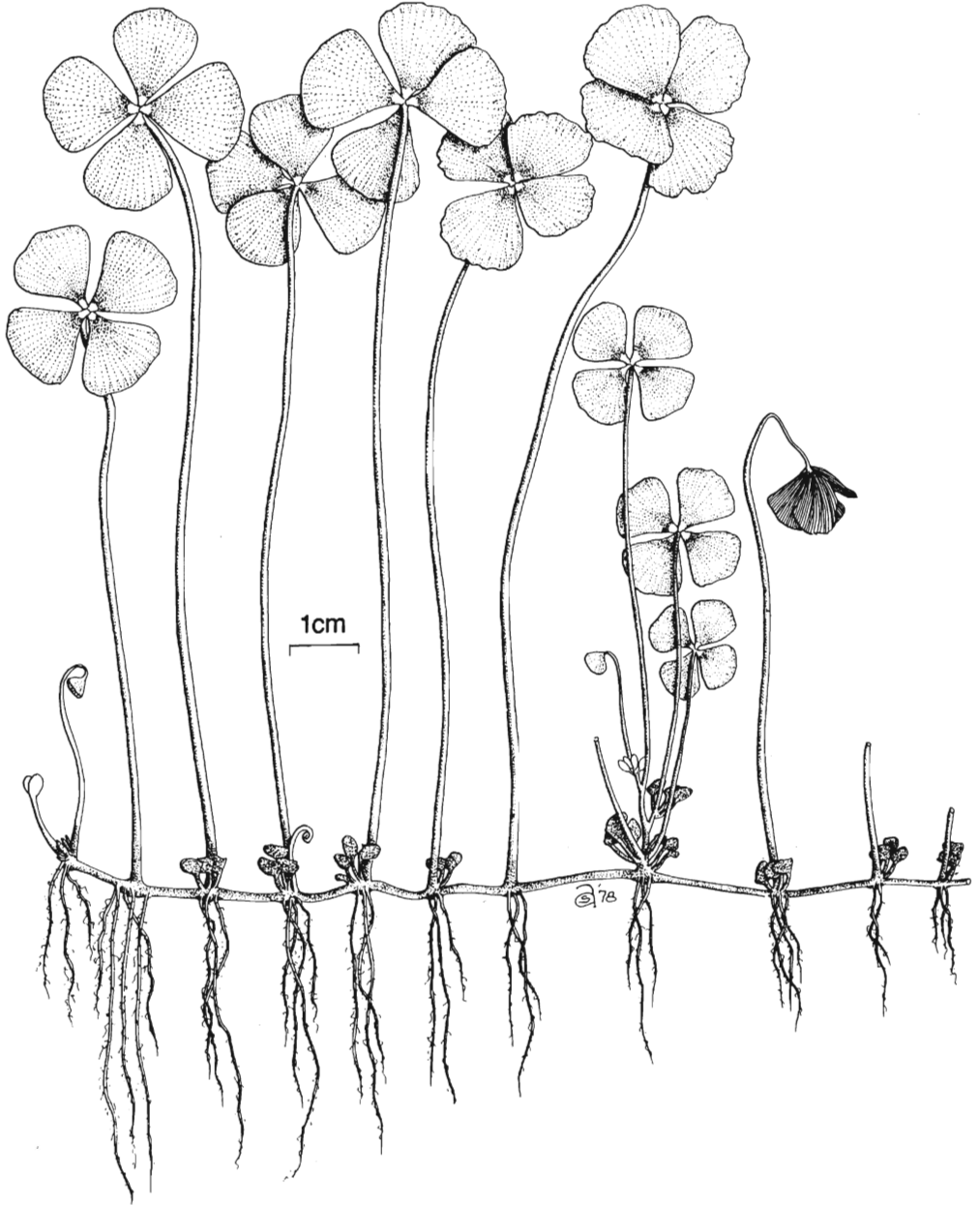
F. miliacea is eaten by cattle, but the seeds are mostly undigested and germinate near the dung.

Natural enemies

So little is known about its natural enemies (Table 4.11.1) that it is not possible to evaluate the prospects for biological control. A survey is necessary in tropical America.

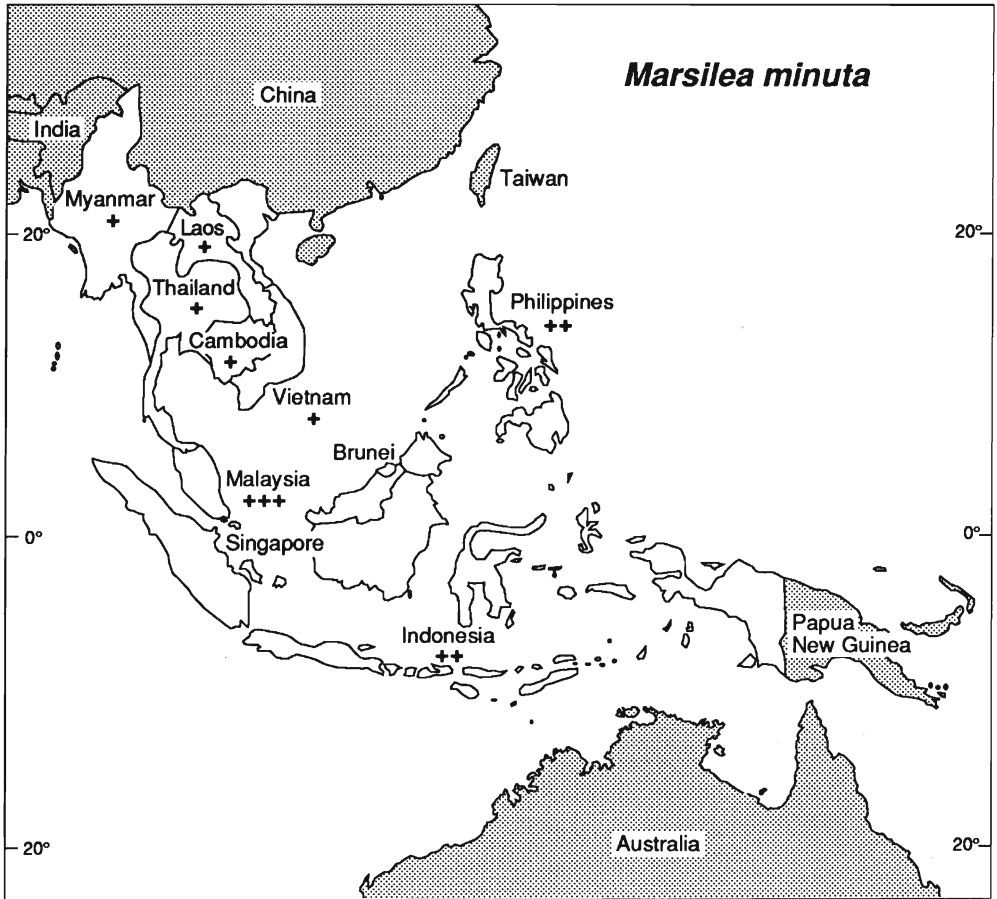
Table 4.11.1 Natural enemies of *Fimbristylis miliacea*.

Species	Location	Other hosts	References
INSECTS			
Hemiptera			
PENTATOMIDAE			
<i>Scotinophara latiuscula</i>	Philippines	rice, <i>Commelina benghalensis</i> , <i>Echinochloa crus-galli</i>	Barrion & Litsinger 1987
Lepidoptera			
<i>Creatonotos gangis</i> (= <i>Amsacta</i>)	Philippines	rice, many weeds	Catindig et al. 1993
FUNGI			
<i>Corticium sasakii</i>	India	<i>Commelina benghalensis</i> , <i>Cynodon dactylon</i> , <i>Eleusine indica</i> and other grasses	Roy 1973
NEMATODES			
<i>Criconemella onoensis</i> <i>Hirschmaniella</i> spp.		rice, many weeds rice, maize, sugarcane, many weeds	Luc et al. 1990 Luc et al. 1990
<i>Meloidogyne graminicola</i>	India	rice, many weeds	Luc et al. 1990, Rao et al. 1970
<i>Meloidogyne oryzae</i>	Surinam	rice, plantain, wheat, potato, tomato	Maas et al. 1978
<i>Rotylenchulus reniformis</i>	Trinidad	very polyphagous	Singh 1974



Marsilea minuta

(after Soerjani et al. 1987)



Map 4.12 *Marsilea minuta*

Marsilea minuta, water clover, is thought to be of tropical African origin, but no account of its natural enemies there is available. A survey would thus be required to evaluate the prospects for its biological control.

4.12 *Marsilea minuta* L.

(=*M. crenata*)

Marsileaceae

water clover, clover fern, pepperwort; pak vaen (Laos), chuntul phnom (Cambodia), semànggi (Indonesia), phak waen (Thailand), tapah itik (Malaysia) paang itik (Philippines).

Rating

	+++	Msia
12	++	Indo, Phil
	+	Myan, Thai, Laos, Camb, Viet

Origin

Africa or possibly tropical Asia (Jacobsen 1983). It consists of a complex of strains including a diploid ($n = 20$) and a sterile triploid ($2n = 60$) (Tryon and Tryon 1982).

Distribution

Marsilea minuta is widespread over most of the African continent and it is pantropical in Asia. The Marsileaceae contains about 65 species, of which 16 occur in Africa and, of these, *M. minuta* is amongst the most widespread (Jacobsen 1983).

Characteristics

A very variable, perennial water fern of aquatic or marshy sites. Its stems are creeping rhizomes rooted in the mud. Leaves are clover-like, with four leaflets borne on a petiole 2 to 30 cm long. Leaflets have fan-shaped, repeatedly bifurcating veins and normally float on the water surface. Sporocarps occur near the base of the petioles and usually occur under the mud or water surface. Reproduction is by spores or rhizomes.

Importance

Although *M. minuta* has a rating of 12 and is widely reported as a weed in Southeast Asia, there are surprisingly few references to it as a weed in the literature except for those dealing with chemical control. In Thailand it is common in rice fields and along canals and other waterways. It is one of the seven most important weeds in the Muda area of Malaysia (Itoh 1991a). It is one of the more important emergent weeds in shallow water rice fields in the central lowlands in Vietnam (Nguyen Van Vuong 1973) and in the lowland area of Vientiane in Laos (Sisounthone and Sisombat 1973). In Indonesia its vegetative growth and reproduction is very rapid. It can grow under water and, after weeding, rapidly re-establishes itself unless well buried in the soil. It is an effective competitor for nutrients, particularly in the early part of the growth period after transplantation of rice seedlings when *M. minuta* rapidly covers the ground surface. In the Philippines it caused 19% crop loss when sown together with rice (Suriapermana 1977).

The young leaves of water clover are sometimes eaten as a vegetable in Indonesia.

Natural enemies

Very little information concerning natural enemies emerged from computer-aided searches of the literature on *Marsilea minuta*, which also included searches of its synonyms: *M. crenata* and *M. erosus* in Asia and *M. diffusa*, *M. perrieriana* and *M. senegalensis* in Africa (Table 4.12.1). In Africa *Marsilea minuta* appears to be regarded, at most, as a minor weed. This is possibly due to the fact that rice is far less important there than in Asia, or it may be due to the presence of effective natural enemies in Africa, although these have not yet been reported.

In the Philippines, larvae of the ephydrid flies *Notiphila latigenis* and *N. similis* are common on emergent *M. minuta* and damage its stems. Their eggs are usually laid on the stems and serve as alternative hosts of *Trichogramma* wasps attacking rice stem borers (Barrion and Litsinger 1986). The contents of upwards of 90% of the sporocarps from *M. minuta* growing under terrestrial conditions in northwestern India were destroyed by larvae of the weevil *Echinochneumus*. The larval and pupal stages are completed in 40 to 45 days (Loyal and Kumar 1977). In Indonesia the case-forming larvae of the widely distributed pyralid moth *Elophila* (= *Nymphula*) *responsalis* attacked *M. minuta* and several other aquatic plants including *Salvinia* spp., *Lemna purpusilla*, *L. polyrhiza*, *Monochoria vaginalis*, *Azolla pinnata* and *Pistia stratiotes*. However, tests have shown that it will not feed on rice. The development period of *Elophila responsalis* ranged from 42 to 56 days. It was attacked by a pupal parasitoid (*Tetrastichus* sp.) and a larval coleopteran predator (Handayani and Syed 1976, Sankaran and Rao 1972, Subagyo 1975). *Elophila responsalis* occurs also in India, Sri Lanka, Myanmar, Japan and Australia.

Comment

A survey for natural enemies attacking *M. minuta* in Africa is required before the prospects for its biological control in Southeast Asia can be evaluated.

Table 4.12.1 Natural enemies of *Marsilea minuta*.

Species	Location	References
INSECTS		
Coleoptera		
CURCULIONIDAE		
<i>Echinochneumus</i> sp.	India	Loyal & Kumar 1977
Diptera		
EPHYDRIDAE		
<i>Notiphila latigenis</i>	Philippines	Barrion & Litsinger 1986
<i>Notiphila similis</i>	Philippines	Barrion & Litsinger 1986

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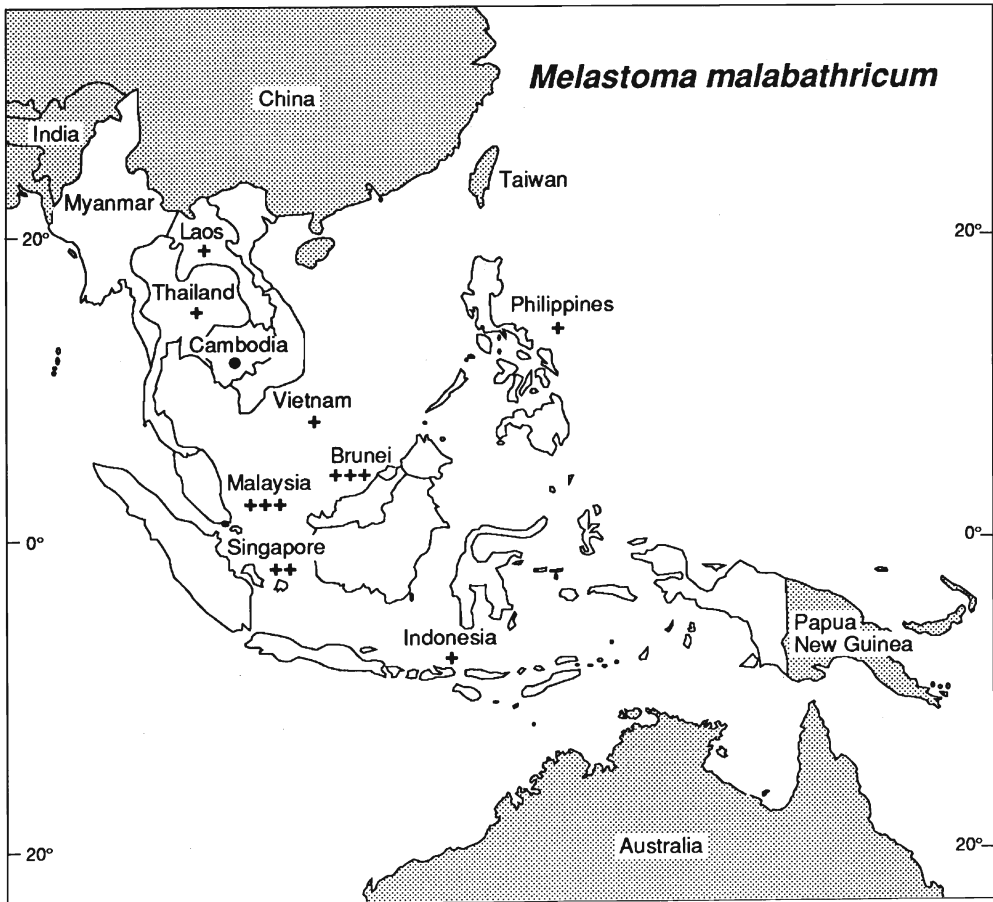
Table 4.12.1 (continued)

Species	Location	References
Lepidoptera		
PYRALIDAE		
<i>Elophila</i> (= <i>Nymphula</i>) <i>responsalis</i>	India, Indonesia	Handayani & Syed 1976, Sankaran & Rao 1972, Subagyo 1975
FUNGI		
<i>Alternaria</i> sp.	India	Menon & Ponnappa 1964
<i>Cercospora marsileae</i>	India	Patil 1975
<i>Phaeotrichoconis crotalariae</i>	India	Menon & Ponnappa 1964
VIRUS		
<i>Pistia</i> virus	India	Menon & Ponnappa 1964



Melastoma malabathricum

(after Soerjani *et al.* 1987)



Map 4.13 *Melastoma malabathricum*

M. malabathricum is a perennial shrub which probably originated in Southeast Asia or neighbouring areas, including Irian Jaya, Papua New Guinea and northern Australia, a region where it is regarded as being of little importance. A survey in this region would reveal whether there are promising natural enemies for biological control.

4.13 *Melastoma malabathricum* L.

(= *Melastoma affine*)

Melastomataceae

melastoma, Indian rhododendron, Straits rhododendron; senduduk (Malaysia)

Rating

	+++	Msia, Brun
13	++	Sing
	+	Thai, Laos, Viet, Indo, Phil
	•	Camb

Origin

Asia, Papua New Guinea, Australia.

Characteristics

M. malabathricum is a perennial shrub growing to 2 m high; its stems are reddish with rough upwardly pointing scales, the leaves are tapered to both ends, are rough to touch and have three distinct ribs. The flowers, which are clustered at the ends of twigs, are pinkish to light violet. The fruit is a berry-like capsule covered with scales.

Importance

Melastoma is common in abandoned clearings, on waste ground and in cultivated lands. In addition to its importance in Southeast Asia, it is a principal weed of rubber in West Africa. It is said to make good firewood. The sweetish black seeds are eaten and chewed leaves are used for burns and against amoebic dysentery. The fruits host a fruit fly species in the *Bactrocera dorsalis* complex which does not attack commercially important fruits (R.A.I. Drew, pers. comm.).

Natural enemies

Krauss (1965) surveyed the natural enemies of species of *Melastoma*, including *M. malabathricum*, in various countries of Southeast Asia and islands of the western Pacific. Twenty six insect species were found on *M. malabathricum* (Table 4.13.1) and a further 34 species on other melastomas. It is very likely that some of the 34 species will also attack *M. malabathricum* and, indeed, the leaf rolling pyralid moth *Ategumia fatualis* does so. After specificity tests *Ategumia fatualis* was liberated in Hawaii and Kauai in 1958 and became established, although it did not become sufficiently abundant to provide effective control (Table 4.13.2) (Krauss 1965).

Another leaf-rolling pyralid *Ategumia adipalis* was liberated in 1965, and was reported to have become established (Davis and Chong 1969), but at low population levels. Next a noctuid moth *Selca brunella* was introduced to Kauai and Hawaii from Malaysia and Singapore in 1964 and was recovered the next year. The larvae feed avidly

in flower buds, bore into terminal stems and eat leaves. In heavily infested localities considerable dieback has resulted, at places flowering was prevented and in others up to 50% of fruits were destroyed by larvae. Larvae have been found recently on *Tiboochina urvilleana* and *Heterocentron subtriplinenum* (both Melastomataceae) in Hawaii (C.J. Davis pers. comm. 1993). A braconid wasp *Meteorus* sp. attacks *S. brunella* larvae (Davis 1970, Davis and Chong 1969).

An unidentified grasshopper and an unidentified lepidopterous larva attack *M. malabathricum* in Thailand but not the chrysomelid beetle *Altica cyanea* which is present there and attacks it in Indonesia and Malaysia (Napompeth 1982).

Comment

Although a number of insects are known to attack *M. malabathricum* in Southeast Asia (and especially in Malaysia), they clearly do not reduce its status to the level required and thus are of limited value for classical biological control in that region. However, if as postulated, the area of origin includes Papua New Guinea, (Irian Jaya) and Australia it is possible that there may be useful natural enemies in the region that do not occur in countries to the north and west. Certainly, *Melastoma* is not listed as an important weed in Papua New Guinea.

Table 4.13.1 Natural enemies of *Melastoma malabathricum*.

Species	Country	Food	References
INSECTS			
Hemiptera			
APHIDIDAE			
<i>Aphis</i> sp.	Singapore	leaf	Krauss 1965
CICADELLIDAE			
<i>Tettigella</i> (= <i>Tettigoniella</i>) sp.	Malaysia	leaf	Krauss 1965
COCCIDAE			
<i>Rastrococcus</i> sp.	Malaysia	leaf	Krauss 1965
MEMBRACIDAE			
<i>Gargara</i> sp.	Malaysia		Krauss 1965
<i>Leptocentrus taurus</i>	Malaysia	branch; also on <i>Melastoma</i> <i>polyanthum</i>	Krauss 1965
<i>Nilautama minutispina</i>	Malaysia		Krauss 1965
<i>Sipylus dilatatum</i>	Malaysia		Krauss 1965
<i>Sipylus</i> sp.	Malaysia	branch	Krauss 1965
<i>Tricentrus</i> sp.	Malaysia	branch	Krauss 1965
	Singapore	branch	Krauss 1965
MIRIDAE			
<i>Helopeltis antonii</i>	Indonesia		Soerjani et al. 1987
<i>Hyalopeplus vitripennis</i>	Malaysia	leaf	Krauss 1965
RICANIIDAE			
<i>Pochazia antica</i>	Malaysia	leaf	Krauss 1965

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Table 4.13.1 (continued)

Species	Country	Food	References
Coleoptera			
CHRYSOMELIDAE			
<i>Altica cyanea</i>	Indonesia, Malaysia		Kamarudin & Shah 1978, Napompeth 1982
CURCULIONIDAE			
<i>Alcidodes</i> sp.	Malaysia	shoot	Krauss 1965
<i>Ceutorhynchus</i> sp.	Malaysia	flowers	Krauss 1965
<i>Cryptorhynchus</i> sp.	Malaysia	flowers	Krauss 1965
<i>Imerodes</i> (?) sp.	Singapore	flowers	Krauss 1965
Diptera			
TEPHRITIDAE			
<i>Bactrocera dorsalis</i> (= <i>B. pedestris</i>)	Malaysia, Singapore, Sri Lanka	fruit	Krauss 1965
Lepidoptera			
ARCTIIDAE			
Species of Lithosiinae	Malaysia	fruit	Krauss 1965
GELECHIIDAE			
<i>Idiophantis</i> sp.	Malaysia	fruit	Krauss 1965
HYPONOMEUTIDAE			
<i>Argyresthia leuculias</i>	Malaysia	fruit	Krauss 1965
LYMANTRIIDAE			
?Species	Malaysia	flower	Krauss 1965
NOCTUIDAE			
<i>Autoba</i> (= <i>Eublemma</i>) <i>versicolor</i>	Malaysia	leaf	Krauss 1965
<i>Selca brunella</i>	Malaysia, Singapore	leaf, twig, fruit	Julien 1992, Krauss 1965
PYRALIDAE			
<i>Agrotera basinotata</i>	Malaysia	leaf	Krauss 1965
<i>Ategumia adipalis</i>	Malaysia, Singapore	leaf	Julien 1992, Krauss 1965
<i>Ategumia fatualis</i>	Philippines	leaf	Krauss 1965
TORTRICIDAE			
<i>Archips micaceana</i>	Malaysia	leaf	Krauss 1965
FUNGI			
<i>Phytophthora palmivora</i>	Sarawak	black pepper	Anon 1979

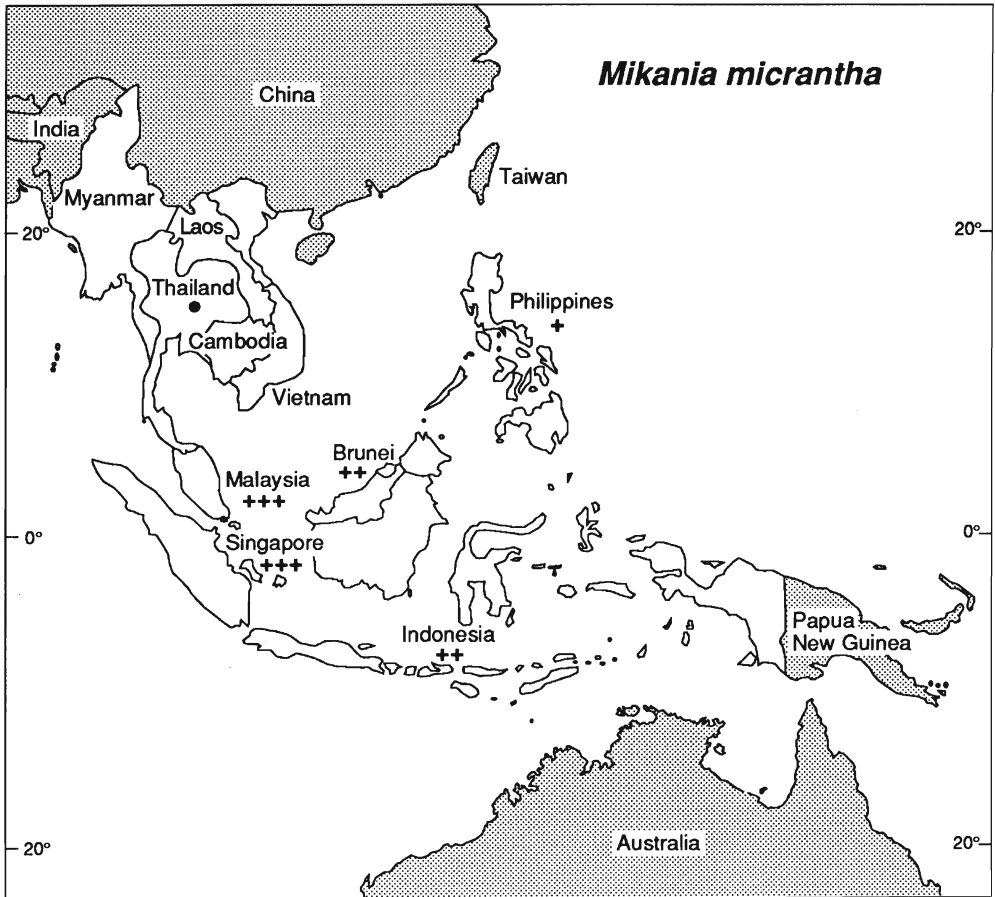
Table 4.13.2 Introductions to Hawaii for the biological control of *Melastoma malabathricum*.

Species	Source	Liberated	Established	References
INSECT				
Lepidoptera				
NOLIDAE				
<i>Selca brunella</i>	Malaysia, Singapore	1965	+	Davis 1960, Davis & Chong 1968, Davis & Krauss 1962, 1966, 1967, Julien 1992, Krauss 1965
PYRALIDAE				
<i>Ategumia adipalis</i>	Malaysia, Singapore	1965	+	Davis & Chong 1969, Julien 1992
<i>Ategumia fatualis</i>	Philippines	1958	+	Davis & Krauss 1966, Julien 1992



Mikania micrantha

(after Holm *et al.* 1977)



Map 4.14 *Mikania micrantha*

Mikania micrantha is a perennial vine, native to Central and South America.

A number of very promising, and probably specific, natural enemies are known in Central and South America where *M. micrantha* is not regarded as a weed. One of these, a thrips *Liothrips mikaniae* has been released in Malaysia and the Solomon Is, but extremely high predation is believed to have prevented its establishment. A bug *Teleonemia* sp., several chrysomelid beetles and an eriophyid mite *Acalitus* sp. warrant serious consideration. A number of other natural enemies, whose specificity has not yet been adequately investigated, also attack *M. micrantha*.

In spite of the lack of success with the thrips, *M. micrantha* appears to be a prime target for the introduction of one or more of the other organisms that attack it in its area of origin.

4.14 *Mikania micrantha* Kunth

Asteraceae

mile-a-minute weed; cheroma, ulam tikus (Malaysia), sembung rambat (Indonesia).

This chapter updates that in Waterhouse and Norris (1987), with special reference to Southeast Asia.

Rating

	+++	Msia, Sing
11	++	Brun, Indo
	+	Phil
	•	Thai

Origin

The weedy species in Southeast Asia and the Pacific is *M. micrantha* from Central and South America and not the North American *M. scandens* or the Old World *M. cordata* (Parker 1972).

Distribution

M. micrantha belongs to a genus containing about 250 species of mostly Central and South American origin. In addition to its native distribution in tropical America, it has spread to Mauritius, India, Sri Lanka, Bangladesh and Southeast Asia (as above). It occurs widely as a weed in the Pacific, including Papua New Guinea (Waterhouse and Norris 1987), but is not yet present in Australia. It was introduced from Paraguay to Bogor Botanic Gardens (Indonesia) in 1949 and, in 1956, was used as a soil cover in rubber: it has since spread throughout Indonesia (Soerjani et al. 1987).

Characteristics

Mikania micrantha is an extremely fast growing, sprawling, perennial vine, with opposite, heart-shaped leaves, longitudinally ribbed, branched and hairless stems and numerous small heads of densely clustered white flowers. It creeps and twines, roots readily at the nodes and produces abundant small (2 mm long) black seeds bearing a terminal tuft of white bristles that aid wind dispersal.

In its natural habitat in tropical America, *M. micrantha* is usually found in disturbed situations. It seldom occurs on poor soils and is most commonly found in damp or swampy places. Typical sites in South America are roadsides in wet forest and the edges of freshwater swamps. Flowering occurs mainly in the dry season and only in sunny situations (Cock 1982a).

Importance

With its rapid growth, ready rooting at nodes, smothering habit and prolific seed production, *M. micrantha* rapidly colonises disturbed habitats, retarding, by competition and

through plant inhibitors that it elaborates (Wong 1964), the growth of crops or natural vegetation. In comparison with a nitrogen-fixing legume, it is of restricted value in the role of a cover crop. For example, in Malaysia the girth of rubber trees was 27% less with a cover of *M. micrantha* than of a legume and the yield over the first 32 months of production was 27 to 29% less (Teoh et al. 1985). In many parts of Southeast Asia it is a serious pest of plantation crops (oil palm, coconut, cocoa, tea, rubber, teak). Its climbing habit enables it to reach and then dominate the crowns of bushes or trees up to 10m high, where it is difficult to attack either mechanically or chemically without risk of damaging the crop (Parker 1972). It recovers rapidly from slashing. It is eaten by cattle, but is less valuable as fodder than many of the pasture plants it is able to smother. Nevertheless, it is viewed by some as being useful to control soil erosion, to serve as a mulch when cut, and as being preferable to many alternative plants that might occupy the space vacated by its control. In its native habitat it is seldom a weed.

Natural enemies

MAJOR SPECIES

TROPICAL AND SOUTH AMERICA

Valuable information is available on 9 major and 22 minor natural enemies of *M. micrantha* in its native region as a result of studies by Cock (1982a,b) and Freitas (1991). Several of the major natural enemies are reported to be promising biological control agents (Table 4.14.1) and all these, and probably some of those less extensively studied (Table 4.14.2), are worthy of serious consideration. Details of their biology and possible relevance for biological control are summarised below.

Table 4.14.1 Major natural enemies of *Mikania micrantha* in its native range in Central and South America (after Cock 1982a).

INSECTS

Thysanoptera

PHLAEOTHIRIPIDAE

Liothrips mikaniae

Hemiptera

TINGIDAE

Teleonemia sp. or spp. nr *prolixa*

Coleoptera

CHRYSOMELIDAE

Desmogamma conjuncta

Echoma marginata

Echoma quadristillata

Physimerus pygmaeus

APIONIDAE

Apion luteirostre

CURCULIONIDAE

Pseudoderelomus baridiiiformis

MITE

ERIOPHYIDAE

Acalitus sp.

Table 4.14.2 Additional natural enemies of *Mikania micrantha*, not known to be polyphagous, from Central and South America (Cock 1982a, Freitas 1991).

Species	Distribution	Feeding location	Host range
INSECTS			
Hemiptera			
LYGAEIDAE			
<i>Xyonysius basalis</i> (= <i>X. inaequalis</i> = <i>X. sp. nr ementitus</i>)	Trinidad, Venezuela	inflorescence	Probably other <i>Mikania</i> spp. or other Asteraceae
MEMBRACIDAE			
<i>Entylia sinuata</i>	Colombia, Costa Rica	stems and leaves	<i>M. cordifolia</i>
<i>Entylia sp.</i>	Trinidad, Peru, Venezuela	stems and leaves	<i>M. cordifolia</i>
<i>Micrutalis binaria</i>	Ecuador Trinidad, Colombia	stems and young leaves	<i>M. vitifolia</i> and <i>M. trinitaria</i>
MIRIDAE			
<i>Pycnoderes incurvus</i>	Colombia, Ecuador, Costa Rica	leaves	probably specific
TINGIDAE			
<i>Leptocysta sexnebulosa</i>	Venezuela Colombia, Peru	mature leaves	<i>M. cordifolia</i>
Coleoptera			
CHLAMISIDAE			
<i>Exema complicata</i>	Trinidad, Peru, Costa Rica, Colombia	leaves	<i>Mikania</i> spp., <i>Chromolaena</i> <i>odorata</i> and possibly other Asteraceae
CHRYSOMELIDAE			
<i>Longitarsus sp.</i> nr <i>amazonus</i>	Colombia, Peru	leaves	probably specific
<i>Sceloenopla sp.</i>	Trinidad	leaves	<i>M. trinitaria</i>
Diptera			
AGROMYZIDAE			
<i>Calycomyza mikaniae</i>	Trinidad, Colombia, Costa Rica	leaf miner	<i>Mikania</i> spp. and possibly related Asteraceae
CECIDOMYIIDAE			
<i>Neolasioptera sp.</i>	Trinidad, Colombia	flowers	<i>M. cordifolia</i>
TEPHRITIDAE			
<i>Xanthaciura insecta</i>	Trinidad	flower head	various Asteraceae
Lepidoptera			
GELECHIIDAE			
<i>Onebala tegulella</i>	Trinidad, Costa Rica	leaf roller	<i>M. vitifolia</i>
<i>Recurvaria sp.</i>	Trinidad	flowers	various Asteraceae

(continued on next page)

Species	Distribution	Feeding location	Host range
GEOMETRIDAE			
<i>Chloropteryx</i> sp.	Trinidad	flowers	various Asteraceae
<i>Eupithecia</i> sp.	Trinidad	flowers	various Asteraceae
LYCAENIDAE			
<i>Thereus</i> (= <i>Thecla</i>) <i>palegon</i>	Trinidad	flowers	various Asteraceae
NYMPHALIDAE			
<i>Tegosa claudina</i> (= <i>Tegosa similis</i>)	Brazil, Trinidad, Colombia	leaves	possibly specific
PTEROPHORIDAE			
<i>Adaina bipuncta</i>	Trinidad	flowers	various Asteraceae
PYRALIDAE			
<i>Lamprosema distincta</i>	Trinidad, Panama, Costa Rica	leaf roller	possibly specific
TORTRICIDAE			
<i>Lobesia</i> (= <i>Polychrosis</i>) <i>?carduana</i>	Trinidad	flowers	various Asteraceae
<i>Phalonidia</i> <i>multistrigata</i>	Trinidad	flowers	various Asteraceae

***Acalitus* sp. Acarina: Eriophyidae**

Feeding on the leaves by this eriophyid mite causes the formation of raised patches (erinea) in which the mites and their immature stages congregate. In Venezuela the patches mostly protrude on the undersurface of the leaf, whereas elsewhere they are mostly on the uppersurface, which may indicate taxonomic differences. At low mite densities the small number of erineum patches appear to have little effect on the growth and vigour of the plant. However, in dense infestations, erineum patches cover all the young leaves and spread into the flower heads, resulting in shortened internodes and reduced flowering. Plant vigour is significantly reduced.

Eriophyid mites are usually restricted to a single plant species. Although erineum patches occur widely on *M. micrantha*, they were not seen on any other species of *Mikania* encountered in Cock's (1982a) studies, suggesting a high degree of specificity. Predatory or scavenger mites occur quite commonly in and around the erineum patches. If field specificity trials with potted plants of closely related Asteraceae placed among heavily infested *M. micrantha* prove negative, this mite would be a promising biological control agent. Similar mites on *Lantana* in South America appear to discourage insect attack (K.L.S. Harley pers. comm.).

***Apion luteirostre* Coleoptera: Apionidae**

Eggs of this weevil are laid in unopened host flower heads. Larvae feed initially on the petals, stigma and stamens and, later, destroy the developing seeds. They pupate in the flower head. The adults make small holes in young leaves.

In extensive field studies *A. luteirostre* larvae were not recorded from *Chromolaena odorata*, although they were found on *M. micrantha* and *M. vitifolia*, but not on *M. cordifolia*. Starvation tests using adults resulted in their feeding on five species of *Mikania* and on *Bidens pilosa*, but not on *Chromolaena odorata*.

Larvae of *Apion luteirostre* are attacked by the non-specific eulophid parasitoid *Horismenus? aeneicollis* and the pteromalid *Zatropis* sp. A number of *Apion* species have been used successfully in biological control of weeds programs (e.g. *Emex australis* and *E. spinosa*). Further host specificity trials are needed to evaluate the potential value of *A. luteirostre*.

***Desmogramma conjuncta* Coleoptera: Chrysomelidae**

This chrysomelid beetle occurs widely, but at low density, on *M. micrantha* in Central and South America and a related species *D. bigaria* occurs on *M. micrantha* in Venezuela.

Eggs are laid on the host leaves on which the larvae feed. Pupation occurs in the soil. No field records are available of feeding on plants other than *M. micrantha* and, in limited multiple choice tests, adults offered *Bidens pilosa* (cobble's pegs), *Chromolaena odorata* and *M. micrantha* (all Asteraceae) attacked only the latter. No natural enemies have been recorded.

The chrysomelid subfamily Chrysomelinae to which this species belongs includes several successful biological control agents such as the *Chrysolina* species on St John's Wort, *Hypericum perforatum angustifolium*. If species of *Desmogramma* are specific to *M. micrantha* they may prove to have potential as biological control agents.

***Echoma (= Omoplata) marginata* and *E. quadristillata* Coleoptera: Chrysomelidae**

Adults and larvae of these chrysomelid beetles feed openly on *M. micrantha* and *M. cordifolia* leaves and cause general defoliation. *E. marginata* is uncommon, but *E. quadristillata* is quite common around Turrialba (Costa Rica). They appear to have a low reproductive potential (Cock 1982a). In limited-choice tests, *E. quadristillata* fed on *M. micrantha* and *M. cordifolia*, but not on *Bidens pilosa* or *Sonchus* sp. (Asteraceae). In another experiment, no preference was shown between its two host species, but it would not feed on another species of *Mikania*, which was probably *M. vitifolia*.

A tachinid pupal parasitoid *Hyalomyodes triangulifer* is known from *E. marginata* and a chalcidid pupal parasitoid *Brachymeria russelli* from *E. quadristillata*.

***Liothrips mikaniae* Thysanoptera: Phlaeothripidae**

This thrips occurs in Colombia, Costa Rica, Peru, Surinam, Trinidad and Venezuela. The eggs are mainly laid on the undersurface of the host plant leaves or at the base of leaf stalks and the larvae feed there in groups. The prepupae and pupae are found among leaf litter beneath the plant and the adults return to the youngest leaves to feed, mate and oviposit. *L. mikaniae* has been found only on *M. micrantha* growing in full sunshine and it never occurs on plants in shady situations. This limits its potential effectiveness to sunlit stands of the weed. The life cycle (egg to egg-laying adult) takes about 35 days, males living about 28 days, females about 35 days and laying between 21 and 111 eggs (Ooi et al. 1993). The feeding by larvae and adults on the young leaves produces small to moderate-sized lesions on the undersurface, which dry to form brown scars and these cause extensive distortion of the leaves as they grow.

Laboratory studies in Trinidad (Cock 1982b) and field observations (Cock 1981, 1982a,b) show that *L. mikaniae* is restricted to the genus *Mikania* and most probably to

M. micrantha, although *M. cordifolia* and *M. vitifolia* may be fed on to a limited extent in the laboratory. Additional studies carried out in England by CIBC confirmed its host specificity before permission was obtained to introduce *L. mikaniae* to Malaysia. Rearing methods are described by Cock (1982b) and Ooi et al. (1993).

***Physimerus pygmaeus* Coleoptera: Chrysomelidae**

This halticine chrysomelid is one of a group of five *Physimerus* species occurring on *M. micrantha* in South America.

The larval feeding habits are unknown, but they may attack roots. The adults feed on young leaves and petioles, causing the dieback of growing tips, and they may be destructive when in high densities. This species is uncommon in Trinidad, where it is restricted to shady conditions, whereas in Colombia it also occurs in the open.

Adults of *P. pygmaeus* have been found feeding on both *M. vitifolia* and *M. hookeriana*, in addition to *M. micrantha*. Field-collected adults fed on *Bidens pilosa*, but not on *Chromolaena odorata*. No natural enemies have been recorded. Further specificity tests with larvae and adults would be necessary before the potential of this species could be evaluated. Various halticine beetles, *Longitarsus* spp., show great promise for the biological control of ragwort *Senecio jacobaea*, Paterson's curse *Echium plantagineum* and common heliotrope *Heliotropium europaeum*.

***Pseudoderelomus baridiiformis* Coleoptera: Curculionidae**

Larvae of this weevil are not known and may be root or stem gall feeders. The adult burrows into the flowers, damaging the petals, stamens and stigma and prevents seed production from the flowering head it occupies. When common, levels of 25% damage have been recorded.

Adults of *P. baridiiformis* occur mainly in the flowers of *M. micrantha*, but have also been recorded from *M. trinitaria* and *M. vitifolia*. They occur rarely in the flowers of *Chromolaena odorata* and have been recorded once from *Neurolaena lobata*. No natural enemies are known.

Although the level of damage caused may be considerable, further studies of life history and host specificity are required.

***Teleonemia* sp. or spp. nr *prolixa* Hemiptera: Tingidae**

A taxonomic study of the bug genus *Teleonemia* (which contains more than 80 species) is required to enable the determination of correct identity of the one or more species of brown tingid bugs feeding on *Mikania* flowering heads. The species is not *T. prolixa*, which is highly specific to *Lantana camara* (Harley and Kassulke 1975).

The eggs are laid into the flower bracts and the nymphs and adults feed on the flower heads, but do not appear to cause much damage at low densities. Faeces deposited on the opening flowers may be sufficient to prevent seed production, particularly when these serve as a substrate for fungal growth. *T. harleyi* in Trinidad has a similar life cycle and feeding habits in *Lantana camara* flowers (Harley and Kassulke 1975).

Adults and nymphs of *Teleonemia* were found by Cock (1982a) on a number of *Mikania* species (*micrantha*, *vitifolia*, *trinitaria*, *hookeriana*). Although *T. prolixa* has been recorded from *Cinchona* sp. (Drake and Poor 1938), *Lantana camara* (Monte 1939)

and *Acacia riparia* (Drake and Ruhoff 1965), the records for *Cinchona* and *Acacia* appear to be in error (Harley and Kassulke 1975). A parasite attacks the eggs of *Teleonemia* and the lygaeid *Xyonysius* sp. in *M. micrantha* flowers. *Teleonemia scrupulosa* has been used in a number of countries to considerable effect to help in the control of *Lantana camara*. If the flower-feeding *Teleonemia* that attack *Mikania* cause similar effects through injection of saliva, they may cause more damage than is apparent at first sight.

MINOR SPECIES

Cock (1982a) and Freitas (1991) list a further 22 species of insects attacking *M. micrantha* in Central and South America (Table 4.14.2). There are 7 species of Hemiptera, 3 Coleoptera, 10 Lepidoptera and 3 Diptera. Five of these are considered at this stage of knowledge to be promising.

Exema complicata Coleoptera: Chlamisidae

Adults and larvae of this beetle are leaf feeders on *Mikania* spp., *Chromolaena odorata* and perhaps other Asteraceae.

Longitarsus nr *amazonus* Coleoptera: Chrysomelidae

Adults of this halticine beetle feed on leaves of *M. micrantha* and larvae probably on roots. *Longitarsus* species generally have a very restricted host range.

Neolasioptera sp. Diptera: Cecidomyiidae

The larvae of this fly feed within the flower head and scar the seed shell, but the effect of this damage on seed viability is unknown. This species is parasitised by a eulophid *Tetrastichus* sp.

Sceloenopla sp. Coleoptera: Chrysomelidae

Adults of this hispine beetle feed on leaves and larvae are leafminers on *M. micrantha* and *M. trinitaria*. *Horismenus? aeneicollis* is recorded as a larval parasitoid. Hispine beetles have proved to be very effective against *Lantana camara*.

Tegosa claudina Lepidoptera: Nymphalidae

Earlier referred to as *Tegosa similis*, the larvae of this butterfly are leaf feeders on both *Mikania micrantha* and *M. cordifolia*. Eggs are laid in clusters and larvae are gregarious, passing through six instars (Freitas 1991).

Attempts at biological control

MALAYSIA

An extensive evaluation of natural enemies attacking *M. micrantha* was made in peninsular Malaysia prior to a decision to embark upon a biological control project (Teoh et al. 1985). Of the insects collected from or reared on the host plant, 2506 were classified and separated into commonly found and minor natural enemies (Table 4.14.3).

Although numerous insects were found to attack *M. micrantha*, not only was the extent of damage insignificant, but most of the abundant species were known pests of economic crops. For example, *Halticus minutus* and *Lamprosema diemenalis* are major

pests of leguminous cover crops, *Homoeocerus serrifer* attacks rice and *Helopeltis* spp. are serious pests of cocoa. None of the natural enemies recorded in Tropical and South America were found in the survey. A number of fungi were also found, of which *Colletotrichium gloeosporioides* was the most important, comprising 84% of the samples. Other fungi included *Colletotrichium* spp., a non-sporulating brown fungus, *Rhizoctonia* spp., *Curvularia* spp. and *Pestalotia* spp. It was concluded that a strong case existed for the introduction of effective natural enemies.

Table 4.14.3 Insects attacking *Mikania micrantha* in peninsular Malaysia (Teoh et al. 1985).

Species	Effects
MAJOR SPECIES	
Orthoptera	
ACRIDIDAE	
<i>Acrida turrita</i>	holes in leaves
Hemiptera	
APHIDIDAE	
<i>Aphis spiraeicola</i>	wrinkled leaves
CERCOPIDAE	
<i>Clovia conifer</i>	yellow spots on leaves and stems
CICADELLIDAE	
<i>Bothrogonia ferrugenea</i>	brown spots on stems
COREIDAE	
<i>Homoeocerus serrifer</i>	brown spots on leaves
<i>Riptortus linearis</i>	brown spots on leaves
MEMBRACIDAE	
<i>Centrotypus flexuosus</i>	necrosis on stems
MIRIDAE	
<i>Halticus minutus</i>	necrotic lesions on leaves
<i>Helopeltis</i> spp.	necrotic lesions on leaves
Lepidoptera	
PYRALIDAE	
<i>Lamprosema diemenalis</i>	
MINOR SPECIES	
Orthoptera	
ACRIDIDAE	
<i>Catantops humilis</i>	
Hemiptera	
APHIDIDAE	
<i>Aphis gossypii</i>	
CICADELLIDAE	
<i>Nephotettix</i> spp.	
Thysanoptera	
THRIPIDAE	
<i>Isotrips</i> spp.	
<i>Microcephalothrips</i> spp.	

(continued on next page)

Table 4.14.3 (continued)

Species	Effects
<i>Parthenothrips</i> spp.	
<i>Thrips hawaiiensis</i>	
<i>Thrips tabaci</i>	
Coleoptera	
CHRYSOMELIDAE	
<i>Dactylispa bipartista</i>	
COCCINELLIDAE	
<i>Coelophora bissellata</i>	
<i>Epilachna indica</i>	
Diptera	
TEPHRITIDAE	
<i>Sphaeniscus atilus</i>	
Lepidoptera	
AMATIDAE	
<i>Amata huebneri</i>	
PYRALIDAE	
<i>Hellula undalis</i>	

Liothrips mikaniae was introduced to Malaysia from Trinidad via England in 1989 for additional host specificity trials. Difficulties were experienced initially in mass rearing, due to unsuitable environmental conditions (lighting, temperature, aeration) low plant nutritional quality and predators (spiders, ants, and particularly a predatory thrips, *Xylopthrips* sp. which destroyed 90% of the culture). Also, there were differences in the *M. micrantha* plants used. Some were hairless and others hairy. Larvae hatching from eggs along stems of the latter found difficulty in moving among the trichomes and many failed to reach the nearest leaf. Nevertheless, in Trinidad, *L. mikaniae* was found breeding on both plant types. After passing tests with 18 Malaysian crop species, 13 161 adult thrips were released in 25 batches of 99 to 1400 at 5 different sites from April 1990 to June 1991, but no establishment resulted (Table 4.14.4). Further thrips were imported in January 1992 to extend the genetic base of the rearing colony. Two releases were made into a fenced site, 18 000 adults, together with their rearing plants in pots, in May 1992 and 1500 adults about a month later. The pots were watered daily for two months. However, *L. mikaniae* gradually disappeared and, after eight months, none could be found. An ant that made its nest amongst *Mikania* leaves was observed to feed voraciously on adult, larval and pupal stages of *L. mikaniae*, but showed little interest in eggs, whereas a predatory *Haplothrips* sp. preferred eggs. About 20 other potential predators were evaluated, but were not implicated (Liau et al. 1991, 1993, Norman et al. 1992, Teoh et al. 1985, Ooi 1993, Ooi et al. 1993).

SOLOMON ISLANDS

A consignment of *L. mikaniae* was sent from Malaysia to the Solomon Is and released in the field in 1988, but the site was flooded shortly afterwards. Further releases were made, but no establishment has occurred (M. Vagalo pers. comm.). It was suggested that there

may be differences in hospitability to *L. mikaniae* of the host plant between the Caribbean and Solomon Is.

PAPUA NEW GUINEA

Part of a consignment of *L. mikaniae* sent to the Solomon Is in 1989 was taken to Papua New Guinea, but there is no information on its fate (Williams et al. 1990), although it is believed to have died in quarantine (F. Dori pers. comm. 1993).

SRI LANKA AND ASSAM

In Sri Lanka and Assam it has been found that the plant parasite *Cuscuta chinensis* will suppress *Mikania* and prevent it spreading into tea plantations, although *C. chinensis* is not sufficiently selective to be used in the plantations themselves (Parker 1972). On Espiritu Santo (Vanuatu) a related species *Cuscuta campestris* is reported to suppress *M. micrantha* (M.J.W. Cock pers. comm.).

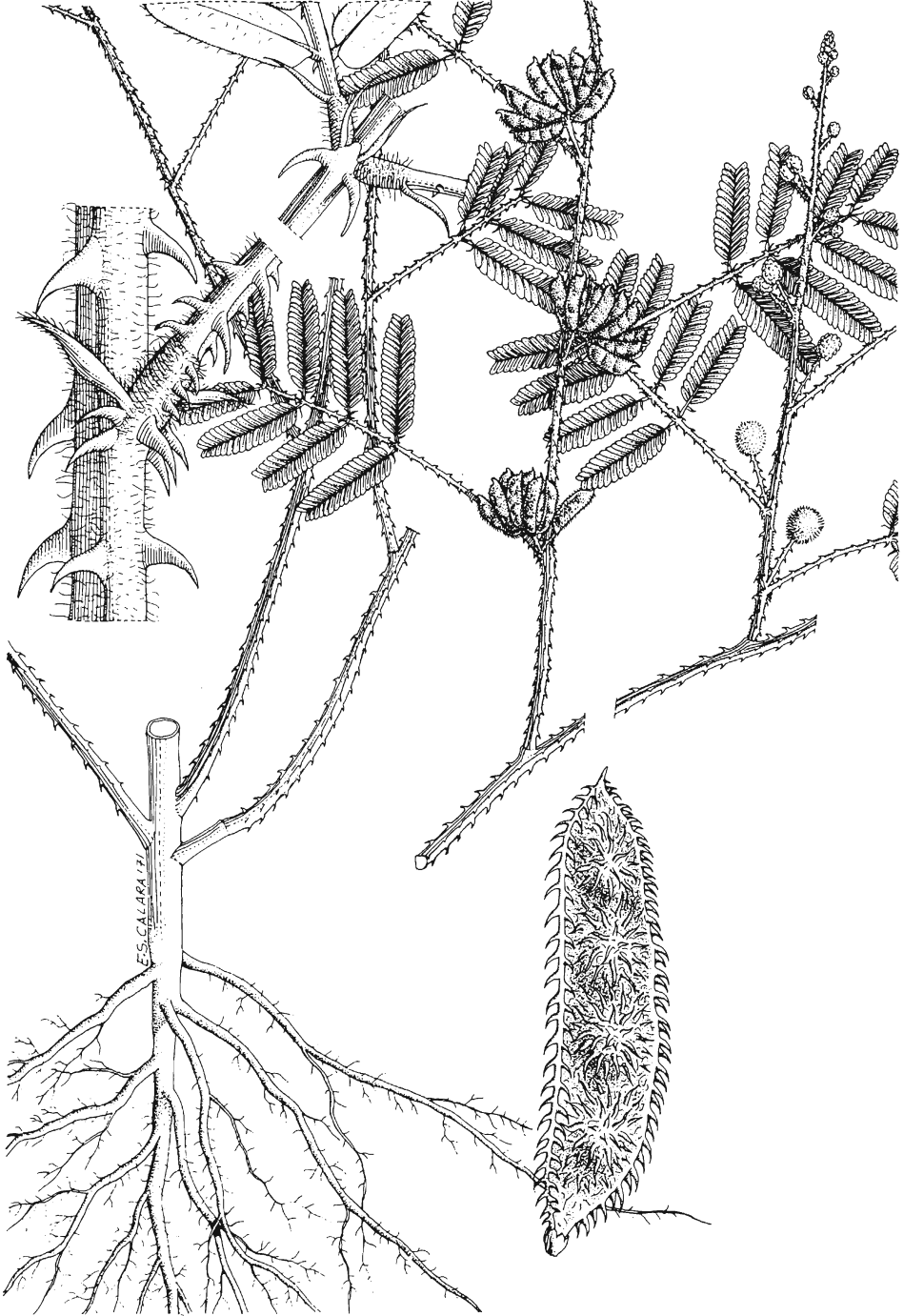
Table 4.14.4 Liberations for the biological control of *Mikania micrantha*.

Species	Where	From	When	Result	References
Thysanoptera					
PHLAEOTHIRIPIDAE					
<i>Liothrips mikaniae</i>	Malaysia	Trinidad via UK	1991	–	Liau et al. 1991, 1993, Norman et al. 1992
	Solomon Is	Trinidad via UK	1988	–	M. Vagalo pers. comm., Williams et al. 1990

Comment

Mikania micrantha is an introduced weed of widespread importance in plantation crops throughout Southeast Asia. It is not a significant weed in its native range in tropical Central and South America, where it is attacked by a wide range of arthropod natural enemies. Several appear to be not only damaging to the weed, but also highly specific. It must be concluded that *M. micrantha* is a highly appropriate target for an attempt at biological control.

The failure of *Liothrips mikaniae* to become established in Malaysia is disappointing. The most probable explanation, partly supported by observations, is that heavy predation was the cause. Although the same guild of predators may be widespread on continental Southeast Asia, the same may not apply to island nations, particularly those in the southern Pacific, which have a far less diverse fauna and releases there might lead to successful establishment.



Mimosa invisa

(after Holm et al. 1977)



Map 4.15 *Mimosa invisa*

Creeping sensitive plant, *Mimosa invisa*, is native to Tropical America, where it is not regarded as a weed.

At least 70 species of insects attack it in Brazil and additional species elsewhere. Detailed studies have been made on two Hemiptera (*Heteropsylla spinulosa* and *Scamurius* sp.) and a moth (*Psigida walkeri*). *H. spinulosa* has caused extensive damage to *M. invisa* following its establishment in Australia and promising early results in Fiji, Papua New Guinea and Pohnpei, but disappointing results in Western Samoa. *Scamurius* sp. has failed to become established and *P. walkeri* is still under investigation.

The prospects for biological control of *M. invisa* appear to be good, although additional natural enemies may have to be considered.

4.15 *Mimosa invisa* Martius ex Colla

Mimosaceae

creeping sensitive plant; banla saet (Cambodia), borâng, pis koetjing, rêmchètè (Indonesia), duri semalu (Malaysia), makahiyang lalaki (Philippines), maiyaraap thao (Thailand), cò trinh nu móc (Vietnam)

Rating

	+++	Phil
18	++	Myan, Thai, Laos, Viet, Msia, Sing, Indo
	+	Camb

Origin

Tropical America. In Brazil southwards from Bahia to Paraná and westwards to Paraguay and tropical northeast Argentina; also lowlands of Central America from Veracruz (Mexico) southeastwards to Panama and adjacent Colombia.

Distribution

In addition to the above there are, in the Americas, scattered records from Brazilian Amazonia, the Guianas, Jamaica, Hispaniola and Cuba. *M. invisa* is widely distributed in Southeast Asia and the Pacific, also in Queensland, India, Sri Lanka, Taiwan and Nigeria. It was first recorded in Java in 1900 (Soerjani et al. 1987).

Characteristics

Mimosa invisa is a fast growing, abundantly thorny, biennial or perennial shrub with angular branching stems that become woody with age. The leaves are alternate, bipinnate and compound. The pink to purple globular flowers are borne on a short prickly stalk arising from a leaf axil. The seed pods are covered with stiff bristles and separate at transverse grooves into two to four, single-seeded segments.

The genus *Mimosa* does not occur naturally in Southeast Asia or Australia. *M. invisa* is one of three weedy species of *Mimosa* in this region, all of which are treated in this volume. They may be distinguished (i) by the number of pinnae in the leaves: *M. invisa* 4 to 9 pairs; *M. pigra* 6 to 16 pairs; and *M. pudica* 1 to 2 pairs and (ii) the size of the pods: *M. invisa* 4 seeds per pod, *M. pigra* 12 to 24 seeds. In addition, *M. invisa* stems have a dense covering of small prickles, whereas *M. pigra* stems have a sparse covering of large prickles (Lonsdale 1992).

M. invisa folds its pinnate leaves when touched, but is not as sensitive as some other species, such as *M. pudica*. The leaves fold at nightfall.

Unlike the situation in the more tropical regions, such as the Philippines where *M. invisa* flowers all year round, in central and southern Brazil it only flowers from the end of January to mid April. Seeds mature from February to the end of May and plants then senesce, losing most of their leaves, although a few green leaves remain at the stem

base. For two to five months green plants are difficult to find. Senescence is not due to water shortage as well-watered plants in the laboratory also senesce. However, germination occurs when moisture is available, so young plants may appear after showers of rain (Garcia 1982b).

Importance

M. invisa scrambles vigorously over other plants, forming dense tangled thickets up to 2 m high. It is a nitrogen-fixer and its extremely rapid growth smothers useful plants and other weeds. Its sharp, recurved thorns make stock reluctant to graze on it and difficult for them to penetrate the stands. Crops infested with *M. invisa* are difficult to harvest because the thorns puncture and lacerate the hands of the workers. It is common along roadsides and in moist waste places. It causes major problems in coconut, tea and rubber plantations, sugarcane and pineapple fields, crop lands and pastures. It is not a problem in the Americas, western Asia, East Africa or Europe, but is a serious weed in Southeast Asia and the Pacific. A spineless variety, *M. invisa inermis*, has been suggested as a tropical pasture legume, but its tendency to revert to the thorny type and its potential toxicity has discouraged its use (Waterhouse and Norris 1987).

In the Americas, *M. invisa* is most common in the Paraná basin in the State of San Paulo (Brazil), but even there pure stands are not common and it does not appear to invade nearby crops. In forest regions it occurs as thickets among grasses along roads, river banks and in waste places; it occurs more commonly on the fringe of cities (Garcia 1982b).

Natural enemies

Information up to 1986 was summarised by Waterhouse and Norris (1987).

M. invisa is seldom troublesome in Brazil or Argentina and some 70 species of insects and two fungi are known to attack it in Brazil (Table 4.15.1). Additional insects are known in the Americas, but they have not yet been studied. A pathogenic fungus *Corynespora cassiicola* kills *M. invisa* in Australia (Haseler 1984), heavy infestations of scale insects attack it in Fiji (Mune and Parham 1967), a non-specific lymantriid larva feeds on young leaves and flowers in Thailand (Napompeth 1982) and a pierid butterfly *Eurema* sp. breeds on it in Papua New Guinea and New Britain (T.L. Fenner pers. comm.).

More than half of the insects attacking *M. invisa* in Brazil have not yet been identified. Indeed it is probable that most of these are undescribed species and, if so, it follows that there is no published information about them. Where possible, identification, even to a genus, may be valuable. For example, species of the genus *Heteropsylla* are restricted to legumes, with known hosts only in the Mimosaceae or Caesalpinaceae. Of the 35 described species with recorded hosts, 31 are specific to a single host (Hodkinson and White 1981, Muddiman et al. 1992).

Only a few of the 70 insect species attacking *M. invisa* are known as agricultural pests (Table 4.15.1). From the remainder, preliminary observations on a subgroup of about 10 species led to detailed studies on three, *Heteropsylla spinulosa*, *Scamurius* sp. and *Psigida* (= *Psyllopigida*) *walkeri*.

Attempts at biological control

AUSTRALIA

Large numbers of *Heteropsylla spinulosa* were released in coastal Queensland, commencing in 1988 (Table 4.15.2). This involved 33 field sites, averaging thousands of insects per release (M. Ablin pers. comm. 1990). Within two years, the psyllid had dispersed widely into all infestations of *M. invisa* in pastures. Dense clumps of the weed were reduced to small masses of bare stems with stunted growing tips, leading to other vegetation reestablishing itself. Seed production from severely affected plants was reduced by 85 to 100% (Ablin 1992, Anon 1988). It did not attack *M. pudica* plants nearby. A more recent assessment, using insecticide-produced exclusion, found that *H. spinulosa* reduced seed production on average by 80%, growing tip elongation by 77% and the growth rate of tips by 50% (Ablin 1993a). Although *M. invisa* may still produce clusters of seed pods when damage is high, the pods contain very few viable seeds. Mature plants support low populations of *H. spinulosa* during the dry season from July to November. Thereafter, psyllid abundance increases with the onset of summer rains, with peak numbers in April or May (M. Ablin pers. comm. 1993).

Scamurius sp. was liberated in Queensland from 1987 to 1990 and proceeded to kill the tips of many shoots (Anon 1988). However it did not become established. It was also released against *Mimosa pigra* in the Northern Territory where it survived for several months, but fecundity was very low and the colony died out (M. Ablin pers. comm. 1993).

FIJI

H. spinulosa was brought in from both Western Samoa and Australia in 1993 and, after a generation in quarantine, was liberated in Nadi in June. Six weeks later all stages were seen in the field. A mealy bug and *Tetranychus* sp. mites are occasionally found on *M. invisa* in the field (S.N. Lal pers. comm. 1993).

PAPUA NEW GUINEA

Heteropsylla spinulosa from Australia was reared through one generation in quarantine in Port Moresby and released early in 1993 in the Ramu Valley near Lae. Within a few months it had severely damaged *M. invisa* and killed many plants (F. Dori pers. comm. 1993).

POHNPEI

Ten months after release at Palikir, Pohnpei *H. spinulosa* became abundant on *M. invisa* and subsequently killed many plants. Many psyllids were transferred to *M. invisa* in other areas (N.M. Esguerra pers. comm. 1993).

WESTERN SAMOA

A total of 47000 nymphs and adults of *Heteropsylla spinulosa* from Australia were liberated in Western Samoa in 1988 and 1989 and, a year later, the psyllid was reported at some sampling sites to have reduced seed production, although not the area infested (Willson and Ablin 1991).

Scamurius sp. was also liberated in Western Samoa in 1989 and was seen in the field after more than one generation, but not in more recent times. There have been no

reports of its effects. *M. invisa* continues to be a serious weed, with more than 85% of villages on the main island of Upolu being infested (Willson and Garcia 1992).

Important Natural Enemies

INSECTS

Heteropsylla spinulosa Hemiptera: Psyllidae

The average development period of this small (2.5 mm long) pale green, Brazilian psyllid is about 28 days. High populations cause severe stunting and distortion of the leaves and growing tips; flowering is reduced or even prevented. A sticky honeydew is produced which encourages a dense growth of sooty moulds. Females attach eggs by means of a pedicel inserted into the plant tissue between overlapping leaflets. Young nymphs live hidden between the leaflets, whereas adults feed on leaflets and shoots.

In Brazil reduviid bugs pierce nymphs with their proboscis and withdraw them from their shelters, whereas larvae and adults of the predatory coccinellid *Eriopsis connexa* are only able to capture exposed nymphs. Nymphs are also attacked by an encyrtid wasp *Psyllaephagus yaseeni* (Willson and Garcia 1992). The predatory vespidae wasp *Protonectarina sylveiriae* attacks nymphs and an unidentified wasp causes up to 13% parasitisation (Garcia 1985).

In extensive host specificity tests *H. spinulosa* adults and nymphs were unable to live on any plant other than *M. invisa* and its spineless variety *M. invisa inermis*. In the field it did not attack *M. pudica*, even when large infestations of *M. invisa* were destroyed and *M. pudica* was common nearby (M. Ablin pers. comm. 1993). Eggs were laid on 18 other plant species, but only under glasshouse conditions (Garcia 1985, Wild 1987, Willson 1987, Willson and Garcia 1992) and *Heteropsylla spinulosa* was judged safe to liberate in Australia and four other countries (Table 4.15.2)

Psygida walkeri Lepidoptera: Cercophanidae

This moth is widespread in Brazil and Colombia. Females have a wing span of up to 5 cm. When fully grown its greenish, spiny larvae may reach a length of 5 cm. They feed voraciously on leaves, flower buds, tender seed pods and on the top 30 cm of tender stems and branches, preventing both flowering and seed production. The life cycle takes about 2 months and there are 3 generations a year. There is a pupal diapause of up to 4 months in Brazil

Larvae of *P. walkeri* have been found in the field on *M. invisa*, *M. rixosa*, *M. veloziana* and once on *M. somnians*. They have not been found in the field in Brazil on other leguminous plants near *M. invisa* plants bearing larvae, nor on any plants of economic importance (Garcia 1983). However, under artificial conditions larvae can be reared on black wattle *Acacia mearnsii* and may also feed on *Mimosa pudica* and *Leucaena leucocephala*. Although adults will oviposit on *A. mearnsii*, no attack has been observed in the field (Haseler 1984). Further host specificity testing is in progress in Australia.

***Scamurius* sp. Hemiptera: Coreidae**

Both nymphs and adults of this large (up to 2.2 cm) coreid bug feed on the shoots, causing them to collapse, thereby inhibiting vegetative growth and flowering. First instar nymphs moult whether fed or not and, after five instars, mature in about seven weeks. There are about four generations a year, from early summer to autumn, and adults may live for six months or more.

Adults were found to probe many species of plants, but to feed only on species of *Mimosa*. Nymphs were able to develop on *M. invisa* and on two other weedy species, *M. pigra* and *M. pudica*, but not on other plants (Garcia 1984, Wild 1986, 1987). This species was approved for release in Australia and Western Samoa (Table 4.15.2).

FUNGUS***Corynespora cassiicola***

This stem spot fungus is very common in hot humid weather in north Queensland, Papua New Guinea (Keravat, Rabaul) and Western Samoa. It can be very damaging to *M. invisa* if environmental conditions are suitable (Willson and Ablin 1991). The strain involved appears to be specific to *M. invisa*, although fungi with the same specific name are reported from cowpea, papaya and tomato. If suitable environmental conditions persist in the field *M. invisa* plants shed their leaflets and stems die back as lesions cover the plant (M. Ablin pers. comm. 1993).

Comments

The use, in the future, of *H. spinulosa* from Brazil against *M. invisa* is complicated by several introductions of natural enemies that have already been made by Southeast Asian countries (eg. Thailand, Philippines). These introductions were of two parasitic wasps (*Tamarixia leucaenae* and *Psyllaephagus yaseeni*) native to the Caribbean and Central America (Noyes 1990) and one or more predatory coccinellids against a pest psyllid *Heteropsylla cubana* which appeared from the Americas in the 1980s. This pest can cause severe damage to *Leucaena leucocephala* which is widely planted for firewood and as fodder. Tests showed that these natural enemies of *H. cubana* would also attack *H. spinulosa* (Baker 1990). As a result, several countries where *M. invisa* is a serious pest (Australia and most Pacific islands, but not New Caledonia) have deferred introducing natural enemies of *H. cubana*.

Several interesting points, relevant to any investigation for natural enemies in South America, emerge from the *M. invisa* project there:

- Before the studies of C.A. Garcia in the early 1980s almost nothing was known about the insects attacking it, yet within a year 57 insects were listed from Brazil (Garcia 1982a,b) and within two years a further 10. No records are available from elsewhere in the Americas, except of a *Heteropsylla* sp. from Colombia (Garcia 1983).
- It has not been possible for taxonomists to assign a specific name (and sometimes not even a generic name) to the majority of insects collected. Some were not previously represented in any museum collections and many are almost certainly undescribed species.

- Only one (*Scamurius* sp.) of the three insects eventually selected for detailed study was recognised in the first survey which yielded 57 species. It is clear that follow up surveys are essential.
- No study has yet been made of the insects attacking *M. invisa* over a very large area of its presumed native range. From brief observations in Colombia Garcia (1983) commented that larvae of Lepidoptera were 'quite similar to those collected off *M. invisa* in Brazil. Coleoptera in general look different'.
- Should existing biological control be considered inadequate, further detailed studies covering the entire native range of *M. invisa* might well reveal additional, adequately specific insects attacking it.
- Examination of the host specificity of more of the insects recorded from Brazil (Table 4.15.1) might also reveal further adequately specific insects.
- *H. spinulosa* does not thrive under either very wet or very dry conditions. Its populations depend upon the availability of green foliage and, in the dry season, are found on pockets of green foliage. A flush of growth after rain leads to a build up in populations to a level that severe damage may be caused, sufficient to kill many *M. invisa* plants.

Table 4.15.1 Natural enemies of *Mimosa invisa* in Brazil (from Garcia 1982a,b, 1983 and his unpublished monthly reports).

Species	Comment
INSECTS	
Orthoptera	
TETTIGONIIDAE	
sp. 1	attacks flowers
sp. 2	attacks leaves
Hemiptera	
CERCOPIDAE	
<i>Tomaspis</i> (= <i>Zulia</i>) <i>enteriana</i>	
sp.	belongs to Gyopinae
CICADELLIDAE	
sp. 1	common on <i>Mimosa invisa</i> and <i>M. pigra</i> and colonises <i>Acacia mearnsii</i> and <i>M. scabrella</i> during the dry season
sp. 2	
COREIDAE	
<i>Scamurius</i> sp. 1	see text
<i>Scamurius</i> sp. 2	
MIRIDAE	
<i>Horciacinus signoreti</i> (= <i>H. argentinus</i>)	
<i>Taylorilygus pallidulus</i>	
MEMBRACIDAE	
<i>Ceresa ustulata</i>	an agricultural pest
<i>Enchenopa gracilis</i>	
<i>Micrutalis</i> sp.	

(continued on next page)

Table 4.15.1 (continued)

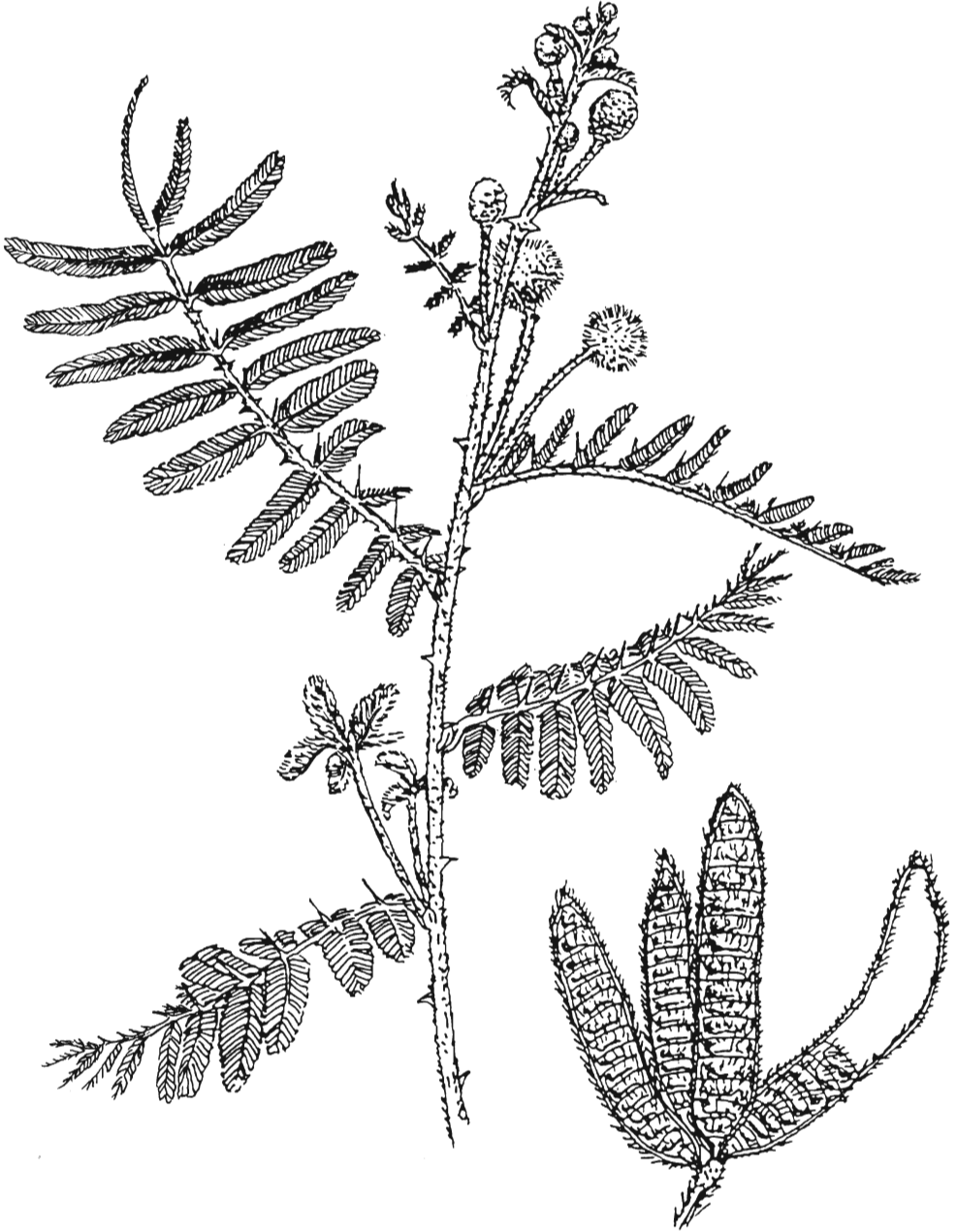
Species	Comment
PENTATOMIDAE	
<i>Acrosternum herbidum</i>	
<i>Dichelops furcatus</i>	an agricultural pest
<i>Edessa mediatubunda</i>	an agricultural pest
<i>Euschistus tristigma cribarius</i>	
<i>Euschistus luridus</i>	
<i>Piezodorus guildinii</i>	an agricultural pest
PSYLLIDAE	
<i>Heteropsylla spinulosa</i>	see text
<i>Heteropsylla</i> sp.	from Colombia
THYREOCORIDAE	
<i>Gyrocnemis</i> sp.	
Coleoptera	
CHRYSOMELIDAE	
<i>Colaspis</i> sp.	most Chrysomelidae were present in low numbers.
<i>Cryptocephalus viridiaeneus</i>	adults eat <i>M. invisa</i> leaves
? <i>Hilax</i> sp.	excellent defoliator; also attacks <i>M. pigra</i>
<i>Lactica</i> sp.	
<i>Lexiphanes ?semicyaneus</i>	
<i>Lexiphanes</i> sp.	
<i>Metaxyonycha pallidula</i>	
<i>Nodonota</i> sp.	
<i>Pachybrachys</i> sp.	
<i>Systema s-littera</i>	
<i>Temmodachrys</i> sp. nr <i>aphodoides</i>	
CURCULIONIDAE	
<i>Asynonychus godmani</i> (= <i>Pantomorus cervinus</i>)	adults eat leaves and show strong preference for <i>M. invisa</i> , but will also attack <i>M. pudica</i> , <i>Calliandra selloi</i> and <i>Acacia mearnsii</i>
<i>Chalcodermus</i> sp.	larvae bore stems, brown adults eat leaves
<i>Chalcodermus</i> sp. nr <i>segnis</i>	black adults bore green seeds, but did not attack pods of 7 other legumes
<i>Hypanthus</i> sp.	
<i>Promecops</i> sp. 1	
<i>Promecops</i> sp. 2	
<i>Sibinia aspersa</i>	adults eat ovaries, larvae the seeds; recorded from <i>Mimosa albida</i> and <i>M. quadrivalis</i> , but would not attack six other legumes including <i>Leucaena leucocephala</i>
<i>Sibinia ?subulirostris</i>	<i>semnicola</i> group, larvae eat seeds, adults the leaves and ovaries and are also found in <i>Mimosa rixosa</i>
<i>Sibinia</i> sp.	
Lepidoptera	
AMATIDAE	
sp.	red hairy larva
CERCOPHANIDAE	
<i>Psigida walkeri</i>	see text
GEOMETRIDAE	
sp. 1	debris-covered larva
sp. 2	twisted larva

(continued on next page)

Species	Comment
sp. 3	reddish green larva
sp. 4	common slim larva
sp. 5	thick twig larva
HESPERIIDAE	
<i>Cogia</i> (= <i>Caicella</i>) <i>calchas</i>	occurs in Mexico and Argentina; eggs laid also on <i>M. pudica</i> , <i>M. scabrella</i> , <i>Indigofera anil</i> , <i>Skrankia</i> sp., larvae are heavily parasitised
LYCAENIDAE	
<i>Hemiargus hanno</i>	larvae eat leaves, flowers and seed pods; also <i>M. pudica</i> flowers
<i>Tmolus</i> (= <i>Thecla</i>) <i>azia</i>	larvae eat leaves and flowers; also <i>M. pudica</i> and groundnut flowers
NOCTUIDAE	
sp. 1	velvet black larva; also on <i>M. pudica</i> , <i>M. scabrella</i> , <i>Acacia mearnsii</i> , <i>Calliandra selloi</i> , <i>Leucaena leucocephala</i>
sp. 2	reddish larva
sp. 3	green larva
sp. 4	small green larva
PIERIDAE	
<i>Eurema tenella</i>	occurs in Brazil, Argentina, Paraguay, Bolivia; larvae defoliate <i>M. invisa</i> ; also eat <i>M. pudica</i> , <i>M. scabrella</i> , <i>Acacia mearnsii</i> and (reluctantly) <i>Leucaena leucocephala</i>
TORTRICIDAE	
sp. 1	flower/twig roller
sp. 2	pod eater
sp. 3	larvae eat leaves
sp. 4	larvae roll flowers
FAMILY UNKNOWN	4 species, two bore in the stem tips, 1 eats pods and 1 the flowers
FUNGI	
<i>Cercospora canescens</i>	
<i>Fusarium</i> sp.	
<i>Uredo mimosae-invisae</i>	from Venezuela (H.C. Evans pers. comm. 1992)

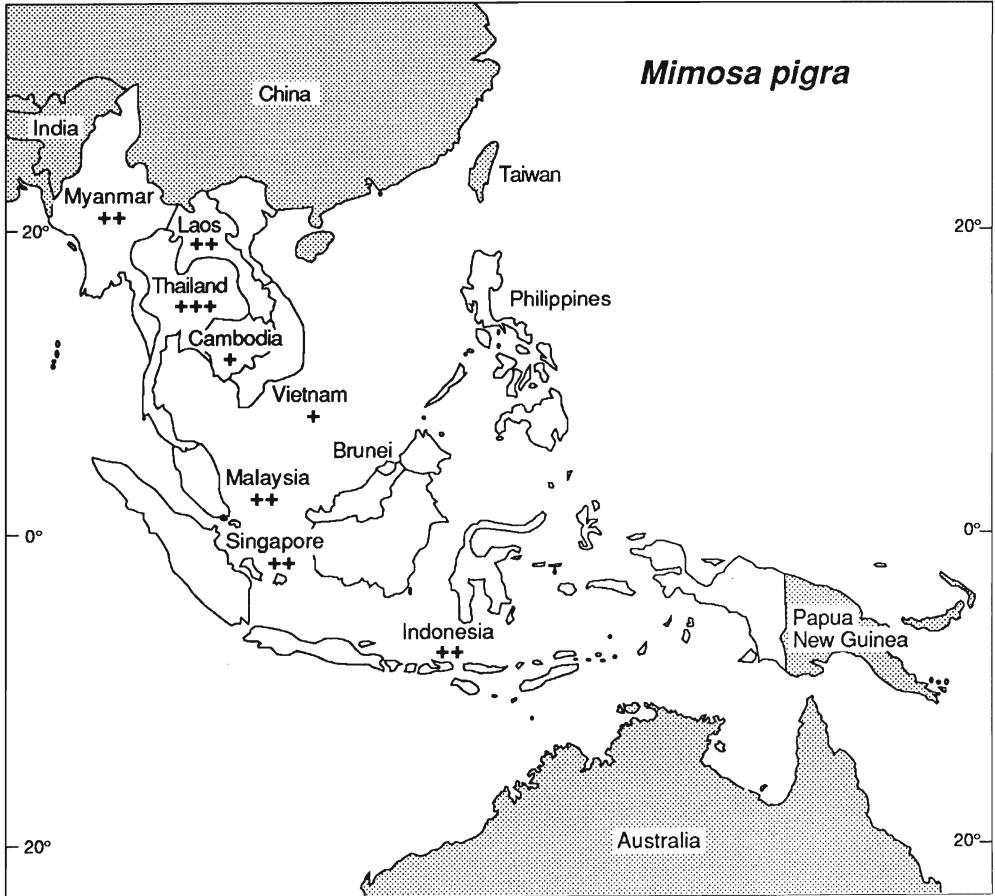
Table 4.15.2 Liberations for biological control of *M. invisa*.

Species	From	Liberated	When	Result	References
<i>Heteropsylla spinulosa</i>	Brazil	Queensland	1988	+	Ablin 1992, Anon 1988
		Fiji	1993	?	S.N. Lal pers. comm. 1993
		Papua New Guinea	1993	+	Ablin 1993b, F. Dori pers. comm. 1993
		Pohnpei	1992	+	N.M. Esguerra pers. comm. 1993
<i>Scamurius</i> sp.	Brazil	Western Samoa	1988	+	Willson & Garcia 1992
		Queensland	1987	-	Anon 1988
		Western Samoa	1988	?	



Mimosa pigra

(after CSIRO, 1992)



Map 4.16 *Mimosa pigra*

Mimosa pigra originated in the area extending from Mexico to Amazonia and Venezuela. Four beetles and two moths have been established on *M. pigra* in Australia in the past 10 years. Two stem-boring moths *Neurostrota gunniella* and *Carmenta mimosa* are having a significant effect on the vigour of the weed. *N. gunniella* has spread widely, infests most stems and is reducing seed production. All except *N. gunniella* have been liberated in Thailand. *N. gunniella* was not liberated because it can attack the aquatic vegetable *Neptunia oleracea*. However the two seed-feeding bruchids are destroying up to 20% of the seed in Thailand

A specific, highly pathogenic fungus, *Phloeospora mimosae-pigrae*, has been approved for release in Australia and six insects and a rust fungus are under study.

There are grounds for confidence that a group of natural enemies will become available that, acting together, will cause significant damage to *M. pigra*.

4.16 *Mimosa pigra* L.

Mimosaceae

giant sensitive plant; mai yah raap yak, maiyarap ton, chi yop luang (Thailand); kembang gajah, semalu gajah (Malaysia); trinh nu nhon (Vietnam); putri malu (Indonesia)

Rating

	+++	Thai
15	++	Myan, Laos, Msia, Sing, Indo
	+	Camb, Viet

Origin

Mexico, southern Venezuela, or central Amazon basin.

Distribution

Throughout the tropics and still spreading. It was an early invader of tropical Africa and is spreading aggressively in northern Australia and Southeast Asia. It is not present in the Philippines or the oceanic Pacific. Details of its distribution and time of recognition in various countries are given in Lonsdale (1992).

Characteristics

M. pigra is a perennial leguminous shrub, growing up to 6 m high on a wide range of soils, and found in moist open sites with a rainfall between 750 and 2250 mm in the tropics. Its leaves are bipinnate and sensitive to the touch, through movements of the petiole and pinnules. Petioles bear a slender prickle at the junction of each of the 6 to 16 pairs of pinnae and sometimes have stouter prickles between each pair. The stems bear broad-based, sharp thorns up to 7 mm long. Mature plants have many branches growing from the base, with a skirt of adventitious roots forming in seasonally inundated sites. They have a large central taproot which penetrates 1 to 2 m deep and a lateral root system that extends up to 3.5 m from the stem at a depth of about 5 cm. The flowers are mauve to pink, massed in globular heads 1 cm in diameter, with each head containing about 100 flowers. Seed pods are produced in clusters of about 7, are densely bristly, 3 to 8 cm long and break transversely into segments each containing a seed. The bristles facilitate floating and thus rapid spread of the weed along river systems. In regions with pronounced wet and dry seasons, the former is the main period of growth, with flowering mainly from mid to late wet season. Development from flower bud to ripe seed takes about 5 weeks (Lonsdale 1992). Average seed production is about 9000 seeds per plant, but up to 220 000 has been recorded. Although most seeds that lodge on or near the soil surface probably germinate within two years many seeds deeper in the soil lie dormant for long periods (at least 23 years).

Previously, two varieties were recognised var. *pigra* and var. *berlandieri*, of which only *pigra* has spread around the world. Variety *berlandieri* has recently been renamed *Mimosa asperata* (Barneby 1989, Lonsdale 1992).

Importance

In tropical America *M. pigra* usually occurs as small clumps of multi-stemmed plants growing in seasonally flooded habitats. However, in many countries to which it has been introduced, *M. pigra* is a serious weed of wetlands. Dense, prickly thickets compete with pastures, prevent access to water and hinder mustering. The thickets exclude native vegetation and so alter the environment that many native plants and animals are eliminated or seriously affected (Lonsdale 1992). The weed leads to sediment accumulation in irrigation systems and reservoirs and, as the seed segments float, many end up in fallow rice paddies where they germinate rapidly. River sand containing seeds helps to establish new infestations when transported to building sites, road constructions etc.

Cattle and horses occasionally browse on young plants and some wild animals find it acceptable, particularly as a dry-season browse but, in general, it seems to be of low palatability. The leaves contain low levels of the toxic amino acid mimosine. *M. pigra* was introduced to Thailand in 1945 as a green mulch crop and for erosion control in rice paddy irrigation channels, but it was soon found that the problems associated with it far outweighed any advantages (Wara-Aswapati 1983). However it is used still as a source of firewood and bean poles, although it is now regarded as a very serious weed.

Natural enemies

Surveys for natural enemies have been made in Brazil, Mexico, Venezuela (Harley et al. 1983), Honduras (Habeck and Passoa 1982), Costa Rica (Forno 1992) and most recently in Belize and Cuba (I.W. Forno pers. comm.). In Honduras more than 60 species were listed (2 Orthoptera, 27 Hemiptera, 1 Diptera, 15 Coleoptera and 15 Lepidoptera). Although a full list of insects attacking *M. pigra* in its native range has yet to be published, a diverse group of over 200 is known to occur (Forno et al. 1991b). Only 12 species are considered to be pests of agriculture and at least 45 have habits that are likely to lead to restricted host specificity, such as gall forming, leaf mining or stem boring. It is suggested that some 10% may be adequately host specific. These are likely to attack different parts of the plant causing complementary damage, so that the prospects for biological control appear good (Forno et al. 1989b, Wilson et al. 1990).

Six of the tropical American species of insects have been liberated (Table 4.16.1) five more were eventually not released after tests showed (or suggested) that they are insufficiently host specific (Table 4.16.2) and a further six are currently being examined in Australia or Mexico for host specificity (Table 4.16.3). However, the list of potential insects for consideration is far from exhausted. Host testing of agents for *M. pigra* is discussed by Forno and Harley (1992).

Two fungal pathogens of *M. pigra* (*Diabole cubensis* and *Phloeospora mimosae-pigrae*) cause considerable damage in Mexico in spite of being extensively attacked by hyperparasitic fungi. Without these, the pathogens should prove even more damaging. Other, less damaging fungi include *Colletotrichium gloeosporioides*, *Pestalopsis* sp., *Phomopsis* sp. and *Oidium* sp. (Evans 1988, 1990, Evans and Seier 1991, Evans et al. 1993).

Table 4.16.1 Releases for the biological control of *Mimosa pigra*.

Species	Part attacked	Liberated	Result	References
Coleoptera				
APIONIDAE				
<i>Coelocephalapion aculeatum</i>	flower buds	Australia 1992	+	Forno et al. 1994, Wilson et al. 1992
		Thailand 1991	?	Wilson et al. 1992
BRUCHIDAE				
<i>Acanthoscelides puniceus</i>	seeds	Australia 1983	+	Kassulke et al. 1990, Wilson & Flanagan 1991, Harley et al. 1985
		Thailand 1984	+	Julien 1992
		Vietnam 1987	?	Julien 1992
<i>Acanthoscelides quadridentatus</i>	seeds	Australia 1983	+	Forno et al. 1991b, Harley et al. 1985, Kassulke et al. 1990, Wilson & Flanagan 1991
		Thailand 1984	+	Forno et al. 1991b, Harley et al. 1985
		Vietnam 1987	?	Julien 1992
CHRYSOMELIDAE				
<i>Chlamisus mimosae*</i>	pinnae & stems	Australia 1985	+	Julien 1992
		Thailand 1986	+	Julien 1992
		Vietnam 1990	?	Julien 1992
Lepidoptera				
GRACILLARIIDAE				
<i>Neurostrota gunniella</i>	pinnules & stems	Australia 1989	+	Davis et al. 1991, Wilson & Flanagan 1990
SESIIDAE				
<i>Carmenta mimosa</i>	stem	Australia 1989	+	Forno et al. 1991a, Julien 1992
		Thailand 1991	?	Julien 1992

* Introduced from Brazil, the remaining 5 insects from Mexico.

Host specificity tests indicate that *Phloeospora mimosae-pigrae* is specific to *M. pigra* and Australian authorities have granted permission to liberate this pathogen. Testing of *Diabole cubensis* is still in progress.

Attempts at biological control

AUSTRALIA

M. pigra was probably introduced to Australia at Darwin sometime during the 20 years before 1891 (Miller and Lonsdale 1987, Lonsdale et al. 1989) and, after a slow start, underwent a population explosion in the late 1970s and, by 1992, had already covered some 800 km² of wetlands (Lonsdale 1992). In its century of occupation, at least 114 species of phytophagous insects have come to attack it (5 Orthoptera, 3 Isoptera, 49 Hemiptera, 21

Table 4.16.2 Insects tested against *Mimosa pigra*, but not released (after Forno 1992).

Species	Portion attacked
INSECTS	
Coleoptera	
CHRYSOMELIDAE	
<i>Cryptocephalus</i> (= <i>Diplacaspis</i>) nr <i>miserabilis</i>	leaves
<i>Diplacaspis</i> nr <i>prosternalis</i>	stems and leaves
<i>Lexiphanes guerini</i>	young leaves
<i>Syphrea bibiana</i>	seedlings and roots
Lepidoptera	
GELECHIIDAE	
nr <i>Aroga</i>	leaves and stems

Table 4.16.3 Natural enemies of *Mimosa pigra* under investigation (I.W. Forno pers. comm. 1993).

Species	Portion attacked	Status
INSECTS		
Coleoptera		
APIONIDAE		
<i>Coelocephalapion pigrae</i>	flower buds and leaves	awaiting approval for release
CURCULIONIDAE		
<i>Chalcoedermus serripes</i>	flower buds and immature seeds	in quarantine in Australia
<i>Sibinia fastigiata</i>	immature seeds	in quarantine in Australia
<i>Sibinia ochreosa</i>	flower buds	under study in Mexico
<i>Sibinia peruana</i>	flower buds	in quarantine in Australia
<i>Sibinia seminicola</i>	immature seeds	in quarantine in Australia
FUNGI		
<i>Diabole cubensis</i>	leaves	under host testing
<i>Phloeospora mimosae-pigra</i>	stems, leaves, seed pods	approved for release

Coleoptera and 36 Lepidoptera). Of the 114, 47 species are seldom encountered, 39 are occasionally found and 28 are common. Thirty of the species are known pests of cultivated plants and all except two are thought to be polyphagous. These two (a psyllid and a gelechiid moth) probably feed only on a restricted number of leguminous plants. In this survey no plant pathogens were recorded (Flanagan et al. 1990, Wilson et al. 1990).

In spite of this diverse insect attack there is still an enormous difference, two orders of magnitude, between the bank of *M. pigra* seeds in the soil in Mexico (a mean of 117.5/m²) and Australia (a mean of 12 380/m²). This is believed to reflect the differential occurrence of effective natural enemies in each region (Lonsdale and Segura 1987).

The first insects to be liberated—in 1983—for biological control of *M. pigra* were

two seed feeding bruchid beetles, *Acanthoscelides quadridentatus* and *A. puniceus*, both of which established readily (Table 4.16.1). They had previously been shown to be adequately host specific (Kassulke et al. 1990). Although these species have become widespread, on average they destroy only 0.8% of mature seed, so are not having much impact. Of the beetles sampled, 97.8% proved to be *A. puniceus* (Forno et al. 1991b, Wilson and Flanagan 1991, Wilson et al. 1992). A parasitoid, *Dinarmus* sp. (Pteromalidae), was reared from field-collected bruchids, but did not appear to be having much influence on beetle populations (C. Wilson pers. comm.).

Next, in 1985, the stem feeding beetle *Chlamisus mimosae* was released and readily became established (Forno et al. 1991b) and in 1992/93 large populations have been found at the Finnis R., Northern Territory and are severely damaging *M. pigra* stems (I.W. Forno pers. comm. 1993).

During 1989, two stem boring moths *Neurostrota gunniella* and *Carmenta mimosa* were released. *N. gunniella* established rapidly and, within a few months, was not only widespread near the release site but damaging a large number of stems (Forno et al. 1991b, Wilson and Flanagan 1990). By 1993, it had spread to all *M. pigra* infestations and is associated with a naturally-occurring, exotic, die-back pathogen (Wilson 1992). There is a strong negative correlation between seed production and moth populations, suggesting that *N. gunniella* can reduce seed numbers by up to 60% (Anon 1992).

Carmenta mimosa is very damaging to young plants and is spreading rapidly in the Finnis R. region where it is severely damaging stems (I.W. Forno pers. comm. 1993, Wilson 1992).

The flower bud weevil *Coelocephalopion aculeatum* was liberated in 1992 and has become established, but its effects remain to be assessed (Forno et al. 1994, Wilson et al. 1992).

THAILAND

M. pigra was introduced from Indonesia to the Chiang Mai province between 1947 and the early 1960s as a cover and green manure crop. When found useless for the purpose, it was employed for the control of irrigation ditchbank erosion, but has now become one of the worst and most aggressive weeds in the country.

Napompeth (1981) reported 5 insect species attacking *M. pigra* but, of these, only the boring beetle *Sagra femorata* caused much damage. A further study (Napompeth 1983) increased the number to 19 insects, but without adding any promising species.

Both *Acanthoscelides puniceus* and *A. quadridentatus* were liberated in 1984 (Table 4.16.1) and are now destroying between 1% and 20% of mature *M. pigra* seeds, which is significantly higher than that recorded for Australia (Forno 1992). The reasons for this different level of effect are not known. *Chlamisus mimosae* was liberated in 1986 and became established, but is not causing significant damage. The moth *Neurostrota gunniella*, which is producing such spectacular damage in Australia, has not been liberated in Thailand because it has been shown to be capable of developing in the aquatic *Neptunia oleracea*, which is used as a vegetable. Two other species, the weevil *Coelocephalopion aculeatum* and the moth *Carmenta mimosa* were liberated in 1991 (Wilson et al. 1992), but there is no information on their establishment or impact.

MALAYSIA

Acanthoscelides quadridentatus and *A. puniceus* have become established at Kota Bharu in northern Malaysia adjacent to the region where they are established in Thailand (B. Napompeth pers. comm. 1993).

MYANMAR

Acanthoscelides quadridentatus and *A. puniceus* have also become established in Myanmar along the border with Thailand (B. Napompeth pers. comm. 1993).

INDONESIA

M. pigra has been established in Indonesia at least since 1844 but is regarded as a less serious weed than in Thailand (Napompeth 1982, 1983). At least 10 insects were recorded on it and, at times, causing considerable damage in the Bogor area (1 Orthoptera, 3 Hemiptera, 1 Diptera, 2 Coleoptera and 3 Lepidoptera). Only one of these, a cerambycid borer *Milothris irrorata* was regarded as having any potential to cause important damage (Napompeth 1982). As there were doubts about its host specificity (Kalshoven 1981), it was introduced to Thailand for further study but did not survive in culture (Napompeth 1982, 1992b). *Acanthoscelides* spp. have been found in *M. pigra* seed pods collected in Bogor in 1992, although there are no records of releases having been made (B. Napompeth pers. comm. 1993).

VIETNAM

Acanthoscelides puniceus and *A. quadridentatus* from Thailand were liberated in 1987 and *Chlamisus mimosae* in 1990, but there is no information on their establishment (Julien 1992).

Important natural enemies***Acanthoscelides quadridentatus* Coleoptera: Chrysomelidae*****A. puniceus***

These two species occur widely in Mexico and *A. quadridentatus* is also recorded from Texas, Nicaragua and Honduras. There are also two additional species, *A. pigricola* and *A. zebratus*, that are apparently specific to *M. pigra* seeds (Habeck and Passoa 1982). Eggs are laid during the day in or near crevices between pod segments. At 25°C each larva hatches after 10 days and tunnels through the pod into a single seed in which it completes its development. Pupation occurs in a cell and adults emerge by chewing a hole through the seed coat. On average *A. quadridentatus* females live 93 days and lay 65 eggs, whereas *A. puniceus* females live 130 days and lay 178 eggs (Kassulke et al. 1990).

***Carmenta mimosa* Lepidoptera: Sesiidae**

This species is native to Mexico and Cuba. In Mexico the larvae tunnel in the stems of *M. pigra*, thereby weakening the plant. The upper two-thirds of the stems frequently snap off, resulting in spectacular damage. Females lay 1 to 5 eggs at a time (up to a total of about 260) in the axils of the topmost, fully expanded leaves on a stem. At 25°C larvae hatch after 11 days and tunnel into the stem at a node or the swelling at the base of a leaf petiole. They feed on the outer layers of the plant, sometimes ringbarking it, or tunnel

through the pith; they are cannibalistic if they meet another larva. They eject frass onto the surface of the stem. Occasionally larvae leave the stem and re-enter below the soil surface, grazing on and in the root, causing damage which sometimes kills the plant. Depending upon plant quality, there are 8 or 9 larval instars in 40 to 99 days before larvae spin a silken cocoon in which they pupate. The duration of the pupal period is 18 to 21 days, giving an average life cycle of 98 days. Larvae can be reared on an artificial diet. In host specificity tests, *C. mimosa* was found to complete its development only on *M. pigra* (Forno et al. 1991a, 1994, Smith and Wilson 1992, Wilson et al. 1992).

***Chalcoedermus serripes* Coleoptera: Curculionidae**

This weevil is native to Mexico. Adults feed on young leaves, flower buds and seeds. Eggs are inserted into the ventral side of pods so that they are at the embryo end of a developing seed. They hatch in 6 days and larvae feed on the soft developing seed, destroying the embryo (I.W. Forno, pers. comm.).

***Chlamisus mimosae* Coleoptera: Chrysomelidae**

This species is native to Brazil. Females mate 2 weeks after emergence and then begin to lay eggs. Each egg is enveloped in faecal material and attached to the underside of a leaf by a fine stalk. At 25°C larvae hatch after 3 weeks and construct a conical case which is added to as the larva grows. Larval development time is 83 days and the pupal stage lasts 25 days. Adults live up to 95 days. Adults and larvae graze on the epidermis of the growing tips, on green stems and on leaves. In Darwin (Northern Territory) cultures of *C. mimosae* were attacked by a pupal parasitoid and predatory mites (Wilson et al. 1992).

***Coelocephalopion aculeatum* Coleoptera: Apionidae**

This species is native to Mexico. It lays one egg at a time into a separate flower bud (of which an inflorescence contains up to 100). Larvae hatch after 2 days and feed on the developing flower buds, destroying the reproductive parts and sometimes the pedicel. Larval development takes about 7 days and pupal development 3 days. Preoviposition is about 7 days, adults live at least 3 months and may lay up to 5 eggs per day. Adults chew into the unopened flower buds and feed on the anthers and the pistil (Heard 1992, Wilson et al. 1992). This species could develop satisfactorily only on *M. pigra* (Forno et al. 1994).

***Coelocephalopion spretissimum* and *C. pigrae* Coleoptera: Apionidae**

The life cycle of these species is similar to that of *C. aculeatum*. Adults feed on young leaves as well as on flower buds. The host testing of *C. pigrae* has been completed.

***Neurostrotta gunniella* Lepidoptera: Gracillariidae**

This species is widespread in tropical or subtropical, moderately wet to semi-arid habitats wherever *M. pigra* occurs from southern Texas to Costa Rica and Cuba. It has been established in Australia.

Eggs are laid singly on the ventral side of the first or second leaf from the branch tip and hatch about 4 days later. The first and second instar larvae are adapted for mining by being flattened dorso-ventrally, having large blade-like mandibles and no thoracic legs.

Each mines up to 5 leaf pinnules. Third instar larvae are cylindrical, enter the leaf rachis and tunnel to the stem tip. Later instars usually tunnel down the stem. They sometimes leave the stem and re-enter it at a node or near a prickle. Frass is usually visible when a larva is inside a stem. Pupation occurs in a cocoon spun between pinnules or inside the stem. The outside of the cocoon is ornamented with small, pearly-white, frothy balls discharged from the anus.

At 25°C the time from egg to adult is about 30 days and equal numbers of males and females are produced. Females mate on the night of emergence and lay an average of 86 eggs, most on the second night. *N. gunniella* caused very severe damage to *M. pigra* in quarantine trials which demonstrated that, except for attack on *Neptunia* species, it was specific to *M. pigra*. The aquatic *Neptunia oleracea*, which is an important vegetable in Thailand was attacked, so it has not been released there. In Mexico *N. gunniella* larvae are heavily attacked by parasitoids (Davis et al. 1991, Forno et al. 1989a, 1991b).

***Sibinia* spp. Coleoptera: Curculionidae**

S. fastigiata occurs from Mexico to Brazil and Peru, whereas *S. seminicola* occurs from Texas and Mexico to southeastern Brazil and northeastern Argentina. These two *Sibinia* species are larger than the two that follow. Larvae of both species develop in the pods of *M. pigra* and feed on the seeds. Larvae of *S. seminicola* feed on green, immature seeds and pupation occurs within the pods while they are still attached to the plants (Clark 1984).

Sibinia ochreosa occurs in Texas, Mexico, Honduras, Nicaragua, Brazil, Argentina and *S. peruana* occurs in Mexico, Guatemala, Honduras, Costa Rica, Panama, Brazil, Peru, Bolivia and Argentina. Larvae of these two species develop in the flower buds of *M. pigra* and, at least the former species, pupates in the flower head (Clark 1984).

FUNGI

***Diabole cubensis* Fungi: Uredinales**

This rust attacks the leaves of *M. pigra* in Mexico and Cuba. It is particularly common and damaging during the dry season when there are high day temperatures and a significant drop at night leading to dew formation. Five hyperparasitic fungi are consistently encountered, often completely overgrowing the rust (Evans 1988, 1990).

***Phloeospora mimosae-pigrae* Fungi: Coelomycetes**

This fungus causes extensive defoliation during the wet season, particularly in the Gulf coast of Mexico, but also occurs in Trinidad, Venezuela, Colombia and Brazil. It attacks stems, leaves and seed pods. It is host specific to *M. pigra* (Evans 1988, 1990, Seier and Evans 1993).

Comment

The majority of natural enemies of *M. pigra* so far studied are flower or seed attacking insects and there are indications already that considerable amounts of seed are being destroyed—up to 60% from *Neurostrotia* alone in Australia and up to 20% by bruchids in

Thailand. However, starting from a seed bank of 9000 per m², this degree of reduction is nowhere like limiting.

The inhibition to tip growth produced in Australia by *Neurostrotta gunniella* is likely to be far more significant and will become even more so if the borer, *Carmenta mimosa*, becomes abundant enough to weaken a considerable proportion of larger stems.

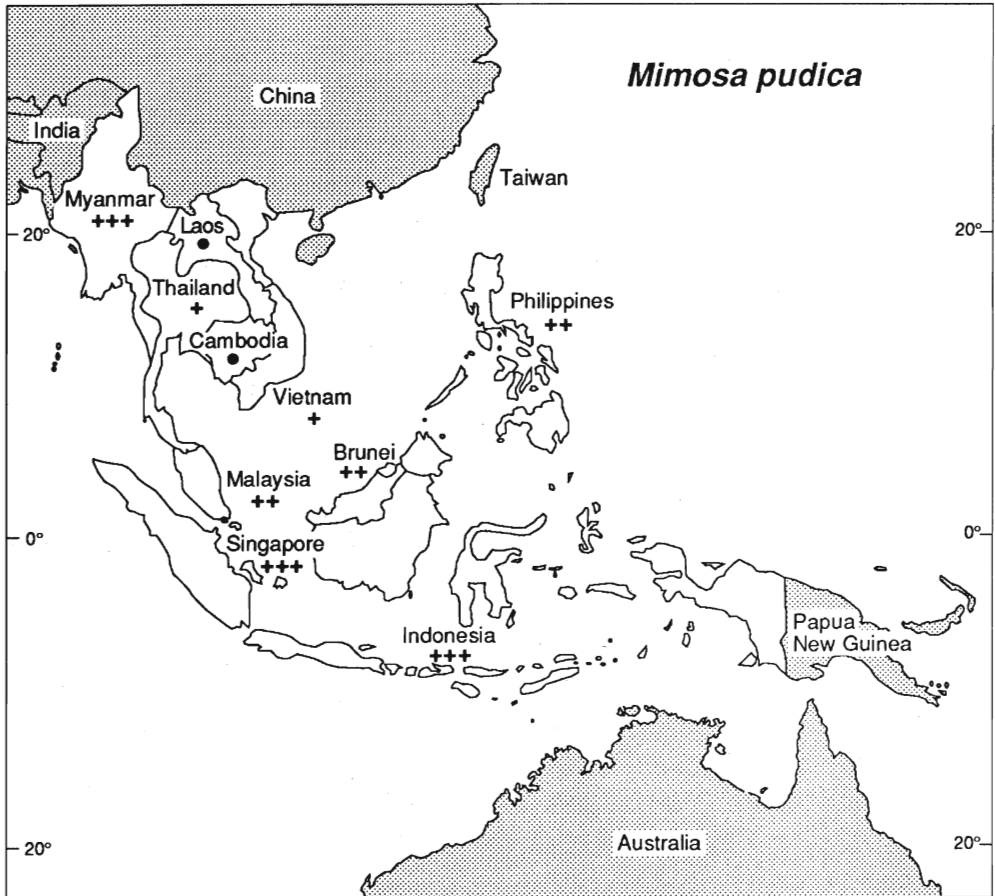
If (when) the two apparently specific fungi are approved for release, it is confidently expected that they will make a major contribution, *Phloeospora mimosa-pigrae* in the wet season and the rust *Diabole cubensis* in the dry.

It is highly probable that a complex of natural enemies will be required to bring about an adequate reduction in competitiveness of *M. pigra*. It is still unclear whether those available or under investigation will be adequate but, if required, there are additional species that could be examined and future priority might well be given to leaf, stem or root feeding species.



Mimosa pudica

(after Holm *et al.* 1977)



Map 4.17 *Mimosa pudica*

Very little is known about the natural enemies of *Mimosa pudica* in its centre of origin in Central America. Most of the species recorded from there or elsewhere are widely polyphagous and few show promise as biological control agents. Since at least three forms of the weed are known it would be desirable to establish which forms are weedy in Southeast Asia so as to enable any searches in Central America to concentrate on that form. On general grounds, it is probable that useful species do exist.

4.17 *Mimosa pudica* L.

Mimosaceae

common sensitive plant; paklab, sampeas (Cambodia), daoen kaget kaget (Indonesia) mala malu (Malaysia), makahiya (Philippines), mai yarap (Thailand) mǎc cǒ (Vietnam)

Rating

	+++	Myan, Sing, Indo
17	++	Msia, Brun, Phil
	+	Thai, Viet
	•	Laos, Camb

Origin

Tropical America.

Distribution

M. pudica is widespread in tropical, subtropical and temperate areas of the world. Its distribution and other relevant aspects were summarised by Waterhouse and Norris (1987). There are at least three distinct varieties (Brenan 1959). *M. pudica hispida* is uncommon in the Americas, but is established in the Philippines (Barneby 1989), the Caroline and Mariana Is, Queensland, India and in African savanna country. *M. pudica unijuga* occurs in Hawaii and probably in other Pacific countries where it is a major weed.

Characteristics

M. pudica is low, much branched, generally perennial, slightly woody at the base, from 15 to 100 cm high and has either an upright or a low trailing habit. Its stiff reddish-brown or purple stems bear scattered thorns. The hairy leaves are alternate, bipinnate and compound. They are sensitive to the touch, the petiole dropping and the leaflets being rapidly drawn back and folded. The pink flowers form small globular heads, each borne on a short hairy stalk arising from a leaf axil. Seeds are produced in pods which split into single-seeded segments bearing bristles, which aid dispersal by animals. In tropical countries the weed flowers all year and each plant may produce up to 700 seeds.

Importance

M. pudica is a weed in 22 crops in 38 countries (Holm et al. 1977). It is common in waste land and is also a weed of lawns, crops, pastures and roadsides. In Southeast Asia and the Pacific it is a serious weed in maize, sorghum, sugarcane, tea, soybeans, upland rice, pineapples and cotton. Because of its tolerance to shading it is an important weed in plantation crops, such as rubber, coconuts, bananas, papaya, coffee, oil palm and citrus. In tropical pastures its dense growth and thorns often deter animals from feeding on suitable forage mingled with it (Holm et al. 1977). The thorns deter hand weeding and, as it sur-

vives mowing, it is a very unwelcome component of lawns. Attempts to select thornless types as pasture plants have not been successful.

Natural enemies

Some information is summarised by Waterhouse and Norris (1987). It is interesting that Holm et al. (1977) report *M. pudica* to be a widespread weed in the Caribbean, but far less important to the north and south of this region. This suggests that it evolved elsewhere in the Americas and has not been accompanied into the Caribbean by its full suite of natural enemies. Nevertheless a preliminary survey in Trinidad (Table 4.17.1) revealed 14 insects attacking it, but they are probably polyphagous, with the possible exception of the arctiid caterpillar *Lophocampa catenulata* and the beetle, *Chlamisus* sp. (Yaseen 1971, 1972). Perez et al. (1988) found that the race *filenus* of *Hemiargus hanno* in Cuba appears not to attack plants other than *M. pudica*, although partially grown larvae of the Trinidad race were able to complete their development on *Aeschynomene sensitiva* and *Cajanus cajan* (Yaseen 1972). *H. hanno filenus* feeds readily on *M. pudica* seeds and is particularly active in spring when the weed is producing most seed (Perez et al. 1988). Four additional insects are known from Brazil (Garcia 1982a,b, 1983) but, so far, no species of *Heteropsylla*, although a special search for one might be rewarding. Although *M. pudica* was often encountered in surveys carried out in Mexico and Venezuela for natural enemies of *M. pigra*, casual observation did not suggest that it was heavily attacked, less so indeed than *M. invisa* (I.W. Forno pers. comm. 1993).

It is not known whether there is any differential attack by natural enemies on any of the three or more varieties of *M. pudica*, which have been established on morphological differences alone.

Table 4.17.1 Natural enemies of *Mimosa pudica*.

Species	Country	Portion of plant attacked	References
INSECTS			
Hemiptera			
COCCIDAE			
<i>Coccus longulus</i>	Fiji	stems	Hinckley 1963
CYDNIDAE			
<i>Microporus</i> (= <i>Microcompsus</i>) sp.	Trinidad		Yaseen 1972
DIASPIDIDAE			
<i>Hemiberlesia lataniae</i>	Fiji	stems	Hinckley 1963
<i>Pinnaspis strachani</i>	Fiji	stems	Hinckley 1963
MARGARODIDAE			
<i>Icerya seychellarum</i>	Fiji	stems	Hinckley 1963
SCUTELLERIDAE			
2 species	Trinidad	flowers	Yaseen 1971
Coleoptera			
CHRYSOMELIDAE			
<i>Chlamisus</i> sp.	Trinidad	flower buds	Yaseen 1971, 1972

(continued on next page)

Table 4.17.1 (continued)

Species	Country	Portion of plant attacked	References
CURCULIONIDAE			
<i>Chalcodermus</i> sp.	Brazil	seed pods	C.A. Garcia pers. comm.
<i>Promecops</i>	Brazil	leaves; mainly on	Garcia 1982a,b, 1983
<i>?campanulicollis</i>		<i>M. invisa</i> , see table 4.15.1	
An unidentified sp.	Trinidad		Yaseen 1971
Lepidoptera			
ARCTIIDAE			
<i>Lophocampa catenulata</i>	Trinidad	leaves	Yaseen 1971
GEOMETRIDAE			
<i>Ptychamalia perlata</i>	Trinidad	leaves	Yaseen 1972
GRACILARIIDAE			
<i>Neurostrota gunniella</i>	Mexico	leaves, stems	Davis et al. 1991
HESPERIIDAE			
<i>Cogia</i> (= <i>Caicella</i>)	Trinidad	leaves, flowers	Cock 1985, Yaseen 1972
<i>calchas</i> (= ? <i>Nisoniades bessus</i>)			
<i>?Staphylus mazans</i>	Trinidad	leaves, flowers	Yaseen 1972
LYCAENIDAE			
<i>Calephelis</i> sp.	Trinidad	leaves	Yaseen 1971
<i>Hemiargus hanno</i>	Cuba, Trinidad	leaves, flowers, pods also on flowers of <i>Aeschynomene</i> <i>sensitiva</i> and <i>Cajanus</i> <i>cajan</i> (= <i>C. indicus</i>)	Dethier 1940, Perez et al. 1988, Yaseen 1972
<i>Tmolus azia</i>	Trinidad	leaves, flowers also on <i>Mimosa pudica</i> and groundnut flowers	Yaseen 1972
NOCTUIDAE			
<i>Spodoptera litura</i>	Fiji	leaves	Hinckley 1963
Sp. 1 (velvet black larva)	Brazil	leaves; also on <i>M. invisa</i>	Garcia 1982a,b, 1983
PIERIDAE			
<i>Eurema lisa</i>	Cuba		Dethier 1940
<i>Eurema tenella</i>	Brazil	leaves: mainly on <i>M. invisa</i> , see table 4.15.1	Garcia 1982a,b, 1983
TORTRICIDAE			
<i>Platynota rostrana</i>	Trinidad	leaves	Yaseen 1972
NEMATODE			
<i>Meloidogyne</i> sp.	Cuba		Holm et al. 1977, Izquierdo et al. 1987
FUNGI			
<i>Oidium</i> sp.	Mexico	mildew on leaves	Evans 1987
<i>?Puccinia</i> sp.	Mexico	rust on leaves	Evans 1987
VIRUS			
unspecified	Germany		Umrath et al. 1979





Monochoria vaginalis

(after Holm *et al.* 1977)



Map 4.18 *Monochoria vaginalis*

Monochoria vaginalis appears to be a major weed only in Southeast Asia and then only in rice. Almost nothing is known of its natural enemies in India and Africa where it occurs, but is not regarded as important. This suggests that a survey in these regions might reveal promising biological control agents.

4.18 *Monochoria vaginalis* (Burm. f.) Presl

Pontederiaceae

monochoria; ka kiad chrach (Cambodia), phak kbiat (Thailand), rau mác lá thon (Vietnam), etjeng padi (Indonesia), biga bigaan (Philippines), kelayar, echeng padi (Malaysia)

Rating

+++	Laos, Camb, Msia, Brun, Indo, Phil
26 ++	Myan, Thai, Viet, Sing

Origin

Tropical Asia and Africa (Holm et al. 1977), but not a pest in Africa or Asia (Soerjani et al. 1987), although it is clearly very important in Southeast Asia.

Distribution

Africa, India, China, Korea, Japan, Southeast Asia to northern Australia, Fiji and Hawaii.

Characteristics

A smooth, fleshy, semi-aquatic annual or perennial, 0.1 to 0.5 m tall; the plant roots in mud and its upper portions grow above water; stemless, base of leaves heartshaped or rounded, shiny deep green; petioles soft, hollow; inflorescence with a large bract and arising about two thirds of the way up the petiole from the base and opposite the leaf; 3 to 25 violet or lilac flowers producing numerous, small seeds throughout most of the year. Seed germination and seedling growth not reduced by submergence. Old plants often form large clumps.

Importance

M. vaginalis occurs in marshy places, freshwater pools, mudflats, ditches, along canal banks and in rice fields. It is a very serious weed of rice in eastern and southern Asia. It is predominantly an annual in flooded ricefields, dying when the fields dry out, but developing again later from seed.

In Taiwan, *M. vaginalis* produced more fresh tissue weight than any other weed in rice, twice that of second ranking *Echinochloa crus-galli* (Lin 1968). However in the Philippines it was outcompeted in rice by *E. crus-galli* (Lubigan and Vega 1971). Only in rice is it reported as a very widespread and important weed, except for its occurrence in taro in Hawaii.

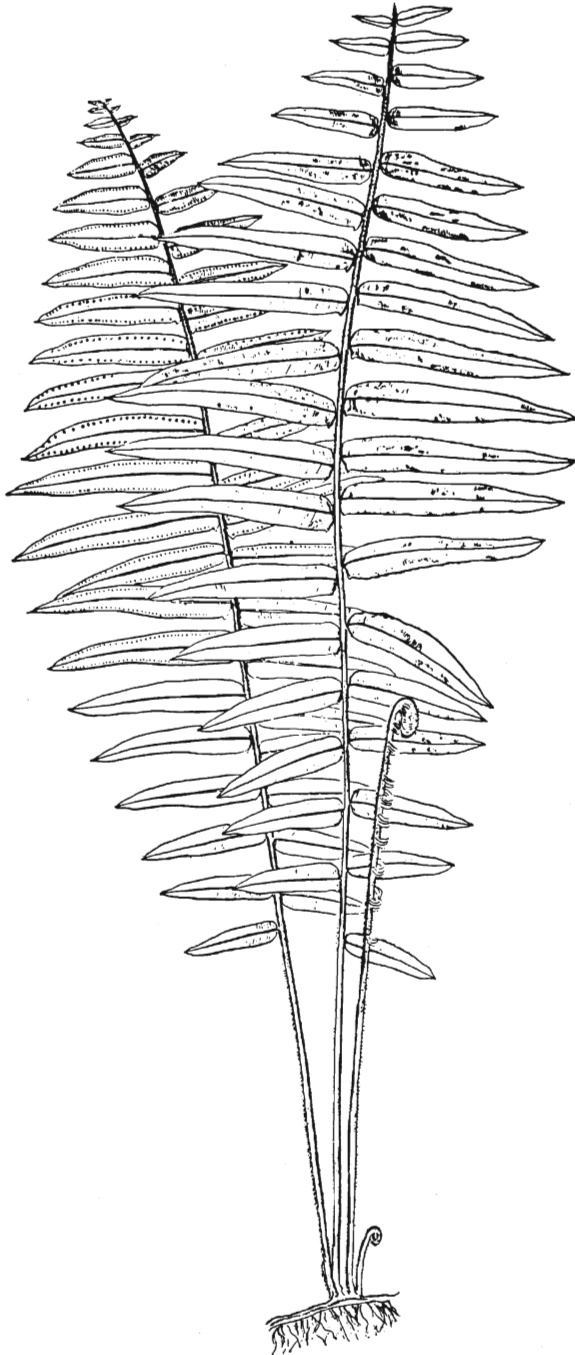
Its leaves are eaten as a pot herb in India and several parts of it are used as herbal medicine, the juice being prescribed for various conditions and the roots for stomach and liver ailments and toothache (Burkill 1935, Soerjani et al. 1987).

Natural enemies

So little is recorded about the natural enemies of *M. vaginalis* (Table 4.18.1) that it is not possible to assess the prospects for biological control. However, the fact that it is apparently not a weed in Africa or western Asia suggests that it would be well worthwhile investigating these regions for suitable agents.

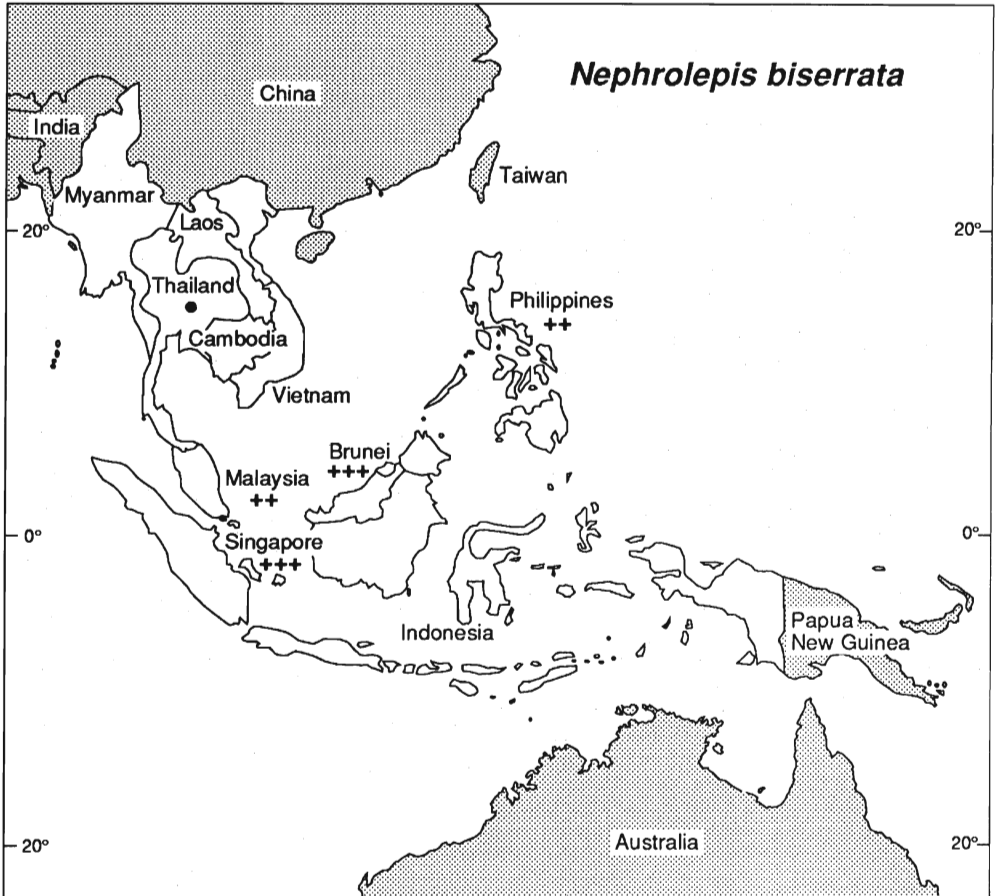
Table 4.18.1 Natural enemies of *Monochoria vaginalis*.

Species	Location	Other hosts	References
INSECTS			
Orthoptera			
ACRIDIDAE			
<i>Gesonula punctifrons</i>	India		Sankaran & Rao 1972
Hemiptera			
CICADELLIDAE			
<i>Macrosteles fascifrons</i>	USA	rice	Way et al. 1983
DELPHACIDAE			
<i>Tarophagus proserpina</i>	Philippines	taro, cassava, sweet potato	Duatin & Pedro 1986
Lepidoptera			
NOCTUIDAE			
<i>Spodoptera litura</i>	India	widely polyphagous	Sankaran & Rao 1972
PYRALIDAE			
<i>Elophila responsalis</i>	Indonesia	<i>Marsilea minuta</i> , <i>Pistia stratiotes</i> , <i>Salvinia molesta</i> , <i>S. cucullata</i>	Handayani & Syed 1976, Mangodihardjo 1975
<i>Nymphula fregonalis</i>	India	probably polyphagous	Sankaran & Rao 1972
SPHINGIDAE			
<i>Hippotion echeclus</i>	India	polyphagous	Sankaran & Rao 1972
NEMATODES			
<i>Hirschmaniella</i> spp.		rice, sugarcane, many weeds	Luc et al. 1990
<i>Meloidogyne graminicola</i>		rice, many weeds	Luc et al. 1990
VIRUSES			
rice ragged stunt	Thailand, Philippines	rice	Parejarearn et al. 1988, Salamat et al. 1987
<i>Pistia virus</i>	India		Menon & Ponnappa 1964
FUNGI			
<i>Cercospora</i> sp.	India		Menon & Ponnappa 1964
<i>Doassansia</i> sp.	India		Menon & Ponnappa 1964
<i>Rhizoctonia solani</i>	India	rice, potato	Gokulapalan & Nair 1983
<i>Thanatephorus cucumeris</i>	Philippines	rice	Moody et al. 1987, Mew et al. 1980
a leaf blight	Philippines	<i>Sphenoclea zeylanica</i>	Bayot et al. 1992
CRUSTACEA			
<i>Triops cancriformis</i>	Japan	<i>Veronica peregrina</i> and some other weeds	Igarashi 1985



Nephrolepis biserrata

(after Barnes and Chan, 1990)



Map 4.19 *Nephrolepis biserrata*

N. biserrata is a widespread fern that probably originated in Tropical Africa. Almost nothing was learnt concerning natural enemies from a literature search. A survey in its area of origin would be required to evaluate whether there were any natural enemies that might be of value for biological control.

4.19 *Nephrolepis biserrata* (Sw.) Schott

Nephrolepidaceae (formerly in the Davalliaceae)

broad sword fern; paku larat (Malaysia)

Rating

	+++	Sing, Brun
10	++	Msia, Phil
	•	Thailand

Origin

Probably Tropical Africa.

Distribution

Pantropical. *N. biserrata* occurs throughout tropical Africa, ranging in the west from Guinea to Angola and in the east from Sudan to Durban (South Africa). It is mainly coastal, but infrequent in the interior. It is most abundant up to 350 m (Jacobsen 1983). In addition to Southeast Asia, it is also known from India, Australia, Japan, the Pacific, USA and Mexico.

Characteristics

N. biserrata is a perennial, terrestrial or epiphytic fern. The rhizome bears abundant scales and produces many long stolons. The fronds are tufted, suberect to arching and green when young, turning brown when old. The pinnae are commonly 15 to 20 cm wide, exceptionally more than 30 cm. Fertile pinnae are narrower than the sterile pinnae and bear sori well clear of the edge. The veins are indistinct and fork once or twice. When rooted in the soil, the fern commonly reaches a height of 2m and, exceptionally in South Africa, up to 4 m.

Importance

N. biserrata is very common in shaded places in the lowlands wherever the conditions are not too dry. It can form dense masses in rubber and oil palm plantations and in orchards and often occurs as an epiphyte on palms. Where pineapples had been grown for up to 10 years in Malaysia, 90% of the viable seeds and spores in the top 15 cm of soil were spores of *N. biserrata* (in particular) and 8 other ferns (Wee 1974), enabling its rapid reappearance after cultivation.

Natural enemies

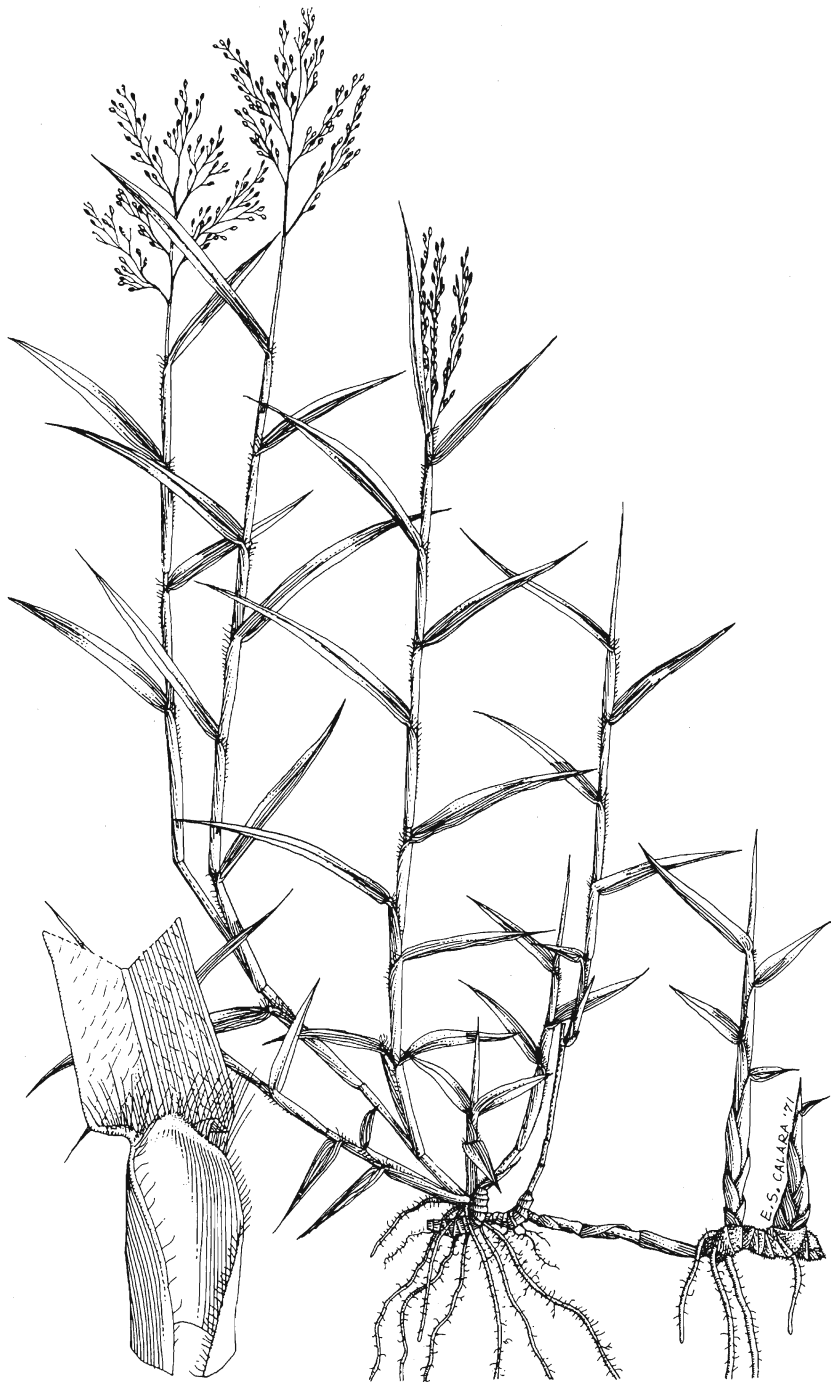
The only records of natural enemies encountered were those of an eriophyid mite on *N. biserrata* in Fiji (Mani and Jayaraman (1987) and of the nematode *Aphelenchoides fragariae* in Hawaii, but there is no evidence that a careful search has ever been made.

Attempts at biological control

There have been none.

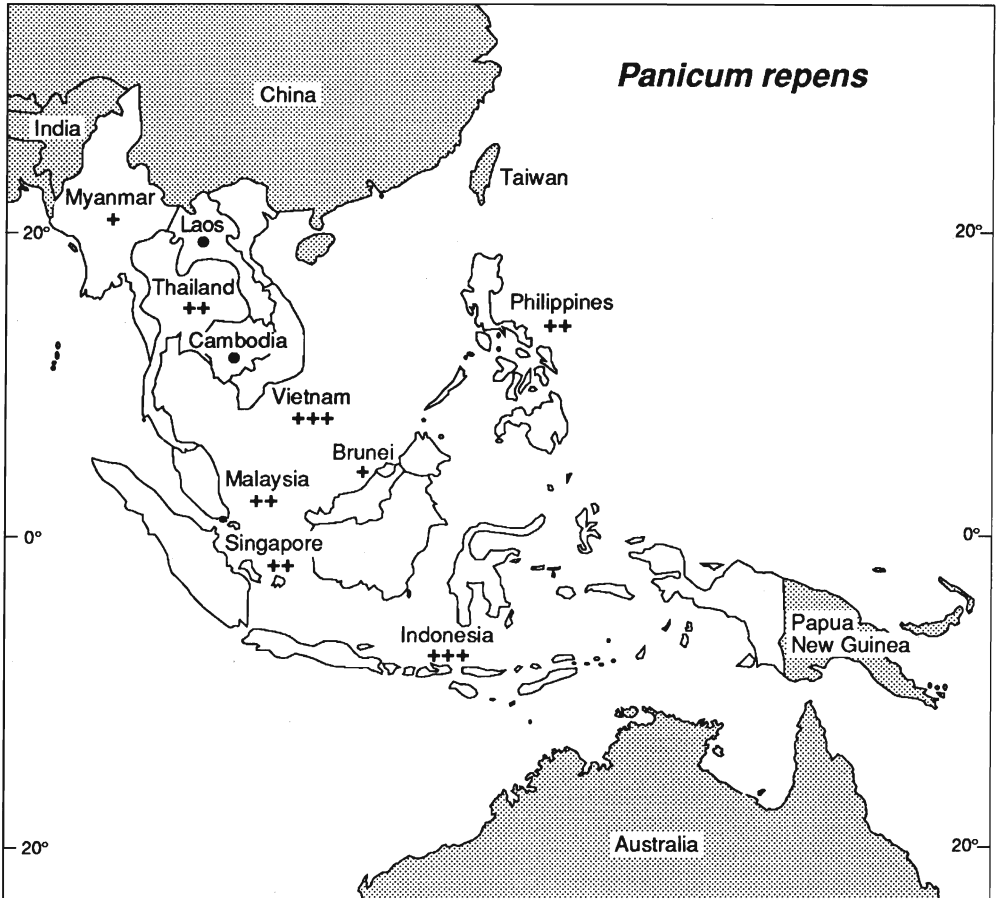
Comment

The genus *Nephrolepis* contains about 20 species (Tryon and Tryon 1982), or 35 species (Jacobsen 1983). It is primitive among the group of oleandroid, davallioid and nephrolepoid ferns to which it belongs and *N. biserrata* and its close allies represents the more primitive element in the genus *Nephrolepis* (Nayar and Bajpai 1976). A survey for natural enemies, particularly in the areas in Africa where it occurs, would reveal whether there are any that might be of value in biological control.



Panicum repens

(after Holm *et al.* 1977)



Map 4.20 *Panicum repens*

P. repens is a major grassy weed in Southeast Asia. It is probably of tropical African/Mediterranean origin, a region where it is not reported to be a problem. Very few natural enemies have been recorded and, without a preliminary survey in its area of origin, it would not be possible to evaluate the prospects for its biological control.

4.20 *Panicum repens* L.

Poaceae

torpedo grass, creeping panic grass; myet kha (Myanmar) yah chan ah kat, yah chanagard (Thailand), chhlong (Cambodia), cò ông (Vietnam), keruong padi, rumput jae jae (Malaysia and Indonesia), luya luyahan (Philippines)

Rating

	+++	Viet, Indo
16	++	Thai, Msia, Sing, Phil
	+	Myan, Brun
	•	Laos, Camb

Origin

Tropical and North Africa, Mediterranean (sometimes said to be native to Asia).

Distribution

Panicum repens is widely distributed in the tropics and subtropics. It was introduced to Java about 1850, but is said not to occur in the Moluccas. No seeds are produced in Indonesia (Soerjani et al. 1987).

Description

Panicum repens is an erect, wiry, creeping, perennial grass, rooting at hairless nodes and bearing flowering stalks 30 to 90 cm tall. It spreads widely (up to 7 m), but does not form dense clumps. Its smooth, sharp-pointed, branched rhizomes are often swollen or knotty and have brownish or whitish scales. Its leaves are alternate. The inflorescence is an open terminal panicle, 6 to 20 cm long, with many tender branches pointing obliquely upwards. The spikelets are pale green or pale yellow and often tinged with purple.

Importance

Panicum repens is one of the most serious grass weeds because of its rapid rate of spread and the persistence and hardness of its coarse, enlarged rhizomes. It suppresses other plants by its allelopathic (inhibiting) products (Perera et al. 1989). It is primarily a weed of moist, coastal, sandy soils, although it also grows in heavy upland soils (to 2000 m in Indonesia). It thrives in open sunny situations, but can stand partial shade and its rhizomes survive even prolonged dry periods. It tolerates temporary flooding, sometimes forms floating mats, and encroaches upon ditches, drains and watercourses. It is common in cultivated lands, grasslands, roadsides and gardens and is frequently reported as a weed in lawns. In Malaysia it is a serious weed of cocoa, coconuts and rubber, in Indonesia of rainfed and upland rice, cocoa, coconut, maize, rubber, sugarcane and tea and in Thailand of rice and orchard crops. In improved pastures it chokes out more nutritionally valuable

grasses. Deep ploughing favours its spread by breaking up and dispersing its rhizomes.

P. repens is quite palatable to stock when young and has the advantage of being able to stand heavy grazing and trampling. However, it contains only 3.3% crude protein and up to 39% crude fibre, so there are other far more nutritious grasses suitable for the same environment (Holm et al. 1977).

Natural enemies

As can be seen in table 4.20.1, very few natural enemies were revealed by an extensive literature search. The only species not known to be both polyphagous and a pest is the mite *Parasteneotarsonemus panici*, recorded so far only from Tamil Nadu, India, where it was found causing rusting symptoms beneath the leaf sheath of *P. repens* (Mohanasundaram 1984).

Absence of attack almost certainly does not represent the true situation, but rather that no relevant surveys have been carried out. For example, there has been little advance in knowledge of cecidomyiid gall flies attacking *Panicum* spp. since the summary by Barnes (1954b) in which were listed at least 13 species (Table 4.20.2). Two of these (the widespread rice stem gall midge *Orseolia* (= *Pachydiplosis*) *oryzae* and *Contarinia* (= *Stenodiplosis*) *panici* are known to be pests (Hegdekatti 1927). The scarcity of information from Africa points to an important gap in our knowledge and the absence of records from the Mediterranean, where most plants have been studied in some detail for native-insects, suggests that *P. repens* is not native to that region.

Comment

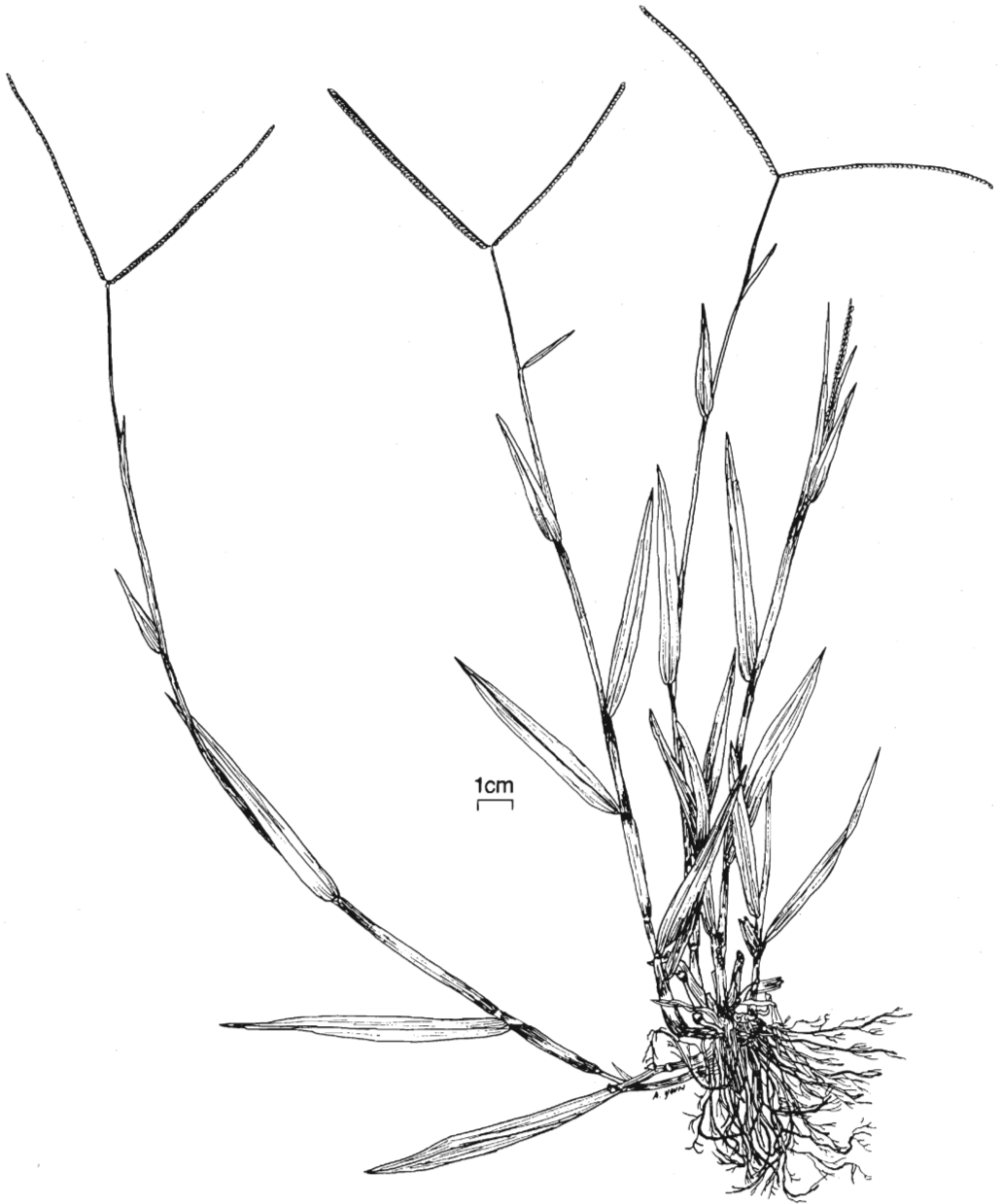
Clearly insufficient information is known about the natural enemies of *P. repens* (although it doubtless must have many) to provide any meaningful assessment of the prospects for its biological control. However, the genus *Panicum* contains a number of good to very good fodder species (e.g. *P. antidotale* (blue panic), *P. bulbosum* (bulbous panic), *P. capillare* (witchgrass), *P. maximum* (guinea grass), *P. paludosum* (swamp panic)) as well as several that are weedy and may cause photosensitivity or poisoning (e.g. *P. coloratum* (coolah grass), *P. luzonense*, *P. miliaceum* (millet panic, or proso), *P. novemnerve*). There are thus likely to be considerable problems in discovering organisms of adequate specificity. Nevertheless, *P. repens* is not reported as a weed of crops in tropical Africa or the Mediterranean (Holm et al. 1977) and a preliminary survey there might well reveal promising natural enemies.

Table 4.20.1 Natural enemies of *Panicum repens*.

Natural enemies	Recorded from	References
INSECTS		
Hemiptera		
CICADELLIDAE		
<i>Thaia oryzivora</i>	Thailand	Leeuwangh & Leuamsang 1967
DELPHACIDAE		
<i>Delphacodes idonea</i>	USA	Ballou et al. 1987
<i>Sogatella kolophon</i>	Australia, Pacific Is, SE Asia, USA, Central & S. America, W. Africa	Ballou et al. 1987
Lepidoptera		
EUPTEROTIDAE		
<i>Nisaga simplex</i>	India	Patnaik et al. 1987
NOCTUIDAE		
<i>Sesamia cretica</i>	Egypt	Ahmed 1980
PYRALIDAE		
<i>Cnaphalocrocis medinalis</i>	Philippines	Abenes & Khan 1990
<i>Cnaphalocrocis</i> (= <i>Marasmia</i>) <i>patnalis</i>	Philippines	Abenes & Khan 1990
<i>Paraponyx stagnalis</i> (= <i>Nymphula depunctalis</i>)	India	Pillai & Nair 1979
MITES		
TARSONEMIDAE		
<i>Parasteneotarsonemus panici</i>	India	Mohanasundaram 1984
FUNGI		
<i>Claviceps</i> sp.	India	Janardhanan et al. 1982
<i>Pyricularia</i> sp.	India	Hilda & Suranarayanan 1976, Holm et al. 1977
<i>Pyricularia oryzae</i>		Paje et al. 1964
<i>Sporisorium overeemi</i>		Rifai 1980
NEMATODE		
<i>Meloidogyne graminicola</i>		Luc et al. 1990

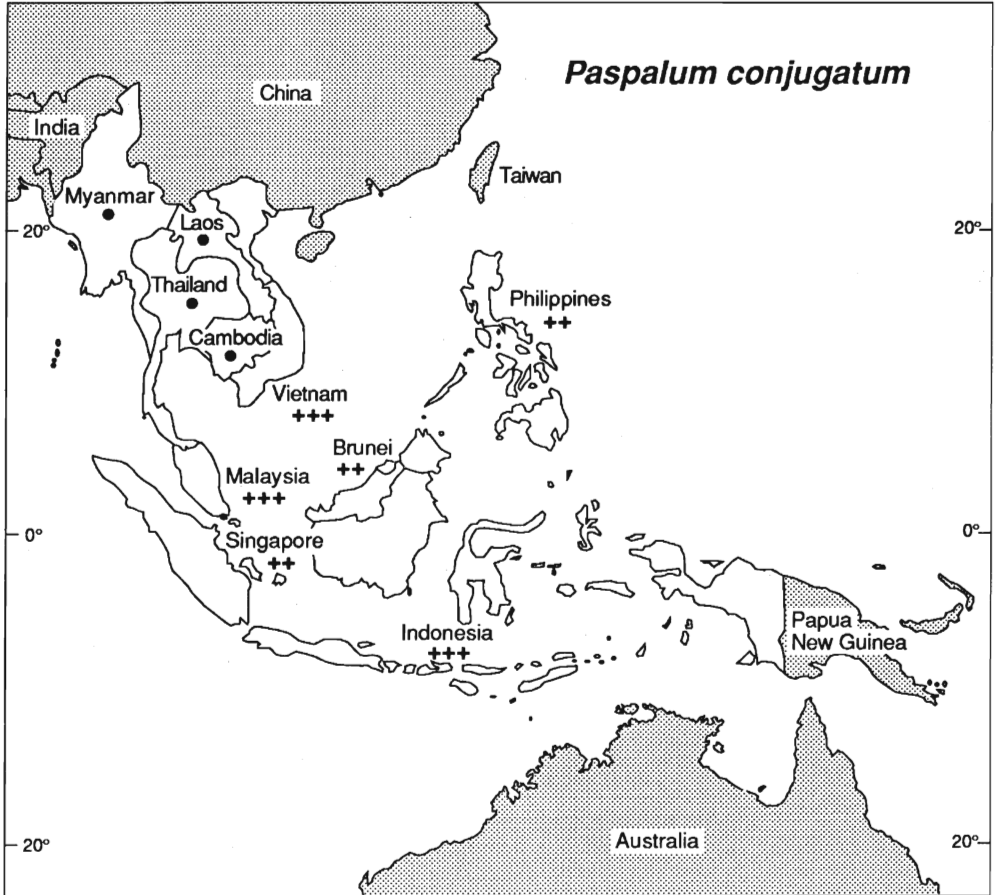
Table 4.20.2 Gall flies (Cecidomyiidae) reported attacking *Panicum* spp. (after Barnes 1954b).

Species	Recorded from	Location
<i>Contarinia</i> (= <i>Stenodiplosis</i>) <i>panici</i>		Yugoslavia, USSR
<i>Lasioptera</i> (= <i>Dyodiplosis</i>) <i>fluitans</i>	<i>Panicum fluitans</i>	S. India
<i>Lasioptera inustorum</i>		USA
<i>Lasioptera kanni</i>		S. India
<i>Lasioptera panici</i>		USA
<i>Lasioptera paniculi</i>		Philippines
<i>Orseolia cynodontis</i>		France, Italy, Algeria, Eritrea, Senegal
<i>Orseolia</i> (= <i>Courteia</i>) <i>graminis</i>		Java, Sri Lanka, S. India
<i>Orseolia</i> (= <i>Dyodiplosis</i>) <i>andropoginis</i>		
<i>Orseolia</i> (= <i>Dyodiplosis</i>) <i>fluvialis</i>	<i>Panicum fluitans</i>	S. India
<i>Orseolia</i> (= <i>Pachydiplosis</i>) <i>oryzae</i>		S and SE Asia, W. Africa
<i>Parallelodiplosis javanica</i>	<i>Panicum indicum</i>	Sri Lanka
<i>Parallelodiplosis</i> spp.		Middle East, Java, Peru



Paspalum conjugatum

(after Holm *et al.* 1977)



Map 4.21 *Paspalum conjugatum*

P. conjugatum is of Tropical American origin, but it is recorded as an important weed in a number of situations in the Caribbean area. Very few natural enemies have been reported. A preliminary survey would be required in its centre of origin before the prospects for its biological control could be evaluated.

4.21 *Paspalum conjugatum* Bergius

Poaceae

sourgrass; paitan, rumput canggah, rumput pait (Indonesian), rumput kerbau, jampang canggah, buffalo grass (Malaysia), hulape (Philippines), ya hep (Thailand)

Rating

	+++	Viet, Msia, Indo
15	++	Sing, Brunei, Phil
	•	Myan, Thai, Laos, Camb

Origin

Tropical America.

Distribution

Paspalum conjugatum occurs as a troublesome weed in Central America, West Africa and the islands and peninsulas of Southeast Asia and the Pacific. These are, for the most part, the humid tropics (Holm et al. 1977).

Characteristics

P. conjugatum is a creeping, stoloniferous, perennial grass. The stolons are up to 2 m in length, often reddish purple in colour and bear roots and a tuft of green to purple leaves at each node.

The flower stalks are erect, range up to 60 cm, and have smooth nodes. At the apex of each stalk there are two racemes (flower spikes) 4 to 15 cm long. The stigmas are white and the anthers bright yellow. The weed can be recognised when in flower by the typical T-shaped inflorescence.

Importance

P. conjugatum is mainly a weed of the warm, wet lowlands, although in Hawaii and Sri Lanka it grows up to 1875 m. It is found in waste areas and along paths and streams, its inflorescences trailing in the water. It is common in cultivated fields and in natural and poorly managed pastures and particularly in perennial or plantation crops where the soil is not ploughed frequently. It spreads rapidly by its stolons, forming dense masses which can suppress or eliminate tree seedlings and other small plants. It tolerates some shade and can grow on poor and acid soils.

In the Philippines it flowers all year round and one plant can produce 1500 seeds. It is also dispersed by broken pieces of stolons rooting after being spread by machines used for cultivation. In the Philippines it is particularly important in bananas, coffee, papaya, rice and pineapple; in Cambodia in rice; in Malaysia in citrus, coconuts, oil palm, rice

and rubber; in Indonesia in tea, oil palm and rubber; and elsewhere in cassava, cocoa, lawns, maize, pastures, sugarcane and vegetables.

P. conjugatum is suitable for grazing only when young and the seeds of older plants have been reported to choke animals by sticking in their throats (Holm et al. 1977).

Natural enemies

The natural enemies of *P. conjugatum* that have been recorded in the literature (Table 4.21.1) are almost all polyphagous and many of them are of economic importance. One possible exception is the bagworm moth *Brachycyttarus griseus*, which was originally described from Vietnam and is also recorded from Malaysia and the Philippines, as well as from Guam and Hawaii to which it has spread. It feeds on *P. conjugatum* in Hawaii and on the grass *Zoysia pungens* in Guam: it probably also feeds on other grasses. In Guam it is parasitised by the tachinid fly, *Stomatomyia* sp. (Davis 1990). However, it does little to control *P. conjugatum* in the countries where it already occurs, so it does not appear to be a promising species to introduce elsewhere.

Perhaps more valuable is the cecidomyiid fly *Cleitodiplosis graminis*, a gall forming fly described from Brazil. The gall consists of the terminal leaves becoming clustered into an ovoid 30 x 20mm mass as a result of the upper internodes being greatly reduced. Thirty to forty sulphur-coloured larvae may be found in a single gall, in which they pupate. They appear in August and September (Barnes 1956). Barnes (1954b) commented that no gall midge had, at that time, been recorded from the inflorescence of *Paspalum*, although *Parallelodiplosis paspali* (from Java and India) and *Lasioptera* sp. had been recorded from the stems.

The chrysomelid beetle *Colaspis* (= *Maecolaspis*) *aerea* also damages cocoa in Brazil (Ferronato 1986) and hence would not be acceptable for introduction elsewhere.

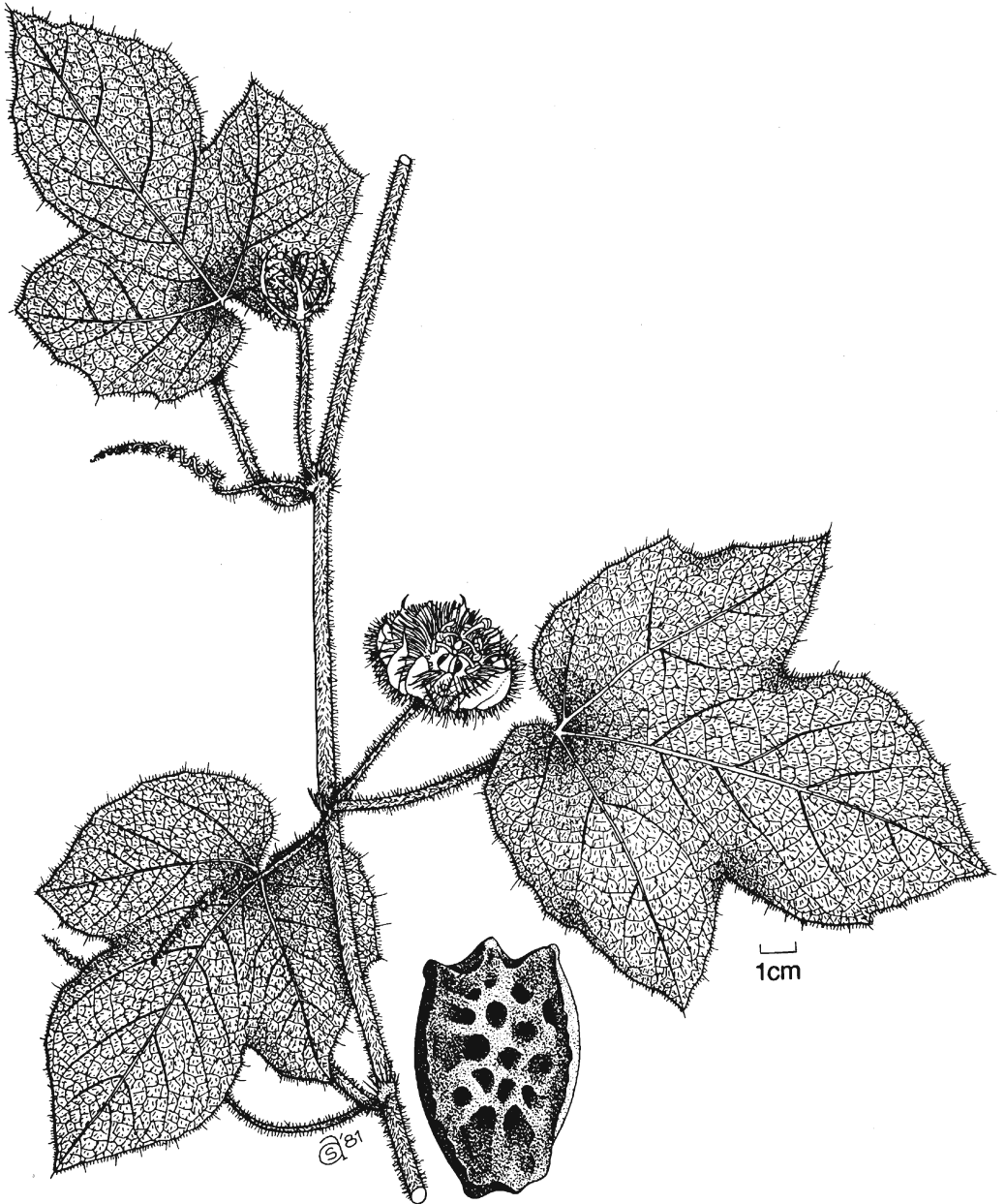
The seeds of *P. conjugatum* are harvested by ants in some areas, but the impact of this on weed density in the field has not been established. Under experimental field conditions in Mexico, the pestiferous fire ant, *Solenopsis geminata*, reduced *P. conjugatum* seed densities by 97% or more but had no effect on the seed densities of *Bidens pilosa* (Carroll and Risch 1984).

Comment

As with *Panicum repens*, so little is known about the natural enemies of *Paspalum conjugatum* that it is not possible to evaluate the prospects for its biological control. Again, there is the limitation that some closely related species in the genus *Paspalum* are of economic value for fodder (e.g. *P. dilatatum* (paspalum), *P. distichum* (saltwater couch), *P. plicatulum*, *P. scrobiculatum* (scrobic), *P. vaginatum* (saltwater couch)). However, a fungus attacks the seeds of the first two species, producing the toxin, ergot, and most of the species are considered weedy in at least some situations, so there may be occasions where a conflict of interests would have to be resolved, should effective agents be discovered. The prospects for finding these are not perhaps very promising, since Holm et al. (1977) record *P. conjugatum* as a weed in a number of countries in and around the Caribbean.

Table 4.21.1 Natural enemies of *Paspalum conjugatum*.

Species	Country	References
INSECTS		
Thysanoptera		
<i>Haplothrips gowdeyi</i>	Hawaii	Sakimura 1937
<i>Haplothrips paumalui</i>	Hawaii	Sakimura 1937
Coleoptera		
CHRYSOMELIDAE		
<i>Colaspis (= Maecolaspis) aerea</i>	Brazil	Ferronato 1986
Diptera		
CECIDOMYIIDAE		
<i>Cleitodiplosis graminis</i>	Brazil	Barnes 1956
Lepidoptera		
ARCTIIDAE		
<i>Cretonotos (= Amsacta) gangis</i>	Philippines	Catindig et al. 1993
HESPERIIDAE		
<i>Taractrocera ina</i>	Australia	Common & Waterhouse 1981
PSYCHIDAE		
<i>Brachycyttarus griseus</i>	Guam, Hawaii, Malaysia, Vietnam, Philippines	Davis 1990
PYRALIDAE		
<i>Cnaphalocrocis medinalis</i>	Philippines	Abenes & Khan 1990
<i>Cnaphalocrocis (= Marasmia) patnalis</i>	Philippines	Abenes & Khan 1990
<i>Parapoynx stagnalis (= Nymphula depunctalis)</i>	Philippines	Bandong & Litsinger 1984
FUNGI		
<i>Exserohilum paspali</i>	Brazil	Muchovej & Nesio 1987
<i>Leptosphaeria proteispora</i>	Hawaii	Stevens 1925
<i>Myriogenospora atramentosa</i>	Brazil, USA, Venezuela	Hanlin & Tortolero 1990
<i>Physarum cinereum</i>	Brazil	Muchovej & Muchovej 1987
<i>Sorosporium paspali</i>	Hawaii	Stevens 1925
BACTERIA		
<i>Xanthomonas albilineans</i>	Australia	Persley 1973
NEMATODES		
<i>Rotylenchulus reniformis</i>	Trinidad	Singh 1974
VIRUSES		
sugarcane mosaic	Hawaii, Japan, Taiwan	Chen et al. 1989b, Holm et al. 1937, Ohtsu & Gomi 1985



Passiflora foetida

(after Soerjani *et al.* 1987)



Map 4.22 *Passiflora foetida*

No searches have been made for natural enemies of *P. foetida* in its area of origin in South America, where it is not a weed. It is known to be attacked there by the larvae of some nymphalid (heliconiine) butterflies.

However studies of the related *P. tripartita*, a serious forest weed in Hawaii, recorded upwards of 200 species of insects. It may thus be inferred that a similar study would reveal many insects attacking *P. foetida*. However, until a relevant study is carried out, it is not possible to evaluate the prospects for its successful biological control.

4.22 *Passiflora foetida* L.

Passifloraceae

stinking passionflower, wild passionfruit; love-in-a-mist; ka thok rok (Thailand), timun padang (Malaysia), buah tikus (Indonesia)

Rating

	+++	Msia
11	++	Brun
	+	Myan, Thai, Laos, Viet, Sing, Phil
	•	Indo

Origin

South America. Natural populations have been observed in the coastal mountain ranges in the State of Parana, Brazil (G.P. Markin pers. comm. 1993).

Distribution

Widespread throughout the tropics and serious in Southeast Asia; also a weed in the Pacific Region, West Africa and Central America. Introduced to Java a long time ago.

Characteristics

A foetid, woody, annual or perennial vine, 1.5 to 6 m long; stem, cylindrical, densely hairy; tendrils arise next to leaves on the shaded side of the stem; leaves heart-shaped to three lobed, alternate, arranged helically, with long-stalked glands and long fine hairs on margins, producing a disagreeable smell when crushed; flowers white to lilac, bisexual. It flowers all year round, opening in the morning and closing before noon. The green to orange or red fruits are enclosed in lacy bracts. A large number of varieties occur (Wagner et al. 1990).

Importance

P. foetida is a weed of upland rice and other field crops. It occurs in wet areas or those where there is a pronounced wet season. It is common in plantations, rough pastures, roadsides and wasteland.

In the Philippines it is sometimes used as a soil cover in coconut plantations to control *Imperata cylindrica* grass or erosion. In Papua New Guinea it is planted between sweet potatoes to suppress *Imperata*. Young leaves are used in Surinam and Java as a vegetable. Seeds are flat, black, woody and enclosed in a sweet aromatic pulp (Swarbrick 1981). Young fruit are cyanogenic. Stems and leaves are suspected of poisoning livestock.

P. foetida contains alkaloids and at least 10 flavonoids. One of the latter, ermanin, is a feeding deterrent to larvae of the nymphalid butterfly *Dione juno* which, in Colombia, do not attack *P. foetida* leaves, but eat large amounts of other *Passiflora* species.

The Passifloraceae contain about 12 genera and 600 species, most of which are tendrill climbing vines native to warm regions of the world. The genus *Passiflora* contains some 500 tropical and subtropical species, mostly from Central and South America. Several have edible fruits and attractive flowers, about 40 species have been cultivated, but fewer than 6 are fruit crops in the neotropics and only one, *P. edulis* (and its varieties, such as the yellow *flavicarpa*), is economically important (Waage et al. 1981). *P. ligularis* is also cultivated in Malaysia (Ong and Ting 1973). A few species, such as *P. foetida* and *P. lonchocarpa*, are extremely foul smelling (Benson et al. 1976). Eleven species, including *P. foetida* and *P. tripartita* (= *P. mollissima*) (in Hawaii) are recorded as weeds in different parts of the world (Swarbrick 1981). Both *P. foetida* and *P. tripartita* are closely related taxonomically, whereas, *P. edulis* belongs to a different subgenus (Waage et al. 1981) and is the only economic crop at risk from oligophagous insects attacking *P. foetida*.

Natural enemies

Upwards of 200 insects are recorded attacking Passifloraceae in Central and South America. The most notable are heliconiine butterflies of the family Nymphalidae. Their larvae develop only on plants of the family Passifloraceae, with the single exception of *Eueides procula*, which will develop on the Turneraceae (Pemberton 1983, Waage et al. 1981). Only 5 of the 65 or so species of heliconiines are recorded as pests of *Passiflora edulis*, namely *Agraulis vanillae*, *Dione juno*, *Dryas julia*, *Eueides aliphera* and *E. isabella*, although larvae of a few other species are occasionally found on it (Waage et al. 1981). It is apparent that heliconiine butterflies are well worth investigating for species of adequate host specificity to *P. foetida*.

Little is known about the natural enemies of *P. foetida* (Table 4.22.1) and no attempts have been made at biological control. The passion vine butterfly *Agraulis vanillae*, an accidental introduction to Hawaii before 1977, is now widespread there. In addition to attacking *Passiflora edulis*, its larvae feed on the leaves of *P. foetida*, *P. manicata* and *P. suberosa*, but they seldom attack banana poka, *P. tripartita*, which is a serious forest weed in Hawaii. *P. foetida* is widely distributed on Hawaii from sea level up to about 500 m and a rainfall from 750 to 3000 mm. It occurs generally in highly disturbed areas, where it is a very minor component among other introduced species. On the west side, the taxon has red fruit and, on the east, green. It has very few natural enemies, with the exception of *Agraulis vanillae*. *A. vanillae* larvae are common but usually in small numbers, although occasionally there are outbreaks that completely defoliate the plants (G.P. Markin pers. comm. 1993). *A. vanillae* is native to the Americas and ranges from Argentina up through Mexico to Florida, the Gulf States and California (Beardsley 1980, Bianchi 1982, 1983, Klots (1951)). In Hawaii it is attacked by a nuclear polyhedral virus which limits its numbers (G.P. Markin pers. comm. 1993), in California by *Phorocera claripennis* (Tachinidae) and in eastern USA by *Brachymeria ovata* (Nakahara 1977). The other species of heliconiine recorded as attacking *P. foetida* is *Heliconius hecale*, which is widespread in Central and South America and attacks a large number of

Passifloraceae (Benson et al. 1976, Waage et al. 1981). On the other hand, larvae of *H. charithonia*, *H. cydno* and *H. erato* did not develop on *P. foetida* (Waage et al. 1981).

In the Ivory Coast larvae of the pterophorid moth *Sphenarches anisodactylus* eat the leaves of *P. foetida*, *Lagenaria siceraria* and *Brillantaisia lamium*. Although the moth also occurs in India and Japan it is not known from *P. foetida* there, but attacks two economic plants, the legumes lablab bean, *Lablab purpureus* and pigeon pea, *Cajanus cajan* (Bigot and Vuattoux 1979). Thus there is some uncertainty whether the host specificity of the African taxon is the same as that in Asia.

The National Parks and Forest Service authorities in Hawaii have been carrying out searches for some years in South America for natural enemies of banana poka, *P. tripartita*. Two insects from Colombia have been introduced to Hawaii (Gardner et al. 1992). One of these was the moth *Cyanotricha necyria* (Dioptidae), which was released in 1988, but did not become established (Casañas-Arango et al. 1990, Julien 1992, Markin and Nagata 1989, Markin et al. 1989). In host specificity tests *C. necyria* did not oviposit on *P. foetida*, but the larvae could develop on its foliage (Markin and Nagata 1989). The fungus *Colletotrichum gloeosporioides* f. sp. *clidemiae* has been mass produced for liberation (E.E. Trujillo memorandum 1989).

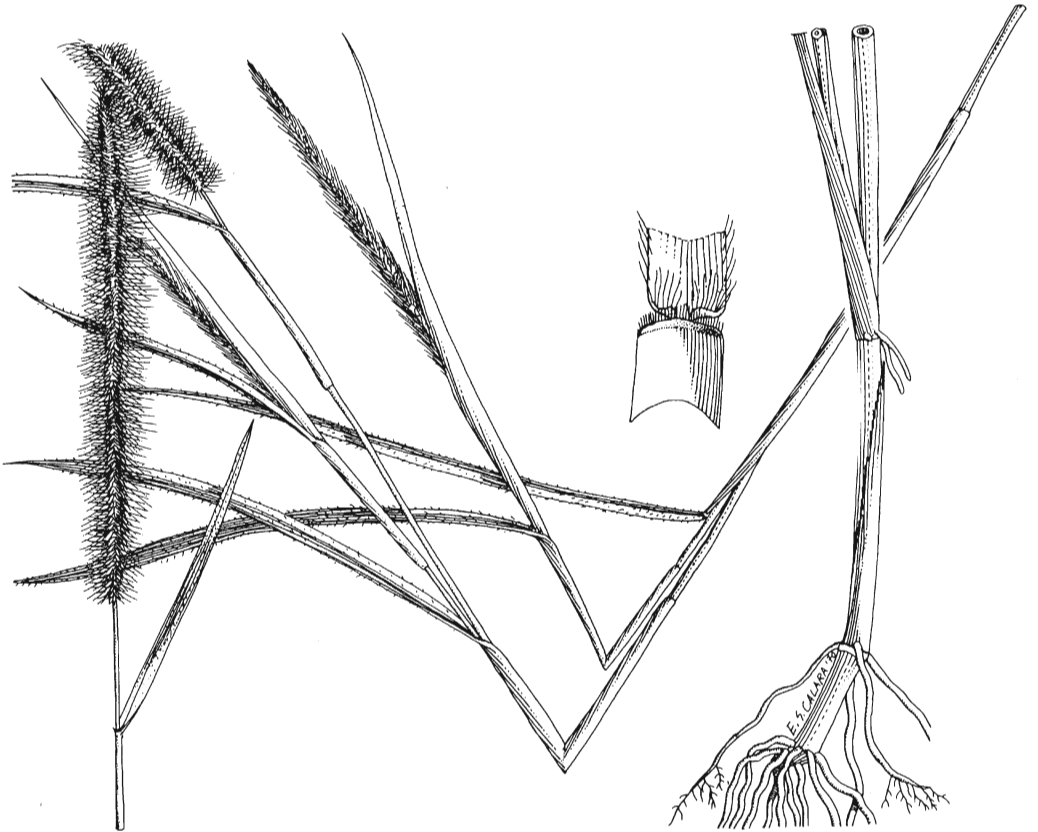
In Hawaii the fungus *Fusarium oxysporum* f. sp. *passiflorae* attacks *P. foetida*, *P. tripartita* and *P. ligularis*, but not *P. suberosa* or the cultivated *P. edulis* f. *flavicarpa* (Gardner 1989).

Table 4.22.1 Natural enemies of *Passiflora foetida*.

Species	Location	Other hosts	References
INSECTS			
Hemiptera			
APHIDIDAE			
<i>Aphis fabae</i>	Kenya	polyphagous	Bakker 1974
<i>Aphis gossypii</i>	Ivory Coast	polyphagous	De Wijs 1974
<i>Aphis spiraeicola</i>	Ivory Coast		De Wijs 1974
<i>Myzus persicae</i>	Japan	polyphagous	Yonaha et al. 1979
<i>Uroleucon compositae</i>	Kenya		Bakker 1974
Diptera			
AGROMYZIDAE			
<i>Melanagromyza polyphyta</i>	Australia	polyphagous, including <i>Passiflora</i> spp.	Kleinschmidt 1960, 1970
<i>Tropicomyia theae</i>	Papua New Guinea	polyphagous	Spencer 1990
Lepidoptera			
NOCTUIDAE			
<i>Helicoverpa zea</i> (= <i>H. obsoleta</i>)	Sumatra	polyphagous	Den Doop 1918
<i>Heliothis virescens</i>	Venezuela	polyphagous	Venturi 1960
NYMPHALIDAE			
<i>Agraulis vanillae</i>	Central America, Hawaii	restricted to some <i>Passiflora</i> spp.	Anon 1977, Beardsley 1980, Bianchi 1982, 1983, Waage et al. 1981

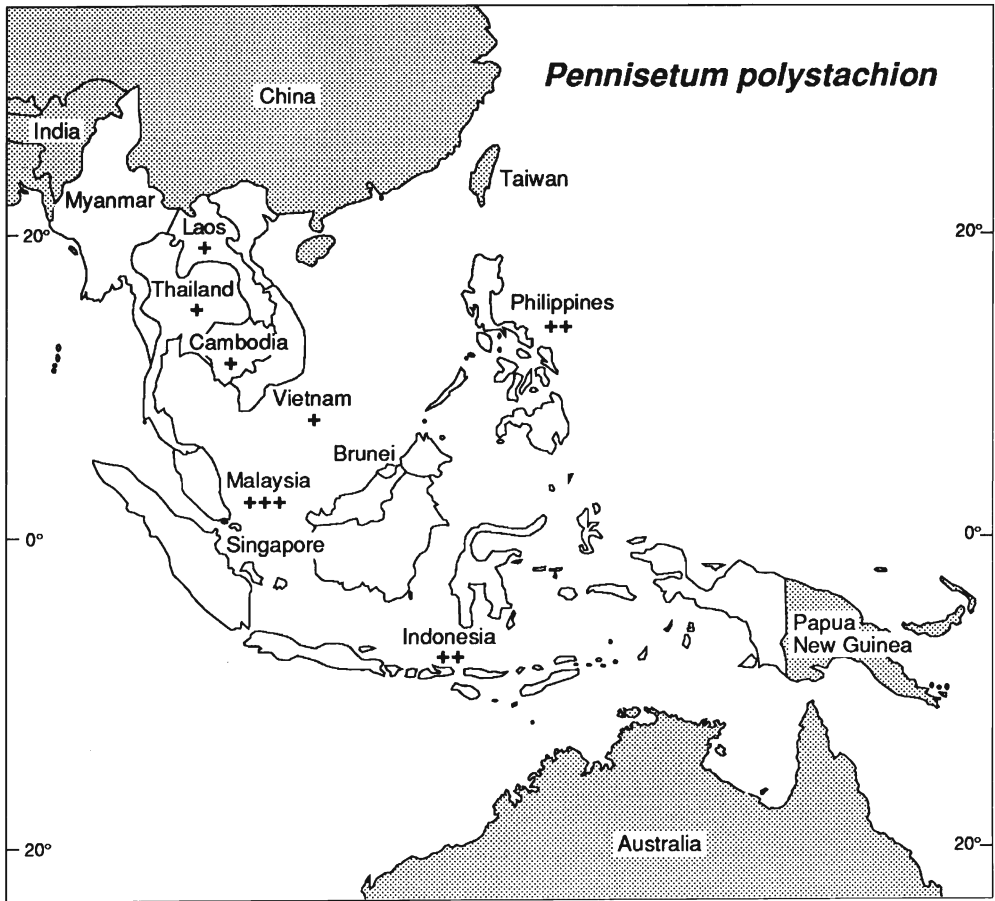
(continued on next page)

Species	Location	Other hosts	References
<i>Heliconius hecale</i>	widespread in Central & South America	restricted to some <i>Passiflora</i> spp.	Waage et al. 1981
PTEROPHORIDAE			
<i>Sphenarches anisodactylus</i>	Ivory Coast	see discussion	Bigot & Vuattoux 1979
FUNGI			
<i>Alternaria passiflorae</i>	Hawaii		Raabe 1965
<i>Alternaria tenuis</i>	Hawaii		Raabe 1965
<i>Colletotrichium gloeosporioides</i>	India		Mallikarjunaiah & Rao 1972
<i>Fusarium oxysporum</i> f.sp. <i>passiflorae</i>	Hawaii		Gardner 1989
<i>Haplosporella passifloridia</i>	India		Pande 1980
<i>Hemphyllium</i> sp.	Hawaii		Raabe 1965
NEMATODE			
<i>Meloidogyne incognita</i>	Australia		Sauer & Alexander 1979
VIRUS			
cucumber mosaic	Japan		Yonaha et al. 1979
passionfruit chlorotic spot	Papua New Guinea		Van Velsen 1961
passionfruit mosaic	Hawaii, Malaysia		Ong & Ting 1973, Raabe 1965
passionfruit ringspot potyvirus	Ivory Coast		Brunt et al. 1990, De Wijs 1974
passionfruit woodiness potyvirus	Australia, Kenya		Anon 1976, Bakker 1974, Brunt et al. 1990, Leggat & Teakle 1975



Pennisetum polystachion

(after Holm *et al.* 1977)



Map 4.23 *Pennisetum polystachion*

This erect, tufted, non-stoloniferous grass, originated in Tropical Africa from where it has spread throughout Asia and Southeast Asia to the Pacific.

Almost nothing is known of the natural enemies of *P. polystachion* or closely related species. It is not possible to evaluate the prospects for its biological control without a search for natural enemies in its region of origin.

4.23 *Pennisetum polystachion* (L.) Schultes

(= *Pennisetum setosum*)

Poaceae

mission grass; feather *Pennisetum*; yaa khaehyon chop (Thailand), rumput gajah, rumput berus, rumput kuning, ekor kucing (Malaysia) rumput jurig (Indonesia)

There are differences in opinion over the spelling of the specific name, *polystachion* or *polystachyon*, with the former being used here. In Africa, there are three subspecies *P. polystachion polystachion*, *P. p. setosum* (sometimes regarded as a true species) and *P. p. atrichum*. There is some evidence of crossing between the varieties of *P. polystachion* and the related *Pennisetum hordeoides* and the production of populations with different chromosome numbers (Brunken 1979).

Rating

	+++	Msia
11	++	Indo, Phil
	+	Thai, Laos, Camb, Viet

Origin

Tropical Africa.

Distribution

P. polystachion is widespread in the tropics of Africa and Asia, but also occurs in northern Australia and the Pacific. It rarely extends beyond 23°N or 23°S. In Africa it occurs mainly in the savanna and open areas in the forest zone of West Africa from Senegal to Cameroun and then south and east to Mozambique and Kenya (Brunken 1979, Kativu and Mithen 1988).

Characteristics

P. polystachion is an erect, tufted annual or perennial grass, with fibrous roots, but no stolons. Its leaves are narrow and 5 to 45 cm long. Its flowering stems are sometimes branched, 50 to 300 cm tall, ending in a cylindrical yellow-brown flowering spike, 5 to 25 cm long, bearing densely hairy, unequal bristles of two lengths, the longer 2 to 5 cm and the shorter 1 cm.

Importance

P. polystachion grows on dry lateritic soils and is often present along roadsides, in wastelands and in upland crops. Propagation is by seeds, but regrowth can occur from dormant buds located at the base of the stems and from aerial nodes.

It becomes dominant in upland tropical hillsides and croplands after forests have

been cleared, or when shifting cultivation or subsistence agriculture have been practised (Holm et al. 1977). Because of the rapid germination of its wind-dispersed seeds and its aggressive and highly competitive growth, it rapidly takes over wastelands. Since a single cultivation rarely kills enough of the weed to provide control, it often impedes further use of areas for crops.

In Indonesia it was first observed in 1972 (Titrosoedirdjo 1990). It is now an important weed of rubber and occasionally a problem in upland rice.

P. polystachion is thought to have reached Malaysia via Thailand as recently as the early 1980s, infesting at least 10 km² of roadsides and is now widely distributed, occurring up to an altitude of 900 m (Baki et al. 1990). It is now a major weed in rubber, oil palm, sugarcane, orchards, vegetables and upland rice (Titrosoedirdjo 1990).

In the Philippines *P. polystachion* is able to compete effectively even with blady grass *Imperata cylindrica* in grassy fields in Central Luzon and in rubber plantations in west Java (Titrosoedirdjo 1990).

P. polystachion is a good fodder grass when young and makes excellent hay.

Natural enemies

Very few natural enemies of *P. polystachion* appear to have been recorded in the literature (Table 4.23.1). The only species of possible relevance are several gall midges from Africa, but very little is recorded of their biology. Three species of gall midge have been reared from *P. polystachion* in the Gold Coast. One is similar to the pestiferous sorghum midge *Contarinia sorghicola* (but may be different), the second belongs to the Trifila group and the third belongs to the Lasiopterariae (Barnes 1954a,b, Geering 1953). Three species of gall midge have been described from ears of *Pennisetum* in southern India, *Cecidomyia penniseti* (from *P. glaucum* = *P. typhoideum*), *Geromyia* (= *Itonida*) *penniseti* (from *P. cenchroides*) and *Geromyia* (= *Itonida*) *seminis* and an unidentified species from the stems. Of these, *G. penniseti* may be predaceous (Barnes 1954b, Felt 1920, 1921).

In Madagascar there is a gall midge (?*Cecidomyia* sp.) whose larvae live in the inflorescence of *Pennisetum* (no species given) and in Sudan a gall midge, possibly *Geromyia seminis*, has been reared from the ears of *Pennisetum* (no species given) (Barnes 1954b).

The larvae of the Brazilian satyrid butterfly *Eryphanis polyxena* were bred in the laboratory on *P. polystachion* (= *P. setosum*) (Dias 1979), but damage is not reported from the field.

Comment

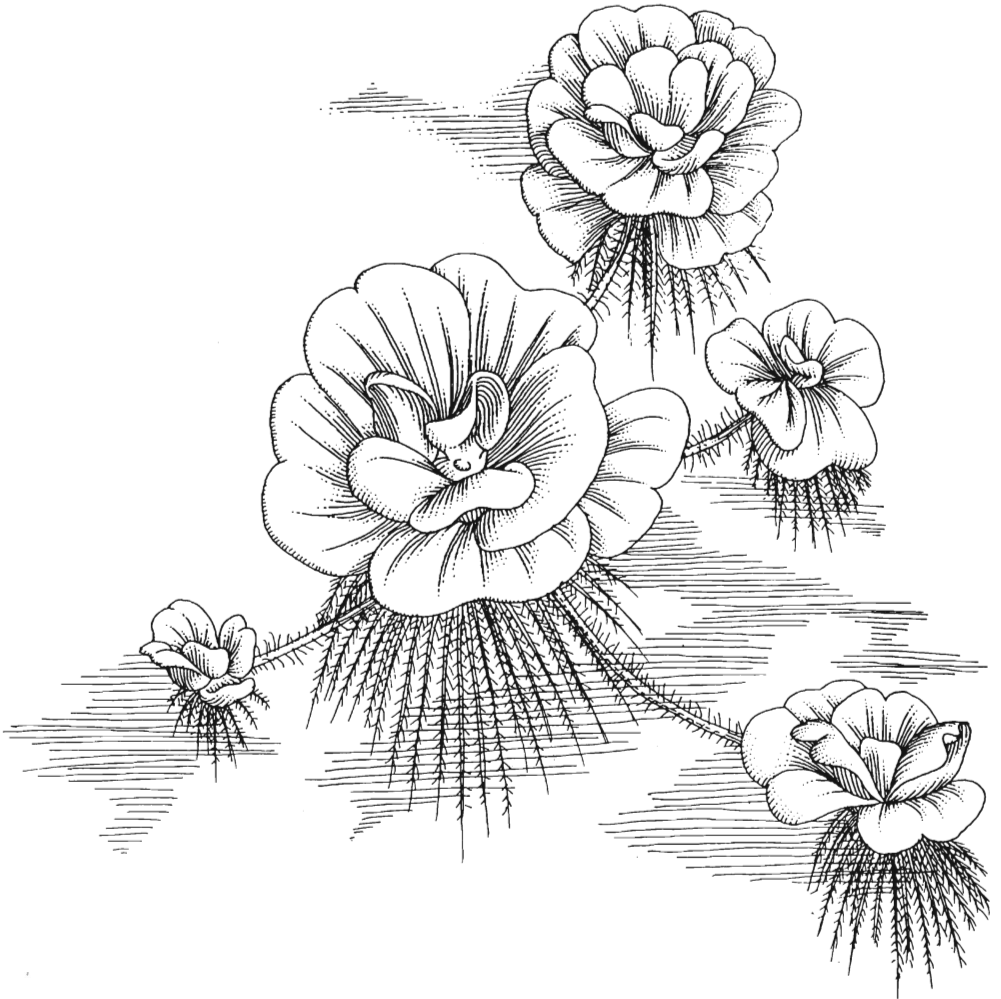
There is little doubt that a range of natural enemies attacking *P. polystachion* would be found if a search were made in Tropical Africa.

Several other weedy species of *Pennisetum* also originated in Africa, in addition to three or more species that have at least some desirable attributes. Perhaps the best known is kikuyu grass, *P. clandestinum*, which is a valuable fodder during the warmer months, although it is a weed in some situations and its nitrate levels can be toxic to grazing animals. *P. glaucum* (= *P. americanum*), pearl millet, is used as food in some areas. *P. purpureum*,

elephant or napier grass, can grow to 3 m, is valuable for fodder when young and can be used as fuel when old. However, it can also be a weed, as in rubber in Malaysia. Little has been recorded of the natural enemies attacking these species of *Pennisetum*. The most interesting are three cecidomyiid gall midges in India, *Geromyia penniseti*, *G. seminis* and *Mycodiplosis indica* from *Pennisetum glaucum* (= *P. typhoideum*) and *Geromyia seminis* from *Pennisetum cenchroides* (Barnes 1931, Felt 1920).

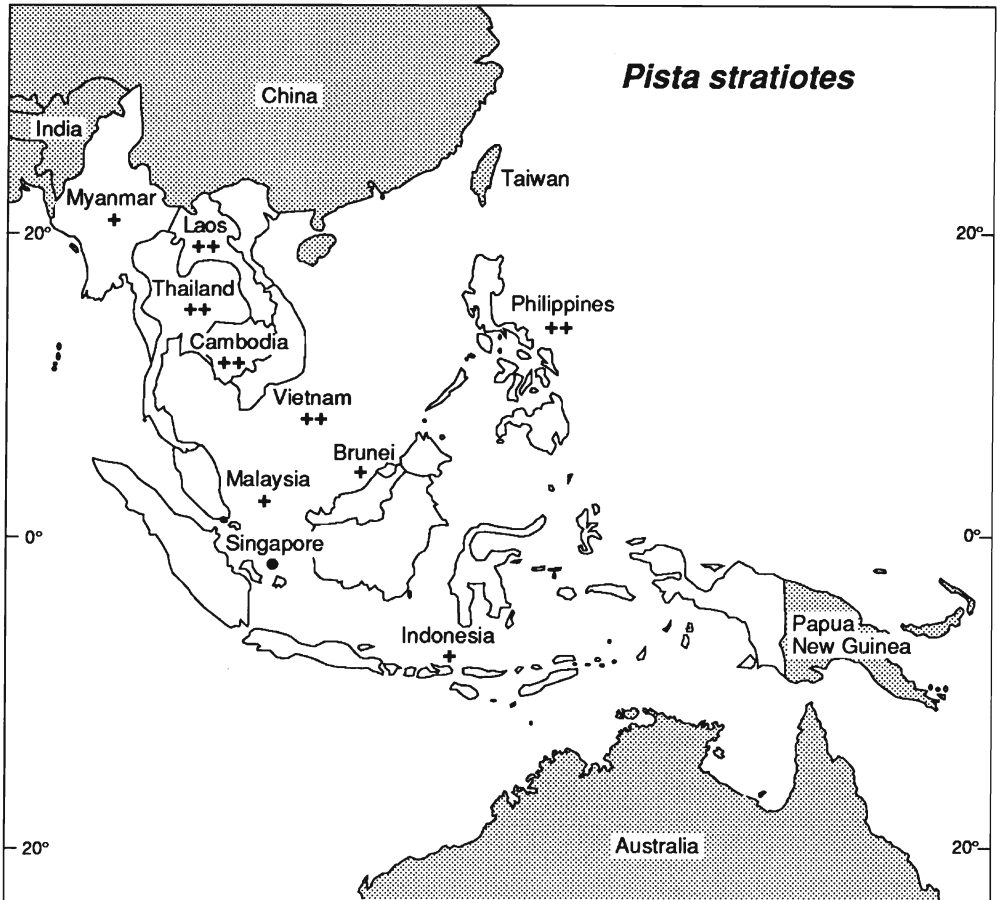
Table 4.23.1 Natural enemies of *Pennisetum polystachion*.

Species	Country	References
INSECTS		
Diptera		
CECIDOMYIIDAE		
<i>Cecidomyia penniseti</i>	India	Barnes 1954b
<i>Contarinia ?sorghicola</i>	Gold Coast	Barnes 1954b
<i>Contarinia</i> sp. 1	Gold Coast	Barnes 1954b
<i>Contarinia</i> sp. 2	Gold Coast	Barnes 1954b
<i>Contarinia</i> sp. 3	Madagascar	Barnes 1954b
<i>Contarinia</i> sp. 4	India	Barnes 1954b
<i>Geromyia</i> (= <i>Itonida</i>) <i>penniseti</i>	India	Barnes 1954b
<i>Geromyia</i> (= <i>Itonida</i>) <i>seminis</i>	India, Sudan	Barnes 1954b
Lepidoptera		
HESPERIIDAE		
<i>Parnara bada bada</i>	Malaysia	C.L. Tan pers. comm. 1993
NYMPHALIDAE		
<i>Eryphanis polyxena</i>	Brazil	Dias 1979
PYRALIDAE		
<i>Cnaphalocrosis medinalis</i>	Malaysia	C.L. Tan pers. comm. 1993
FUNGI		
<i>Bipolaris papendorffii</i>		H.C. Evans pers. comm. 1992
<i>Gloeocercospora</i> sp.		H.C. Evans pers. comm. 1992
<i>Helminthosporium rostratum</i>		Thite & Chavan 1977
<i>Phakospora apoda</i>		H.C. Evans pers. comm. 1992
<i>Puccinia chaetochloae</i>		H.C. Evans pers. comm. 1992
<i>Puccinia substrata</i>		H.C. Evans pers. comm. 1992
<i>Pyricularia oryzae</i>	Brazil	Prabhu et al. 1992
<i>Spacelotheca penniseti</i>		H.C. Evans pers. comm. 1992



Pistia stratiotes

(after Holm *et al.* 1977)



Map 4.24 *Pistia stratiotes*

Water lettuce is a widespread, floating water weed, which probably originated in South America.

The host specific South American weevil, *Neohydronomus affinis*, has been established readily in six countries and, in all, has produced substantial to excellent control. The moth, *Samea multiplicalis*, which attacks *P. stratiotes* and *Salvinia* spp., has been established in Australia but its impact has not been evaluated.

In Thailand, classical biological control has not been attempted, but mass rearing and release of the native noctuid moth *Spodoptera pectinicornis* has replaced the use of herbicides.

The prospects are excellent for classical biological control of *P. stratiotes* in countries where it is still regarded as an important weed.

4.24 *Pistia stratiotes* L.

Araceae

water lettuce; chak thom (Cambodia), apoe apoe, apon apon (Indonesia), kiambang besar (Malaysia), chok, jawg (Thailand), bèo cái (Vietnam)

Rating

	++	Thai, Laos, Camb, Viet, Phil
14	+	Myan, Msia, Brun, Indo
	•	Sing

Origin

The origin of *Pistia stratiotes* is unknown, although the number of host specific insects present there (Table 4.24.1) suggests South America. However, there is also a host specific noctuid moth that ranges from India to Papua New Guinea. Dray and Center (1992) examine the various theories concerning the area of origin of water lettuce.

Distribution

Water lettuce occurs very widely as a troublesome water weed between the tropics of Capricorn and Cancer, particularly in Africa, Asia, Southeast Asia and the Caribbean. Pliny refers to its use in Egypt in AD77 (DeLoach et al. 1979, Holm et al. 1977). It is absent from a number of Pacific countries although recorded as a weed in Papua New Guinea, Solomon Is, Guam, New Caledonia and Hawaii.

Characteristics

Pistia stratiotes is a free-floating, perennial monocotyledon, with a tuft of fibrous feathery roots up to 1 m long. Numerous secondary roots may be up to 4 cm in length. Stolons up to 60 cm are produced from the base of the plant and develop into new plants. Leaves are pale green, upright, 2.5 to 15 cm long, broad at the top and tapered at the base. They are prominently veined beneath and form a rosette. They are spongy in texture and bear numerous fine, water-repelling hairs on both sides. The flowers are bisexual, inconspicuous, green, surrounded by tubular bracts and arise from the centre of the rosette. It is said that water lettuce does not flower in Thailand but a small number of flowers have been observed (B. Napompeth pers. comm. 1993). It flowers in the Philippines, Australia, Africa and USA. The fruit is berry-like and green and contains 4 to 12 small brown seeds which can float on the water for up to 2 days. There are as many as 9 varieties of water lettuce (Neal 1965).

Importance

The free-floating plants are found in reservoirs, ponds, in marshes along the edges of large tropical lakes and in slow-moving or stagnant waters. They multiply rapidly and

can block streams, interfere with fisheries and hydroelectric generating plant and bank up at dams, bridges and culverts, leading to increased flooding problems. Despite earlier claims (Holm et al. 1977), unlike water hyacinth, water lettuce does not increase water loss through evapotranspiration (Lallana et al. 1987). Together with water hyacinth it is a common and important component of the dense aggregations of free-floating vegetation, known as sudds. It grows best at pH 4, whereas water hyacinth produces greatest dry weight at pH 7 (Holm et al. 1977).

Water lettuce plants act as a substrate for sandfly larvae (Ceratopogonidae) and larvae and pupae of the disease-transmitting mosquito genus *Mansonia* obtain their oxygen by attaching to *Pistia* roots. *P. stratiotes* is an important weed of irrigated rice, floating into paddy crops, taking root in the soil and competing much like other weeds.

On the other hand, it has been used as human food in India during famines and is still fed to pigs and ducks. It is said to have some medicinal value as a cure for skin diseases and dysentery, as a laxative, to treat asthma and, its ash rubbed into the scalp, as a treatment for ringworm.

Natural enemies

AUSTRALIA

Although water lettuce was first recorded in the Northern Territory only in 1946 it was already an important weed in some locations in Queensland before the introduction of *Neohydronomus affinis*, although plants in the Northern Territory were rarely thrifty. Heavy damage was observed there by larvae of the moth *Parapoynx* (= *Nymphula*) *tenebralis*, which lays its eggs on the leaves. Newly emerged larvae excise a portion of leaf to make a protective case in which they shelter while feeding and moving around the plant. These larvae also attack *Salvinia molesta*, as do larvae of the related *Parapoynx* (= *Nymphula*) *turbata* (Gillett et al. 1988). In Thailand this species attacks water lettuce (Napompeh 1982), so it presumably has the same habit in the Northern Territory. A bug, *Nisia nervosa* (= *N. atrovenosa*) feeds on water lettuce as it does in India (Gillett et al. 1988, Joy 1978).

CENTRAL AND SOUTH AMERICA

Bennett (1975) listed 12 species of phytophagous insects that had been reared from *Pistia stratiotes* and Cordo et al. (1981) added one more. Particularly notable (Table 4.24.1) is the group of South American weevils which are generally confined to water lettuce, although adults of several may produce minor attack on some of the nearby aquatic plants whose stems and leaves nevertheless would be too small to support larval development. Preliminary host range studies suggest that several may be specific enough to be employed for biological control, although adequate information is available only for *Neohydronomus affinis*. This has been successfully established in several countries (see later). Larvae of the small pyralid moth *Samea multiplicalis*, which occurs from Argentina to the southeastern United States, feed on the growing buds of water lettuce and sporadically cause very heavy damage and dieback of the plants (Cordo et al. 1978, 1981, DeLoach et al. 1976, 1979).

Table 4.24.1 Natural enemies of *Pistia stratiotes*.

Species	Location	References
INSECTS		
Hemiptera		
APHIDIDAE		
unnamed	Thailand	Napompeth 1990a
<i>Rhopalosiphum nymphaeae</i>	Florida	Ballou et al. 1986, Bennett 1975, Joy 1978
COCCIDAE		
<i>Planococcus citri</i>	Nigeria, Trinidad	Bennett 1975
LYGAEIDAE		
<i>Valtissius</i> sp.	Argentina	Bennett 1975
MEENOPLIIDAE		
<i>Nisia nervosa</i> (= <i>N. atrovenosa</i>)	Australia, India	Gillett et al. 1988, Joy 1978
Orthoptera		
ACRIDIDAE		
<i>Paulinia acuminata</i>	South America	Bennett 1966, 1975
TETRIGIDAE		
<i>Criotetrix</i> sp.	Thailand	Napompeth 1990a
Coleoptera		
CURCULIONIDAE		
<i>Argentinorhynchus bennetti</i>	Mexico, Venezuela	O'Brien & Wibmer 1989a,b
<i>Argentinorhynchus breyeri</i>	Argentina, Paraguay	O'Brien & Wibmer 1989a,b
<i>Argentinorhynchus bruchi</i>	Argentina, Paraguay	Cordo et al. 1978
<i>Argentinorhynchus minimus</i>	Venezuela	O'Brien & Wibmer 1989a,b
<i>Argentinorhynchus squamosus</i>	Argentina, Paraguay	Cordo et al. 1978
<i>Neohydronomus affinis</i>	South America	DeLoach et al. 1976
<i>Neohydronomus elegans</i>	Honduras, Cuba	O'Brien & Wibmer 1989c
<i>Neohydronomus pulchellus</i>	Trinidad to Argentina, Cuba	Bennett et al. 1975, O'Brien & Wibmer 1989c
<i>Ochetina bruchi</i>	Argentina	Cordo et al. 1981
<i>Pistiacola cretatus</i>	Argentina, Brazil	Cordo et al. 1981
<i>Pistiacola fasciatus</i>	Central and South America	Wibmer & O'Brien 1989
<i>Pistiacola</i> sp. nr <i>nigrirostris</i>	Argentina	Cordo et al. 1981
Lepidoptera		
ARCTIIDAE		
<i>Spilosoma virginica</i>	Florida	Thompson and Habeck 1988
NOCTUIDAE		
<i>Erastroides curvifascia</i>	India	Chaudhuri & Janaki Ram 1975
<i>Proxenus hennia</i>	Indonesia	Mangoendihardjo & Nasroh 1976
<i>Spodoptera pectinicornis</i>	India, Bangladesh, Thailand	Alam et al. 1980, George 1963, Napompeth 1990a, Sankaran 1974, Sankaran & Rao 1972, Sankaran et al. 1964

(continued on next page)

Species	Location	References
PYRALIDAE		
<i>Argyractis subornata</i>	Brazil	Forno 1983
<i>Elophila responsalis</i>	India, Indonesia	Handayani & Syed 1976, Mangoendihardjo et al. 1977, Sankaran & Rao 1972, Subagyo 1975
<i>Parapoinx</i> (= <i>Nymphula</i>) <i>diminutalis</i>	Thailand	Napompeth 1990a, Suasa-Ard 1976
<i>Parapoinx</i> (= <i>Nymphula</i>) <i>tenebralis</i>	Australia	Gillett et al. 1988
<i>Parapoinx</i> (= <i>Nymphula</i>) <i>turbata</i>	Australia, Thailand	Gillett et al. 1988, Napompeth 1990a, Suasa-Ard 1976
<i>Petrophila drumalis</i>	Florida	Dray et al. 1988
<i>Samea multiplicalis</i>	southern USA, Trinidad, northern South America	Bennett 1966, 1975, Bennett et al. 1975, Dray et al. 1988
<i>Synclita oblitalis</i>	Florida	Dray et al. 1988
MITES		
<i>Hydrozetes subornata</i>	Australia	Gillett et al. 1988
FUNGI		
<i>Cercospora canescens</i>	Australia	Gillett et al. 1988
<i>Cercospora</i> sp.	India	Bennett 1975, Nag Raj and Ponappa 1966
<i>Phyllosticta stratiotes</i>	India	Bennett 1975
<i>Sclerotium rolfsii</i>	India	Bennett 1975

UNITED STATES

Dray et al. (1988) recorded larvae of three species of moth, a mealy bug, a leafhopper and an aphid on water lettuce which has been present in Florida for at least 200 years (Thompson and Habeck 1988). Only one of these insects, a root feeding moth, was considered to be possibly host specific. This was later identified as the pyralid moth *Petrophila drumalis*: the two other moths were *Samea multiplicalis* and *Synclita oblitalis* (Dray et al. 1989). The aphid was probably *Rhopalosiphum nymphaeae*, a well known transmitter of a number of economically important viruses. It has been recorded to cause dieback of water lettuce in Nigeria (Pettett and Pettett 1970). This aphid was reported to be widespread on water lettuce in Florida (Ballou et al. 1986). An aphid, possibly the same species, transmitted a virus that caused widespread dieback of *P. stratiotes* on Lake Volta in Ghana (Okali and Hall 1974), although serious dieback has not been reported in Florida. The non-specific larvae of the arctiid moth *Spilosoma virginica* was also common on water lettuce in Florida (Thompson and Habeck 1988).

INDIA

Larvae of the moth *Spodoptera pectinicornis* cause extensive damage to *Pistia*. On average, a single larva can consume the leaves of two *Pistia* plants during its developmental period of 15 to 20 days. Some 100 larvae developing from an average egg mass destroy all *Pistia* leaves within an area of 1 m² and, during peak abundance in the field, the number of larvae per m² of *Pistia* surface was always higher than this (George 1963, Sankaran and Ramaseshiah 1974). The bug *Nisia nervosa* successfully completes its life cycle on *Pistia*, but is reported as a minor pest of rice (Joy 1978).

INDONESIA

In Java and Sulawesi, water lettuce is attacked by larvae of the noctuid moth *Proxenus hennia* which appears to be specific (Mangoendihardjo and Nasroh 1976). Other species found attacking it were *Elophila* (= *Nymphula*) *responsalis*, *Spodoptera mauritia*, an aphid and a cicadellid (*Zygina* sp.) (Mangoendihardjo and Syed 1974, Mangoendihardjo et al. 1976, 1977, Syed et al. 1977).

THAILAND

Water lettuce is attacked by several insects (Table 4.24.1), of which only the pygmy grasshopper *Criotetrix* sp. and the native water lettuce moth *Spodoptera pectinicornis* are capable of inflicting serious damage. In certain areas where the density of *Criotetrix* was as high as 100 per m² considerable suppression of the weed occurred. Both adults and nymphs were able to walk on the surface of the water and were observed to attack also the water fern, *Salvinia cucullata* (Napompeth 1982). The extensive damage that can be caused by *Spodoptera pectinicornis* is discussed later.

Attempts at biological control

AUSTRALIA

The first attempt to bring about classical biological control of *Pistia stratiotes* was the liberation of adults and larvae of *Neohydronomus affinis* in 1982 near Brisbane. Within two months of release, plants were rotting and sinking and, by eight months, about one third of the plants in a dam were chlorotic and some had been destroyed. Severely damaged plants produced short stolons terminating in small plantlets before sinking and dying, but these plantlets failed to grow to the size of their parents before, in turn, becoming severely damaged, producing plantlets and then sinking. Continued weevil attack led initially to an increase in the number of plants, but a decrease in their size and dry weight. Before long, few water lettuce plants remained (Harley et al. 1984). The moth *Samea multiplicalis* was liberated in Australia in 1981, primarily against *Salvinia molesta*, on which it became established. However, within four years, its effectiveness was restricted by protozoan disease and three hymenopterous parasitoids (Thomas and Room 1986). It presumably attacks *Pistia stratiotes* also, although there seems to be only one observation of it doing so. This was at Townsville (D.P.A. Sands pers. comm. 1993).

PAPUA NEW GUINEA

The moth *Spodoptera pectinicornis* attacks water lettuce, but is unable to prevent its increase when the plant is freed from competition by the biological control of *Salvinia* or

Table 4.24.2 Liberations for the biological control of *Pistia stratiotes*.

Species	Where	From	When	Result	References
Coleoptera					
CURCULIONIDAE					
<i>Neohydronomus affinis</i>	Australia	Brazil	1982	+	Harley et al. 1984, 1990
	Botswana	Brazil via Australia	1988	+	Chikwenhere & Forno 1991 I.W. Forno pers. comm. 1993
	Papua New Guinea	Brazil via Australia	1985	+	Chikwenhere & Forno 1991, Harley et al. 1990, Laup 1987b
	South Africa	Brazil via Australia	1985	+	Cilliers 1987, 1989b
	United States of America	Brazil via Australia	1987	+	Center et al. 1989, Thompson & Habeck 1988, Dray et al. 1990
	Zambia	Zimbabwe	about 1990	+	P. Room pers. comm. 1993
	Zimbabwe	Brazil via Australia	1988	+	Chikwenhere & Forno 1991
	Lepidoptera				
NOCTUIDAE					
<i>Spodoptera pectinicornis</i>	Florida	Thailand	1990	?	Center et al. 1989, Julien 1992
Napompeth 1990a					
PYRALIDAE					
<i>Samea multiplicalis</i>	Australia	Brazil	1981	+	Forno 1987, Room et al. 1984

Eichhornia. *Neohydronomus affinis* was successfully established in the Sepik River system in 1985, but its impact is yet to be recorded (Laup 1987b).

THAILAND

Although no introductions of biological control agents for *Pistia stratiotes* have been made in Thailand, the mass rearing and release of the native noctuid moth *Spodoptera pectinicornis* has replaced the use of herbicides for this weed. Under laboratory conditions mixed instar larvae at the rate of 300 or more per m² gave as fast and effective control as any herbicide. In the field a substantial initial release of larvae, followed by one or two additional releases at two-week intervals has led to complete control within 6 to 10 weeks. Thus, a 4.5 km² infestation of water lettuce was controlled in 6 weeks at Sri Nakarint Dam in 1978 and a 10 km² infestation in 1982 (Napompeth 1982). *S. pectinicornis* occurred throughout the year and in all infestations of *Pistia* (Suasa-Ard and Napompeth 1982).

UNITED STATES

Neohydronomus affinis was released in Florida in 1987, became established readily, multiplied rapidly and soon spread from the release sites to cause considerable damage to water lettuce (Dray et al. 1990). In one release site the *Pistia* population was reduced from 50 to less than 5 acres in 2 years and, in another, a 10 acre site was virtually cleared

in 3 years. However, in a third site, little effect was noted. It was postulated that this might be due to the presence of a different genetic strain of *P. stratiotes*, which had a far greater seed production than that at the other two sites (Dray and Center 1992). *Spodoptera pectinicornis* has also been established in Florida (Center et al. 1989; Napompeth 1990a).

BOTSWANA

N. affinis was released on the Linyanti R at the Selinda spillway in 1988. Excellent control was achieved within 12 months (I.W. Forno pers. comm. 1993).

SOUTH AFRICA

Neohydronomus affinis was released in Kruger National Park and a water lettuce infestation in a motionless water body was completely controlled within 10 months (Cilliers 1987, 1989a,b). The weevil has been less successful on fast-flowing rivers where plants infested with weevil larvae are continually washed down stream and replaced by uninfested plants from higher up. However, even under these circumstances, up to 90% of plants showed signs of feeding damage (Cilliers 1991b).

ZAMBIA

N. affinis was already established by natural spread at Kafubu Lake when *N. affinis* from Zimbabwe was liberated about 1990 and by 1992 there were only scattered plants of *Pistia* but no mats (P.M. Room pers. comm. 1993).

ZIMBABWE

Neohydronomus affinis was released in 1988, was well established in 4 months and, within a year, water lettuce was no longer a problem in the Manyame River (Chikwenhere and Forno 1991).

Major natural enemies

Argentinorhynchus bruchi Coleoptera: Curculionidae

This yellow spotted weevil (4.7 mm long) is known from Argentina, Bolivia, Paraguay and Uruguay (O'Brien and Wibmer 1989a,b). Although it is rare, it has the potential to cause heavy damage to water lettuce. Under laboratory conditions adults ate 1 cm² of leaf surface per day, producing some 10 oval holes all the way through the leaf. Adults feed mostly by night and generally on medium-aged leaves. Field collected females laid on average 1575 eggs among the dense hairs on the leaf surface. Eggs hatch in 7.6 days. First instar larvae enter the leaf and feed on the spongy leaf tissue and second and third instars in the crown. Fourth instar larvae could not be reared: in the laboratory they left the plant and drowned. Adults fed and oviposited only on water lettuce and, except for slight feeding on *Spirodela*, of the 26 plant species tested, larvae only developed on water lettuce. In the laboratory 6 larvae per plant killed water lettuce within a month. It was suggested that egg predation may account for the rarity of *A. bruchi*; also that the difficulty experienced in rearing the fourth instar larvae may indicate that special conditions are required, lack of which may reduce survival (Cordo et al. 1978).

***Neohydronomus affinis* Coleoptera: Curculionidae**

This mottled, brown-grey weevil was earlier confused in the literature with the closely related *N. pulchellus*. It occurs naturally in Argentina, Brazil, Colombia, Paraguay, Peru, Uruguay and Venezuela (O'Brien and Wibmer 1989c). Adults (males 1.8 mm, females 2.1 mm long) feed on the leaves of *Pistia stratiotes* and mine the tissues: they do not appear to attack the crown or roots. Females lay about 1 egg per day beneath the leaf epidermis, usually on the upper surface near the margin. Eggs hatch after 3 to 4 days and larvae tunnel through the leaf tissues to complete development in 11 to 14 days. Pupation occurs in small pockets in the leaf tissues and adults emerge after about 4 days. The period from egg to adult varies from 4 to 6 weeks, but there are only 3 generations a year in Argentina (December, February to March and June). Overwintering probably occurs in the adult stage (DeLoach et al. 1976).

N. affinis is very destructive under laboratory conditions. Maximum damage occurred in midsummer in Argentina, when peak populations of 200 to 600 per m² produced 1.6 feeding spots per cm² of leaf surface. Adult *N. affinis* are occasionally parasitised by nematodes in Argentina (DeLoach et al. 1976).

N. affinis is highly specific to water lettuce, as shown by tests in Zimbabwe (Chikwenhere and Forno 1991), South Africa (Cilliers 1989b), Florida (DeLoach et al. 1976, Dray et al. 1990, Thompson and Habeck 1988, 1989) and Australia (Harley et al. 1990); and also by absence of reported damage to economic plants in any of the countries to which it has been introduced.

***Pisticiola cretatus* Coleoptera: Curculionidae**

This brown 2.3mm long weevil, earlier known as *Onychylis cretatus*, occurs in Argentina and Brazil (Wibmer and O'Brien 1989). Adults feed mainly on the upper surface of the leaves of *P. stratiotes* and oviposit into the leaf tissue. The slender larvae tunnel into the denser tissues of the basal third of the leaf and also into the crown. Pupation occurs within the spongy part of the leaf. In the field, adult *P. cretatus* were found only on water lettuce (Cordo et al. 1981).

***Samea multiplicalis* Lepidoptera: Pyralidae**

This brown moth with dark markings and a wingspan of about 17 mm occurs from Florida to Argentina.

Up to 290 eggs are laid per female, mainly on the upper surface of the leaves. These hatch after 4 days and the larvae construct a silken canopy under which they feed, or they may tunnel into the leaves to feed on the spongy tissues: they also eat the buds. After 5 or 6 instars in the course of 16 days, they pupate in silken cocoons, to emerge as adults 5 days later. Adults live up to 7 days (DeLoach et al. 1979, Knopf and Habeck 1976, Sands and Kassulke 1984). *S. multiplicalis* has three main hosts in Florida, *Pistia stratiotes*, *Azolla caroliniana* and *Salvinia rotundifolia* and it may occasionally attack *Eichhornia crassipes*. Oviposition is highest on *P. stratiotes*. Although medium to large larvae fed on a number of plants under laboratory conditions, *S. multiplicalis* has never been reported

as a pest of cultivated plants in Argentina or Brazil (DeLoach et al. 1979). It passed strict host specificity tests in Australia, larvae completing development on *P. stratiotes*, *Azolla pinnata* and *Salvinia molesta*. Larvae that had fed first on *S. molesta* were unable to complete their development on water lettuce, although they produced minor leaf scars. *S. multiplicalis* was released in Australia, but primarily against *Salvinia molesta* (Sands and Kassulke 1984).

Samea multiplicalis has 3 generations a year in the field in Argentina, with population peaks in December, February and May, when populations reach a maximum of 5 larvae per plant. In laboratory tests females laid 99.3% of their eggs on *P. stratiotes*. Larvae caused heavy, but sporadic, damage to water lettuce in the field. However, in most years, populations were held at low levels, apparently by parasitoids (*Apanteles* sp. and *Podogaster* sp.) (DeLoach et al. 1979). In Florida 52% parasitisation was recorded, 42.7% by three species of Hymenoptera (*Agathis* sp., *Apsilops* sp. and *Temelucha ferruginae*) and 9.3% by a tachinid fly (*Lixophaga* sp.) (Knopf and Habeck 1976). *Nosema* sp. was detected in Australia in some larvae from Brazil and the culture was freed of these before release (Sands and Kassulke 1984).

***Spodoptera pectinicornis* Lepidoptera: Noctuidae**

This moth ranges over an extensive area from India through Sri Lanka, Thailand and Indonesia to Papua New Guinea. Eggs are laid in masses of 70 to 120 on the undersurface of the *Pistia* leaf near its edge. They hatch in 40 to 60 hours to produce pale green larvae that burrow in the leaf parallel to the longitudinal veins. After some 20 days the 1.5 to 2 cm long larvae pupate, to emerge two to three days later as small silvery brown moths about 1cm long (George 1963). In Thailand the period from egg to adult averaged 30 days and females laid an average of 666 eggs. Host specificity tests showed that it would develop only on *Pistia stratiotes* (Suasa-Ard 1976). Napompeth (1990a) reports that it is relatively simple to mass rear in the laboratory and to distribute in the field. Details are available of its rearing and ecology in Thailand (Suasa-Ard 1976, Suasa-Ard and Napompeth 1978). It was mass reared and released in Florida after tests showed that it was sufficiently host specific (Center et al. 1989, Napompeth 1990a).

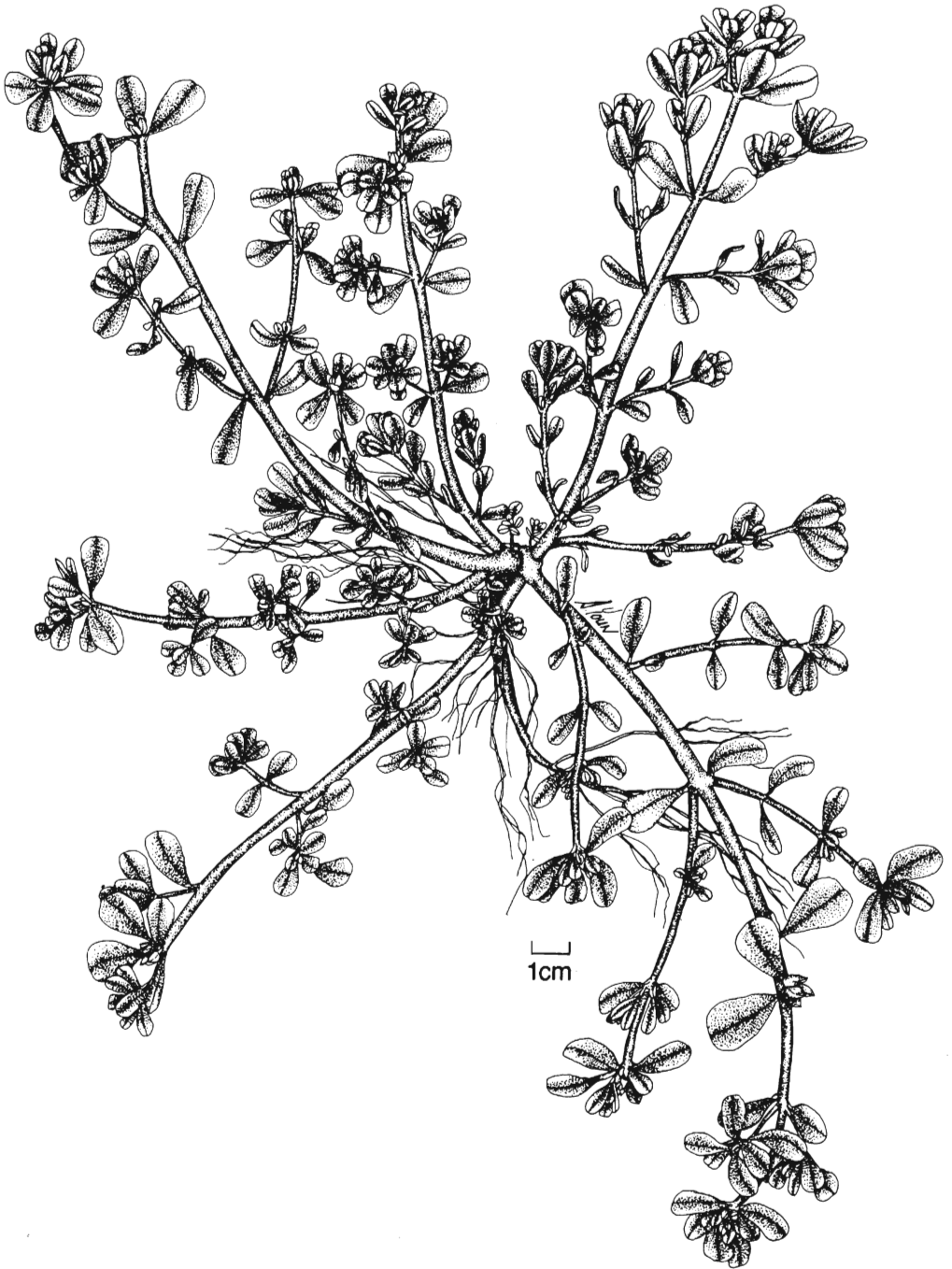
Comment

Pistia stratiotes is seldom more than a minor component of the floating weed mass when either *Eichhornia crassipes* or *Salvinia molesta* or both are present. However, when it occurs alone or when the strong competition from these two weeds is greatly reduced by their effective biological control, water lettuce can increase rapidly to occupy the vacated water surface. Since damaging biological control agents are available for all three weeds, it is sensible to embark on a biological control program for them all, either at the same time or in sequence.

Adequate biological control of water lettuce has been achieved by the introduction of the weevil *Neohydronomus* alone. However, if an even greater degree of control is desired, there are, in South America, additional species of weevil and also several moths

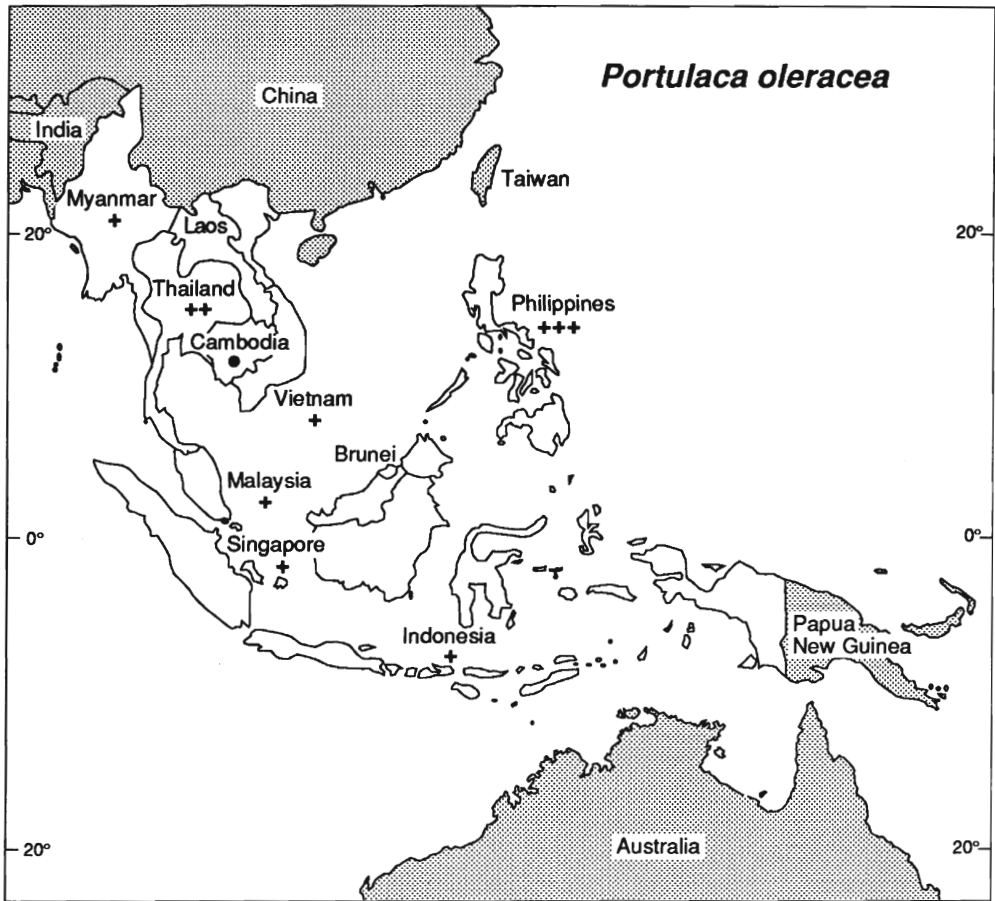
that appear to be well worthwhile investigating further. This is particularly so, as some are known to be heavily attacked by natural enemies and, if introduced without these, would be expected to be even more effective.

It can be concluded with some confidence that water lettuce is a promising candidate for biological control.



Portulaca oleracea

(after Holm *et al.* 1977)



Map 4.25 *Portulaca oleracea*

Portulaca oleracea is a serious weed throughout tropical, subtropical and temperate areas, attaining high overall pest status more because of its very widespread importance than by being amongst the top few weeds in any one country.

About 14 of the 140 or so species of insects that are known to attack it appear to be restricted to the genus *Portulaca* and probably several to *P. oleracea* or its very close relatives. In their native ranges 4 leaf-mining or gall-forming flies, 1 leaf-mining moth, 1 leaf-mining sawfly and 2 weevils all cause considerable damage and show high specificity to *P. oleracea*.

If this group of phytophagous insects is not already present, the establishment of several without their own natural enemies should lead to a significant lowering in the weed status of *P. oleracea*.

Portulaca oleracea is an attractive target for an attempt at biological control.

4.25 *Portulaca oleracea* L.

Portulacaceae

pigweed, purslane; gelang, krokot (Indonesia); gelang pasir, segan (Malaysia); phak bia yai (Thailand), mya byit, mye byet (Myanmar); kbet choun (Cambodia); golasiman, ulasiman (Philippines), rau sam (Vietnam)

Rating

	+++	Phil
10	++	Thai
	+	Myan, Viet, Msia, Sing, Indo

Much of the material in this dossier is summarised from the account in Waterhouse (1993b).

Origin

Uncertain; possibly Central America, but see comment.

Distribution

Very widespread in tropical, subtropical and temperate regions of the world, including Southeast Asia, Australia and the Pacific.

Characteristics

Pigweed is a fleshy annual herb, reproducing by seed, or by stem-fragments rooting when lying on moist soil. The stems are succulent, often reddish and 0.2 to 0.5 m in length. The stems and leaves are smooth and fleshy and form mats. In sunlight the plants are prostrate, but in partly shaded situations they may attain a height of 0.5 m. The leaves are alternate, flowers are yellow, sessile, self-pollinated and either occur singly, or several may occur together, in the leaf clusters at the ends of branches. They open on sunny mornings and later produce numerous tiny (0.5 mm diameter) black seeds.

Importance

P. oleracea was ranked 9th of the world's worst weeds, being recorded in 45 crops in 81 countries (Holm et al. 1977). With a rating of 10 in Southeast Asia, it ranked equal 32nd in the region; also 6th in the Pacific and 49th in Australia (Waterhouse 1993a,b). In Southeast Asia, it is particularly important in many upland crops, including vegetables, rice, maize, sorghum, groundnuts and sugarcane. It is drought hardy, colonising waste places and bare areas but thrives in moist fertile soils. There are many ecological types, some of which are occasionally used as a vegetable. In the Philippines up to 10 000 and in North America up to 243 000 seeds are produced per plant. The tiny seeds are spread by wind, water, as a contaminant of the seeds of crops and by birds, surviving passage through the digestive tract. They also survive burial for long periods and germinate best above 30°C, but poorly below 24°C.

Pigweed does not compete well with other weeds. It is successful because it establishes rapidly after soil disturbance and may flower and seed before being outcompeted by taller plants. The succulent leaves and stems are rich in oxalates and nitrates and have been implicated in livestock deaths. The succulent leaves of some strains have been used as human food (Miyanishi and Cavers 1980).

Natural enemies

The 138 insect species that have been recorded attacking *P. oleracea* were listed by Waterhouse (1993b), most of them from Central and South America (Bennett and Cruttwell 1972) and USA (Romm 1937). A few additional records are now listed in table 4.25.1. Most of these species are known to be (or suspected of being) polyphagous and many are pests. Nevertheless, table 4.25.2 lists 14 insects that, so far as known, are restricted to *P. oleracea*, or at least to the genus *Portulaca*. Eight of these appear to have originated in the Americas, 2 each in Africa and India, and 1 each in France and Southeast Asia. With the exception of the weevil *Ceutorhynchus portulacae*, described from *P. oleracea* in Java, there do not appear to be any reports of native insects which might possibly be restricted to pigweed in Southeast Asia, the Pacific or Australia.

Table 4.25.1 Natural enemies of *Portulaca oleracea*: additional insect records to those of Waterhouse (1993b).

Species	Country	Other hosts	References
Hemiptera			
APHIDIDAE			
<i>Myzus persicae</i>	Australia	polyphagous	author's record
CICADELLIDAE			
<i>Circulifer haematoceps</i>	Israel	polyphagous	Klein & Raccah 1991
<i>Orosius orientalis</i> (= <i>O. albicinctus</i>)	India	polyphagous	Kooner & Deol 1982
LYGAEIDAE			
<i>Nysius cymoides</i>	Italy	jojoba	Parenzan 1985
<i>Nysius vinitor</i>	Australia	polyphagous	Elshafie 1976, Ramesh & Laughlin 1984
Coleoptera			
CURCULIONIDAE			
<i>Hypurus bertrandi</i>	Australia, India, Guam, Northern Marianas	specific	R.E. McFadyen pers. comm. 1993, Zaka-ur-rab 1991, Zimmerman 1957
Diptera			
AGROMYZIDAE			
<i>Liriomyza caulophaga</i>	Australia	<i>Beta vulgaris</i> var. <i>cicla</i>	R.E. McFadyen pers. comm. 1993
<i>Liriomyza trifolii</i>	USA	polyphagous	Chandler & Chandler 1988

(continued on next page)

Table 4.25.1 (continued)

Species	Country	Other hosts	References
Lepidoptera			
NOCTUIDAE			
<i>Agrotis ipsilon</i>	India	polyphagous	Das & Ram 1988
<i>Neogalea (= Spodoptera) sunia</i>	Nicaragua	polyphagous	Savoie 1988
<i>Spodoptera eridania</i>	Nicaragua	polyphagous	Savoie 1988
<i>Spodoptera exigua</i>	Nicaragua	polyphagous	Savoie 1988
PYRALIDAE			
<i>Loxostege bifidalis</i>	N. America	cotton	Allyson 1976

The host specificity has been investigated of 5 of the 6 species of Diptera, Lepidoptera and Hymenoptera listed in table 4.25.2, but, except for *Baris arctithorax* and *Hypurus bertrandi*, both of which appear to be adequately specific (see later), little is known about that of the 8 weevils.

Several of the fungi listed in table 4.25.3 are reported to damage *P. oleracea*, sometimes severely (Waterhouse 1993b), but too little is known about host specificity or host specific strains to evaluate their possible role as classical biological control agents. Nevertheless their specificity certainly merits investigation should the need arise.

Attempts at biological control

There have been no attempts to establish natural enemies as biological control agents for *P. oleracea*. However three insect species have appeared in countries well out of their native range, in particular the European weevil *Hypurus bertrandi*, but also the American sawfly *Schizocerella pilicornis* and the American leaf-mining fly *Haplopeodes palliatus*. These successful, unassisted establishments suggest that there should be little difficulty in securing assisted establishments elsewhere. Unfortunately there is no information available on what effects, if any, these three insects have had on *P. oleracea* in their new countries, but it is suspected that a group of species may be required to secure substantial effects in Australia.

The sawfly *Schizocerella pilicornis* appeared in eastern Australia (Queensland and New South Wales) in the early 1960s; (Benson 1962, Krombein and Burks 1967) but there are no records of it building up in sufficient numbers to cause serious damage. In 1993 *Hypurus bertrandi* and *Liriomyza caulophaga* were bred from *P. oleracea* leaves in Brisbane (R.E. McFadyen pers. comm.), but numbers were too low to cause serious damage. It is not known whether these species have only become established recently. *L. caulophaga* was previously known only from *Beta vulgaris* var. *cicla* (silverbeet) in Australia. Larvae tunnel in the soft white spongy tissue between the vascular strands in the leaf petioles and midribs and pupate there (Kleinschmidt 1960, 1970, Spencer 1990).

EGYPT

Tawfik et al. (1976) recorded *Hypurus bertrandi* attacking *P. oleracea*.

GUAM AND THE NORTHERN MARIANA IS.

Zimmerman (1957) records *Hypurus bertrandi* from Guam, Tinian, Saipan and Agrihan, some of the specimens from Saipan being taken from the crops of swifts.

Table 4.25.2 Insects restricted to *P. oleracea* or at least to the genus *Portulaca* (after Waterhouse 1993b).

Species	Distribution	References
Coleoptera		
CURCULIONIDAE		
<i>Apion</i> sp.	Brazil	d'Araujo e Silva et al. 1968a,b
<i>Baris arctithorax</i>	Egypt	Tawfik et al. 1976
<i>Baris lorata</i>	Sudan	Marshall 1911
<i>Baris portulacae</i>	India	Marshall 1916
<i>Ceutorhynchus oleracae</i>	Java	Marshall 1935
<i>Ceutorhynchus portulacae</i>	India	Marshall 1916
<i>Hypurus bertrandi</i>	Puerto Rico, France, Egypt, USA, Hawaii, Marianas, Australia	Wolcott 1948 Tempère 1943 Tawfik et al. 1976 Clement and Norris 1982 RE McFadyen pers. comm. 1993, Zimmerman 1957
<i>Linogeraeus</i> (= <i>Centrinaspis</i>) <i>perscitus</i>	Colombia, Trinidad, USA	Bennett and Cruttwell 1972, Romm 1937
Diptera		
AGROMYZIDAE		
<i>Haplopeodes palliatus</i>	Australia, USA	R.E. McFadyen pers. comm. 1993, Romm 1937
ANTHOMYIIDAE		
<i>Pegomya dolosa</i>	Trinidad	Bennett and Cruttwell 1972 Cruttwell and Bennett 1972a
CECIDOMYIIDAE		
<i>Asphondylia portulacae</i>	El Salvador, Argentina, Colombia, Bolivia, Leeward Is, St Kitts Nevis, Montserrat, Jamaica	Gagné 1968, Bennett and Cruttwell 1972
<i>Lasioptera portulacae</i>	USA	Felt 1911
<i>Neolasioptera portulacae</i>	Cuba, Florida, St Vincent Trinidad, St Kitts Nevis,	Gagné 1968 Bennett and Cruttwell 1972
Lepidoptera		
HELIODINIDAE		
<i>Heliodines quinqueguttata</i>	Trinidad, Montserrat Puerto Rico	Bennett and Cruttwell 1972, Cruttwell and Bennett 1972b Wolcott 1948
Hymenoptera		
TENTHREDINIDAE		
<i>Schizocerella pilicornis</i>	California, Mexico USA, Australia Argentina to USA	Bennett and Cruttwell 1972 Krombein and Burks 1967 Muesebeck et al. 1951

Table 4.25.3 Natural enemies of *Portulaca oleracea*: fungi, viruses and nematodes.

Species	Country	Other hosts	References
FUNGI			
<i>Albugo portulacae</i>	Europe, Africa, Asia, Americas		IMI 1992, Miyanishi & Cavers 1980
<i>Albugo portulacae</i>	Poland		IMI 1992
<i>Ascochyta portulacae</i>	USSR		IMI 1992
<i>Bipolaris</i> (= <i>Drechslera</i>) <i>indica</i>	USA	many, including <i>Amaranthus spinosus</i>	Evans 1987, Kenfield et al. 1989
<i>Cercospora portulacae</i>	India		IMI 1992
<i>Cercospora dominicana</i>	Dominica		IMI 1992
<i>Dendrographium lucknowense</i>	India		IMI 1992
<i>Dichotomophthora indica</i> (= <i>D. lutea</i>)	USA, West Indies, Europe, India	<i>Helianthus</i> , <i>Pennisetum</i>	Baudoin 1986, IMI 1992, Rao 1966
<i>Dichotomophthora portulacae</i>	Europe, Sudan, Hawaii, California, Jamaica, Venezuela	tarragon, cactus, capsicum, <i>Glycine max</i>	Vegh & Le Berre 1984, Klisiewicz 1985, Klisiewicz et al. 1983, Mehrlich & Fitzpatrick 1935, Mitchell 1986
<i>Helminthosporium</i> (<i>Bipolaris</i>) <i>portulacae</i>	USA	<i>Portulaca grandiflora</i>	IMI 1992, Rader 1948, Strider & Chi 1984
<i>Phoma</i> sp.	France	tarragon	Vegh & Le Berre 1984
<i>Phytophthora palmivora</i>	Sarawak	pepper and several weeds	Anon 1979
<i>Polymyxa betae</i> f. sp. <i>portulacae</i>	Bulgaria, Japan	sugar beet, wheat, many weeds	Abe & Ui 1986, Vrbanov & Krumov 1989
VIRUSES			
anemone brown ring	Hawaii	anemone	Holm et al. 1977
aster yellows	Hawaii	aster	Holm et al. 1977
beet curly top	Hawaii	sugar beet	Holm et al. 1977
chili vein banding	Hawaii	chili	Holm et al. 1977
clover big vein	Hawaii	clover	Holm et al. 1977
cucumber mosaic	Bulgaria, Hungary, USA	many economic plants, cucumber, tobacco	Dikova 1989, Nasser & Basky 1988, Dodds & Taylor 1980
groundnut rosette	Malawi	groundnut	Adams 1967
tobacco broad ring spot	Hawaii	tobacco	Holm et al. 1977
tobacco etch	Hawaii	tobacco	Holm et al. 1977
tobacco mosaic	Philippines	many	Eugenio & del Rosario 1962
tobacco streak	Hawaii	tobacco	Holm et al. 1977
NEMATODES			
<i>Criconebella xenoplax</i>	USA	many legumes and other plants	Zehr et al. 1990
<i>Ditylenchus dipsaci</i>	USSR	polyphagous	Kholod 1983
<i>Helicotylenchus indicus</i>	India	polyphagous	Rahman & Khan 1986
<i>Helicotylenchus multicinctus</i>	Brazil, Ivory Coast	banana	Luc et al. 1990, Zem & Lordello 1983
<i>Heterodera glycines</i>	Colombia	soybean	Quintero et al. 1988

(continued on next page)

Species	Country	Other hosts	References
<i>Heterodera marioni</i>	Hawaii		Linford & Yap 1940
<i>Hoplolaimus indicus</i>	USA	eggplant, tomato	Rahman & Khan 1986
<i>Meloidogyne</i> sp.	Cuba	coffee	Izquierdo et al. 1987
<i>Meloidogyne arenaria</i>	USA	tobacco	Tedford & Fortnum 1988
<i>Meloidogyne hapla</i>	Hungary		Dabaj & Jenser 1990
<i>Meloidogyne incognita</i>	India, USA, Philippines	several weeds	Maqbool et al. 1986, Tedford & Fortnum 1988, Valdez 1968
<i>Meloidogyne javanica</i>	India	polyphagous	Maqbool et al. 1986
<i>Pratylenchus minutus</i>	Hawaii		Linford et al. 1949
<i>Pratylenchus</i> sp.	Ivory Coast	polyphagous	Luc et al. 1990
<i>Radopholus similis</i>	Ivory Coast	<i>Musa</i> sp., several weeds	Luc et al. 1990
<i>Rotylenchulus reniformis</i>	India, USA, Hawaii	ornamentals and many weeds	Heald et al. 1974, Inserra et al. 1989 Khan & Khan 1985 Linford & Yap 1940
<i>Tylenchorhynchus brassicae</i>	India	polyphagous	Rahman & Khan 1986

HAWAII

Pigweed was established in Hawaii prior to 1871 (Hillebrand 1888). *Hypurus bertrandi*, originally misidentified as *Ceutorhynchus* sp., was reported in 1950 to be numerous enough in many cases to defoliate *P. oleracea* and to cause it to collapse as if sprayed with a herbicide (Bianchi 1955). Nevertheless, in 1992, Hawaiian weed scientists considered it as one of their worst weeds (W.C. Mitchell pers. comm. 1992), so the control exerted by *H. bertrandi* and various non-specific insects is clearly insufficient. Zimmerman (1957) postulates that *H. bertrandi* was introduced from the Marianas to Hawaii, possibly with war material being returned from the battlefields. However it is more likely to have moved in the reverse direction.

INDIA

Zaka-ur-rab (1991) records *Hypurus bertrandi* as one of the leaf-mining weevils of the Indian subcontinent.

PUERTO RICO

Wolcott (1948) recorded *H. bertrandi* from Puerto Rico, but no other information is available.

Major Natural Enemies

Summarised below is what is known of the biology of nine of the natural enemies listed in table 4.25.2.

Apion sp. Coleoptera: Curculionidae

Apion sp. produces galls in the flower buds of *P. oleracea* in Brazil (d'Araujo e Silva et al. 1968a,b) and *Apion* larvae also cause significant damage by gall formation in flowers in northern Argentina (Bennett and Cruttwell 1972, Bennett pers. comm. 1992).

***Asphondylia portulacae* Diptera: Cecidomyiidae**

Oviposition by this flower gall midge into the very small pigweed buds causes them to develop abnormally. Usually only one larva develops per bud and occupies a chamber in the swollen receptacle. Galled flowers do not produce seed. *A. portulacae* is heavily attacked by parasitoids (Bennett and Cruttwell 1972) and might be an important natural enemy if freed from them. The genus *Asphondylia* is considered to be highly host specific and 52 of its 54 species are known from only a single host. Each of the two exceptions only attacks two plants of the same genus and Bennett and Cruttwell (1972) suggested, on the basis of this information, that host specificity testing was unnecessary.

***Baris arcithorax* Coleoptera: Curculionidae**

In Egypt this weevil forms stem galls on pigweed, but is not known from any economic plant. Eggs are laid singly in cavities gnawed in the stem by the female, leading to the production of single closed galls in which the larvae feed. Pupation occurs in the soil. Young infested plants produce weak vegetative growth, few seeds and may even be killed. Adult weevils feed on the surface of leaves causing white blotches or holes. At temperatures from 25 to 30°C the development time from egg to adult is about 40 days. Infestations of up to 74% of plants are recorded in summer and a peak of 95% in autumn (Awadallah et al. 1976, Tawfik et al. 1976).

***Haplopeodes palliatus* Diptera: Agromyzidae**

The genus *Haplopeodes* contains 13 species, all from the Americas and known on only four plant families—Portulacaceae (1 species) Amaranthaceae (3 species), Chenopodiaceae (2 species) and Solanaceae (8 species) (Spencer 1990). Each appears to be specific to a single genus and *H. palliatus* is known only from *P. oleracea*. It is a typical leaf miner.

***Heliodines quinqueguttata* Lepidoptera: Heliodinidae**

Eggs, which are laid singly or in groups of up to 6, hatch in 5 to 6 days and larvae wander some distance over the plant before mining into a leaf, stem or seed capsule. After 7 to 8 days the fifth instar larva leaves the mine and pupates within a flimsy silk cocoon attached to the stems or leaves of the plant. Larvae are attacked by a braconid endoparasitoid, *Pholetesor* (= *Apanteles*) sp. (*circumscriptus* group).

Host specificity tests were carried out on a wide variety of economic and non-economic plants, but development was completed only on *Portulaca oleracea*, *P. pilosa* (also weedy) and the ornamental *P. grandiflora*. However, in the field in Trinidad, neither *P. pilosa* nor *P. quadrifida* (also weedy) were attacked and *P. grandiflora* was not grown. There appear to be no records of *Heliodines* species attacking crops and each species appears to be restricted to a single plant family. Cruttwell and Bennett (1972b) suggested, therefore, that it should be considered as a biological control agent.

***Hypurus bertrandi* Coleoptera: Curculionidae**

This tiny (2mm long) weevil has spread unaided from its native France to Egypt (prior to 1926) (Hoffman and Tempère 1944, Tawfik et al. 1976), Puerto Rico (Wolcott 1948), Hawaii (1950) (Davis 1955, Maehler 1954), Guam and the Northern Marianas

(Zimmerman 1957), California (1980) and Queensland (1993) (R.E. McFadyen pers. comm.).

Eggs are deposited singly and larvae mine the leaves. Infested leaves wilt and fall; and the larvae then migrate to fresh leaves, each destroying four or five in its lifetime. If no undamaged leaves are available the outer tissues of stems are attacked. Pupation occurs in a cell formed by soil particles cemented by fecal secretion and, in France, adults overwinter under the bark of trees. Adults feed on leaf margins, stems and developing seed capsules. Development is rapid, from egg to adult in 10 days at 32.2°C and under 16 hours light. *P. oleracea* is its only reported host plant. In France it is parasitised by a number of wasps (Tawfik et al. 1976, Clement and Norris 1982, Hoffmann and Tempère 1944, Norris 1985, Tempère 1943, 1944, 1950).

***Neolasioptera portulacae* Diptera: Cecidomyiidae**

Oviposition in the stem by this midge leads to globular galls up to 1.5 cm in diameter, each containing up to 10 larvae. Galls retard or prevent growth and also flower and seed production. In open, infertile sites every pigweed stem may be infested but, in vigorous growth or in shaded sites, the level of attack is usually very low. The larvae are heavily attacked by parasitoids.

All except one of the 51 species of *Neolasioptera* are restricted to one plant genus and the remaining species only attacks two plant genera. This was taken by Bennett and Cruttwell (1972) to indicate that *N. portulacae* is sufficiently host specific to be employed for biological control.

***Pegomya dolosa* Diptera: Anthomyiidae**

Eggs are laid singly on the underside of the pigweed leaf and hatch after about 3 days. The larvae are leaf miners, devouring the contents of the leaf and then leaving to enter another. Two or more leaves are commonly destroyed by each larva. After feeding for about 7 days larvae leave to pupate in the soil, later emerging as 3 to 4 mm long adults. Eggs are parasitised and larvae are attacked by a pteromalid wasp.

***Schizocerella pilicornis* Hymenoptera: Tenthredinidae**

This leaf-mining sawfly occurs naturally over a very wide range from Argentina and Brazil to USA (Muesebeck et al. 1951). It appeared unaided in eastern Australia (Benson 1962, Krombein and Burks 1967). There are two biotypes. The larvae of one which is widespread in USA mines the leaves, whereas those of the other (from Mississippi northwards) feeds externally on the leaves.

Females mate soon after emergence and lay up to 40 eggs singly in the edges of the leaves. The larvae mine the leaves, damaging each to the point of collapse before moving to another. At least two leaves are destroyed by each larva. The mature larvae enter the soil and spin cocoons. The life cycle can be completed in 13 days and there are a number of generations each year (Clement and Norris 1982, Gorske et al. 1976). In California prepupae in diapause overwinter in the soil. Adults live for a day and do not feed. In California up to 84% of *P. oleracea* leaves were severely damaged, leading to defoliation and sometimes death of the plant. When *P. oleracea* was protected by insecticide from both *S. pilicornis* and *Hypurus bertrandi* it produced about four times as much seed as

unprotected plants, although the latter still produced enough (4000 to 5000/m²/day) to maintain a high seed bank in the soil (Force 1965, Garlick 1922, Gomes de Lima 1968, Gorske et al. 1977, Norris 1985, Webster and Mally 1900).

S. pilicornis has not been recorded from any economic plant and, in starvation tests, was only able to feed on *P. oleracea* and the related *Montia perfoliata* (Gorske et al. 1976). A microsporidan, *Nosema pilicornis* causes high mortality in infected *S. pilicornis* larvae in USA and should be eliminated during any transfer of the sawfly to new areas (Gorske and Maddox 1978).

Comment

It is generally believed that, through coevolution, there are likely to be a number of specific (or nearly specific) natural enemies of an organism in its area of origin. Furthermore, that not all such organisms will have accompanied their host when it has moved outside its area of origin. If this generalisation is applied to *P. oleracea* it can be seen that 8 of its 14 specific (or nearly specific) natural enemies are of American origin but no more than 2 from any other region of the world (Table 4.25.2). The inference from this is that *P. oleracea* is probably of American origin, an inference supported by the finding of seeds in Louisiana, Illinois and Kentucky dating between 1000BC and 750AD and pollen and seeds in Ontario sediments dating back to 1350AD (Miyaniishi and Cavers 1980). This suggests that, if it is desired to evaluate insects additional to those listed in table 4.25.2, they should first be sought from the Americas and possibly from amongst those listed by Waterhouse (1993b).

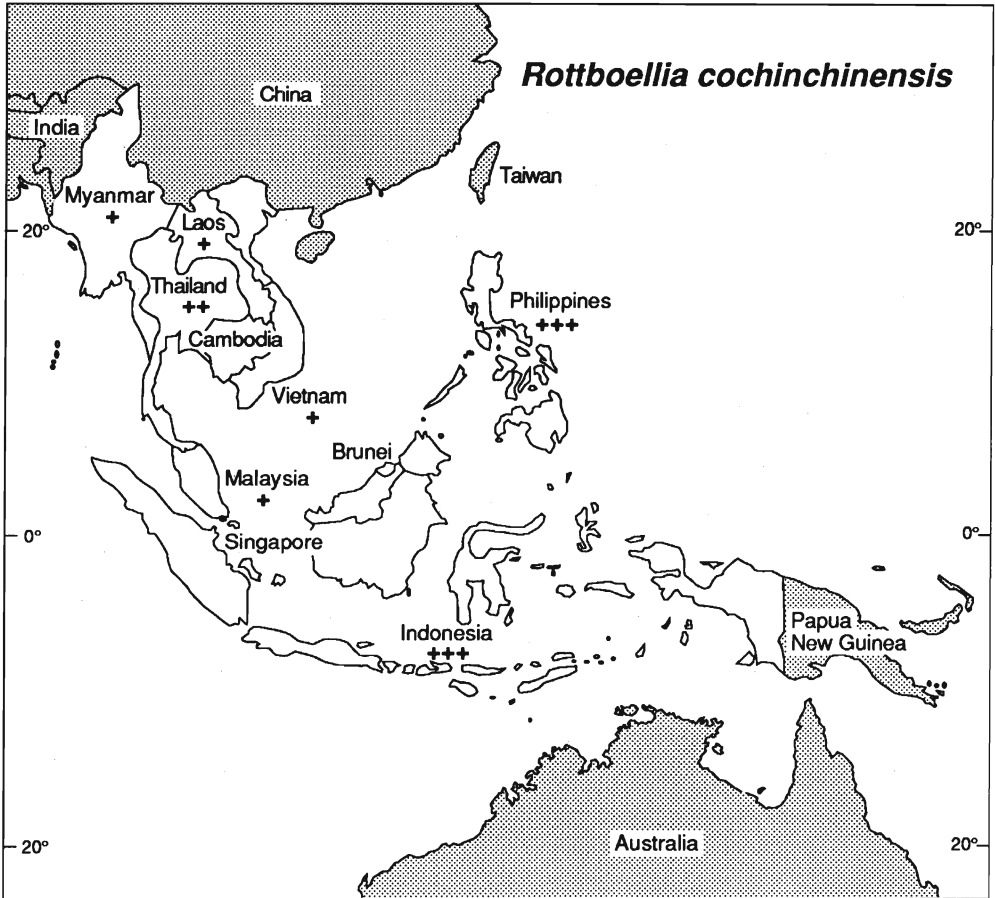
The family Portulacaceae is relatively small with 20 genera and about 250 species worldwide, of which the genus *Portulaca* contains about half (West 1990). Very few Portulacaceae are cultivated: *Portulaca grandiflora* as a brightly flowering garden plant, *Talinum paniculatum* and *T. triangulare* as pot herbs (but they are sometimes regarded as weeds), *Montia fontana* for salads, *Lewisia* spp. as rockery plants and *Anacampseros* as a succulent; but these are not considered to be of great economic importance (Cruftwell and Bennett 1972a).

From what is known about the biology of the insects in table 4.25.2 it appears that, if a group of them is established in a new country without their own natural enemies, they should cause serious damage to *P. oleracea* and significantly reduce its competitiveness and seed production.



Rottboellia cochinchinensis

(after Holm *et al.* 1977)



Map 4.26 *Rottboellia cochinchinensis*

Rottboellia cochinchinensis is probably of Southeast Asian or Indian origin, although one biotype may have evolved in East Africa. Very little is known of its insect enemies in these regions and they certainly merit investigation. Current research on fungal pathogens indicates that *Sporisorium ophiuri* is a potential agent for the Americas and other regions where it does not yet occur.

If preliminary surveys for specific insect enemies in Asia and Africa support a Southeast Asian origin it is unlikely to be an attractive early target for classical biological control in this region.

4.26 *Rottboellia cochinchinensis* (Lour.) W.D. Clayton

(= *Rottboellia exaltata*)

Poaceae

itch grass; myet ya, myet ya nge (Myanmar), brânjângân (Indonesia), aguiñgay (Philippines), yaa prong khaai (Thailand)

Rating

	+++	Indo, Phil
12	++	Thai
	+	Myan, Laos, Viet, Msia

Origin

Uncertain but probably India to Southeast Asia; one biotype in East Africa.

Distribution

Worldwide, and weedy between 23° north and south latitudes (Holm et al. 1977). Formerly known as *Rottboellia exaltata*. Two biotypes have been recognised in USA and at least five in the Philippines (Fisher et al. 1987). The origin of *R. cochinchinensis* has not been completely resolved. It is said to be native to India (Holm et al. 1977), but in his survey of fungal pathogens and their specificity (or lack of it) Evans (pers. comm. 1992) was led to the conclusion that it may be Southeast Asia; and furthermore, that there is a distinct East African biotype, with possibly specific natural enemies of its own. It is interesting that, of the 14 Kenyan tribes visited by Ellison and Evans (1990), 13 had a separate and specific vernacular name for itch grass. Although it was a common weed and dense stands occurred at the edge of fields and along roadsides, control was achieved by early season hoeing and none of the farmers suggested it was a major problem. This evidence was taken as reinforcing the theory that East Africa is the centre of origin at least of the local biotype of the weed.

Characteristics

R. cochinchinensis is a tall, erect, strongly tufted, annual grass growing to 3 m. It has stilt roots. Its leaves and stems have long, sharp, fragile, siliceous, irritating hairs that break off in the flesh on contact. The inflorescence is a single cylindrical spike.

Importance

It is an aggressive C4, annual grass of 18 tropical and subtropical crops in 28 countries, including maize, rice, sorghum, soybeans and sugarcane. The heaviest infestations occur in the Caribbean, Central America, and parts of South America, to which it is a relatively recent introduction; also a widespread weed in southern Africa. It is an important weed in sugarcane, maize and upland rice in the Philippines. It is often a primary coloniser of disturbed land. It flowers all year round. Reproduction is by seed and up to 8 000 may be

produced per plant. The seed is about the size of a rice grain and is not easily separated from intermingled rice grains. Some seeds germinate immediately, whereas others lie dormant for varying periods, sometimes years. Buried seeds may germinate and emergence take place from a depth of 15 cm. It is common in open, well-drained places, but also grows in wet places and even in shallow water. It commonly occurs on contour banks and roadsides. It prefers sunny or no more than moderately shaded situations, but can grow in deep shade. Its many needle-like hairs deter hand removal of older plants, since the hairs penetrate hands and clothing and result in painful infections.

R. cochinchinensis is sometimes grazed and used for green fodder, although avoided at times by some animals because of its sharp hairs.

Natural enemies

Fungi are the only natural enemies (Tables 4.26.1 to 4.26.3) for which there is any reasonably comprehensive information. Fungi have been surveyed and their specificity is being examined in a joint International Institute of Biological Control and Long Ashton Research Station project covering East Africa, South America, India, Nepal, Sri Lanka and Thailand (Ellison 1992, Ellison and Evans 1990, 1993, Evans 1991, Natural Resources Institute 1992).

As indicated earlier, *R. cochinchinensis* shows high biotype variation between countries and this is correlated with varying levels of susceptibility to different fungal isolates. Also, a clear positive correlation was found between high pathogen virulence and inadequate specificity to itch grass (Ellison 1992). Maize (*Zea mays*) proved to be the crop species most at risk from itch grass pathogens, which is not surprising in view of the close evolutionary relationship of the two genera involved. This suggests that the use of fungi for classical biological control of itch grass may not show great promise, but that their use as mycoherbicides might prove effective. All except one of the fungi from tropical America that have been tested are non-specific to itch grass and most are local pathogens that have transferred from local grasses (Evans 1987). In Kenya, in addition to at least 10 non-specific fungi attacking itch grass, a head smut, *Sporisorium* (= *Sphacelotheca*) *ophiuri* was found, which appears to be restricted to *Rottboellia* and the closely related genus *Chasmopodium* (Ellison and Evans 1990, Zundel 1953).

S. ophiuri is recorded as occurring in East Africa, Sri Lanka, Philippines and Thailand, but apparently not in the Americas. It is often locally damaging, significantly reducing vigour and virtually eliminating seeding. Its host specificity is under detailed investigation (Ellison and Evans 1993, Evans 1991) as a potential candidate for classical biological control for areas where it does not already occur. In an annual weed where seeds are the only means of propagation, a destructive seed head disease, such as *S. ophiuri*, is a highly promising biological control agent (Evans 1991).

A *Curvularia* isolate from Trinidad proved highly damaging to itch grass, while not damaging rice, maize, sugarcane or pearl millet (Evans 1991). A *Curvularia* from Somalia was able to kill *R. cochinchinensis* in a few days, but was also able to infest maize. However the crop readily recovered (Ellison 1992). If further tests confirm its specificity, it may be a potential biological control agent. The same applies to *Puccinia*

rottboelliae about which less is recorded (Evans 1987). Special attention is now being paid to the possibility of developing preparations of one or more of these fungi as a mycoherbicide. An isolate from Thailand of *Colletotrichum* sp. which appears to be specific to itch grass has been selected from 900 fungal samples and field trials have already demonstrated that an appropriate formulation has potential against this weed, particularly when combined with low doses of herbicide (Ellison 1992, Ellison and Evans 1993, Natural Resources Institute 1992).

Surprisingly few insects (Table 4.26.1) have been recorded attacking itch grass and only one unidentified gall midge recorded in India from *Rottboellia compressa* (Barnes 1946) might, if it attacks *R. cochinchinensis* also, be specific enough to be a candidate agent. It is regrettable that parallel observations were not made on insects during the extensive fungal surveys. In East Africa a stem borer, a lepidopteran leaf feeder and a fly larva all proved to be non-specific graminaceous feeders (H.C. Evans pers. comm. 1992, 1993).

R. cochinchinensis is an alternative host for a number of viruses, almost all of them serious diseases of maize (Table 4.26.3). It is surprising that the only record encountered dealing with nematodes related to a study of 16 plant parasitic species attacking sugarcane in the Philippines. This found that itch grass was not infected by *Meloidogyne* sp. (Reyes and Beguico 1978).

Comment

Rottboellia belongs to the same grass tribe (Andropogoneae), but not to the same subtribes, as *Saccharum*, *Sorghum* and *Zea* (Table 4.26.4). This suggests that candidates for classical biological control of this weed will have to pass extensive host specificity testing against all of the crop and pasture grasses belonging to these and related genera before being considered for release.

Table 4.26.1 Natural enemies of *Rottboellia cochinchinensis*: insects.

Species	Location	Other hosts	References
Orthoptera			
GRYLLIDAE			
<i>Euscirtus concinnus</i>	Philippines	<i>Eleusine indica</i> , <i>Dactyloctenium aegyptium</i> , <i>Cyperus rotundus</i> , <i>Digitaria sanguinalis</i>	Barrión & Litsinger 1980
<i>Pteronemobius</i> sp.	Sierra Leone		Alghali & Domingo 1982
Hemiptera			
APHIDIDAE			
<i>Myzus persicae</i>	Peru	a very wide range	Ortiz 1981
<i>Uroleucon</i> (= <i>Dactynotus</i>) <i>ambrosiae</i>	USA	sorghum, maize	Koike 1977

(continued on next page)

Species	Location	Other hosts	References
CICADELLIDAE			
<i>Nephotettix nigromaculatus</i>	Sierra Leone	rice, <i>Ischaemum rugosum</i> , <i>Paspalum vaginatum</i>	Alghali & Domingo 1982
DELPHACIDAE			
<i>Peregrinus maidis</i>	Venezuela	a virus transmitter on many hosts	Ferreira et al. 1989, Migliori & Lastra 1980, 1981, Trujillo et al. 1974
Coleoptera			
COCCINELLIDAE			
<i>Chnootriba (= Epilachna) similis</i>	Sierra Leone		Alghali & Domingo 1982
Diptera			
AGROMYZIDAE			
<i>Pseudonapomyza philippinensis</i>	Philippines	known only from <i>R. cochinchinensis</i>	Spencer 1961
CECIDOMYIIDAE			
a gall midge	India	recorded only from <i>Rottboellia compressa</i>	Barnes 1946
MUSCIDAE			
<i>Atherigona soccata</i>	Kenya	rice	Ogwaro 1978
Lepidoptera			
LYMANTRIIDAE			
<i>Psalis pennatula</i>	Kenya	generalist Poaceae leaf eater	H.C. Evans pers. comm. 1993
NOCTUIDAE			
<i>Sesamia</i> sp.	Ghana		Sampson & Kumar 1986
<i>Spodoptera frugiperda</i>	USA	many graminaceous crops	Rajapakse et al. 1988
PYRALIDAE			
<i>Chilo</i> sp.	Ghana		Sampson & Kumar 1986
sp.?	Kenya	generalist Poaceae leaf eater	H.C. Evans pers. comm. 1993

Table 4.26.2 Natural enemies of *Rottboellia cochinchinensis*: fungi.

Fungi	Location	Other hosts	References
<i>Ascochyta</i> sp.	Kenya	no tests on other plants	Ellison & Evans 1990, 1993
<i>Bipolaris perotidis</i>	Australia	many other grasses	QDPI, unpublished
<i>Cercospora</i> spp.	Kenya, Ethiopia, Zanzibar, Madagascar, Americas, SE Asia	maize mildly	Ellison & Evans 1990, 1993

(continued on next page)

Table 4.26.2 (continued)

Fungi	Location	Other hosts	References
<i>Cercospora fusimaculans</i>	Sudan, Zambia, Ghana, Guinea, Togo, Uganda, Jamaica	many grasses	Evans 1987
<i>Cercospora rottboelliae</i>	Guinea		Evans 1987
<i>Cochliobolus</i> (<i>Helminthosporium</i>) <i>bicolor</i>	Zimbabwe, Somalia	sugarcane, maize, pearl millet	Ellison & Evans 1990, 1993
<i>Cochliobolus</i> (<i>Curvularia</i>) <i>cymbopogonis</i>	Bolivia, Kenya, Trinidad, Zanzibar, USA, SE Asia	sugarcane, maize, pearl millet, sorghum	Ellison & Evans 1990, 1993, Evans 1987, Walker & White 1979
<i>Cochliobolus heterostrophus</i> (<i>Drechslera maydis</i>)	Kenya, Papua New Guinea, SE Asia	sugarcane, maize	Ellison & Evans 1990, 1993, Evans 1987
<i>Colletotrichum</i> sp.	Thailand	(this species is close to <i>C. graminicola</i>)	Ellison 1992, Ellison & Evans 1993
<i>Coniothyrium</i> sp.	Africa, SE Asia		Ellison & Evans 1993
<i>Curvularia</i> spp. (many)	Trinidad, Papua New Guinea, Madagascar, Somalia, Zanzibar	most (not all) attack economic crops	Ellison 1992, Evans 1991
<i>Diaporthe</i> (<i>Phomopsis</i>) sp.	Kenya, SE Asia	maize mildly	Ellison & Evans 1990, 1993
<i>Diplodia</i> sp.	Kenya	no tests on other plants	Ellison & Evans 1990, 1993
<i>Fusarium moniliforme</i> (<i>Gibberella fujikuroi</i>)	Guatemala	the particular strain tested had limited host range with no symptoms in maize, sorghum or sugar cane, but other strains attack these and rice	Jimenez et al. 1990
<i>Glomerella</i> (<i>Colletotrichum</i>) <i>graminicola</i>	India, Nepal, Sri Lanka, Thailand	No <i>Colletotrichum</i> infection observed in East Africa	Evans 1987, 1991
<i>Leptosphaeria</i> sp.	Kenya, SE Asia	no tests on other plants	Ellison & Evans 1990, 1993
<i>Magnaporthe</i> (<i>Pyricularia</i>) <i>grisea</i>	Kenya, Zimbabwe	maize mildly, also <i>Eleusine</i> spp.	Ellison & Evans 1990, 1993, Evans 1987
<i>Phaeoseptoria</i> sp.	Kenya, SE Asia	no tests on other plants	Ellison & Evans 1990, 1993
<i>Phyllachora sacchari</i>	Asia, Nigeria, Sicily, Argentina		Anahosur and Sivanesan 1978
<i>Puccinia rottboelliae</i>	Kenya, Madagascar, Ghana, Uganda, Zambia, Ethiopia, Guinea, Nigeria, Sierra Leone, Sudan, Zimbabwe, India	limited host range	Ellison & Evans 1990, 1993, Evans 1987

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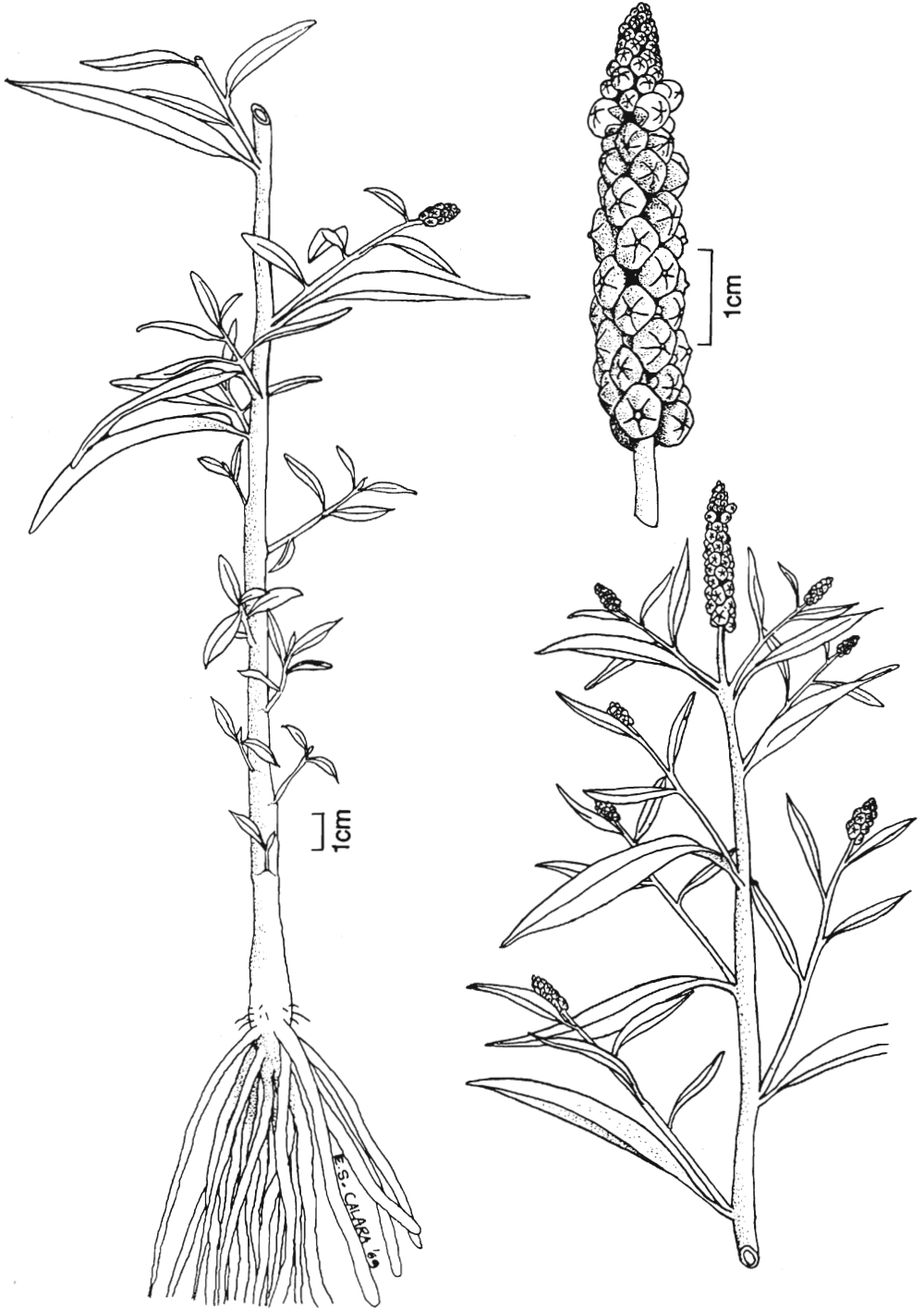
Fungi	Location	Other hosts	References
<i>Pyrenochaeta sp.</i> <i>Sphacelotheca rottboelliae</i>	SE Asia Malawi, India	also on <i>Saccharum spontaneum</i>	Ellison & Evans 1993 Evans 1987
<i>Sporisorium</i> (= <i>Sphacelotheca</i>) <i>ophiuri</i>	Kenya, Somalia, Sudan, Uganda, Zimbabwe, Sierra Leone, Sri Lanka, Philippines	limited host range, and not present in the Americas	Ellison & Evans 1990, 1993, Evans 1987, 1991
<i>Ustilago scitaminea</i>	Philippines		Latiza 1980

Table 4.26.3 Natural enemies of *Rottboellia cochinchinensis*: viruses.

Virus	Location	Other hosts	References
corn leaf gall virus	Philippines		Agati & Calica 1950
maize stripe tenuivirus	USA	sorghum	Bradfute & Tsai 1990
maize stripe virus	USA	sorghum	Gingery et al. 1981
maize hoja blanca	Venezuela	sorghum	Ferreira et al. 1989
maize white leaf	Venezuela		Trujillo et al. 1974
maize rayado fine	Texas	several grasses	Nault et al. 1980
maize mosaic	Guadeloupe, French Guinea	sorghum	Migliori & Lastra 1981
maize dwarf mosaic	USA	sorghum, sugarcane	Gillespie & Koike 1973
maize yellow mottle	Nigeria		Thottapilly et al. 1992
virus like disease of maize	Guadaloupe	sorghum	Migliori & Lastra 1980
rice leaf gall	Philippines		Agati & Calica 1950

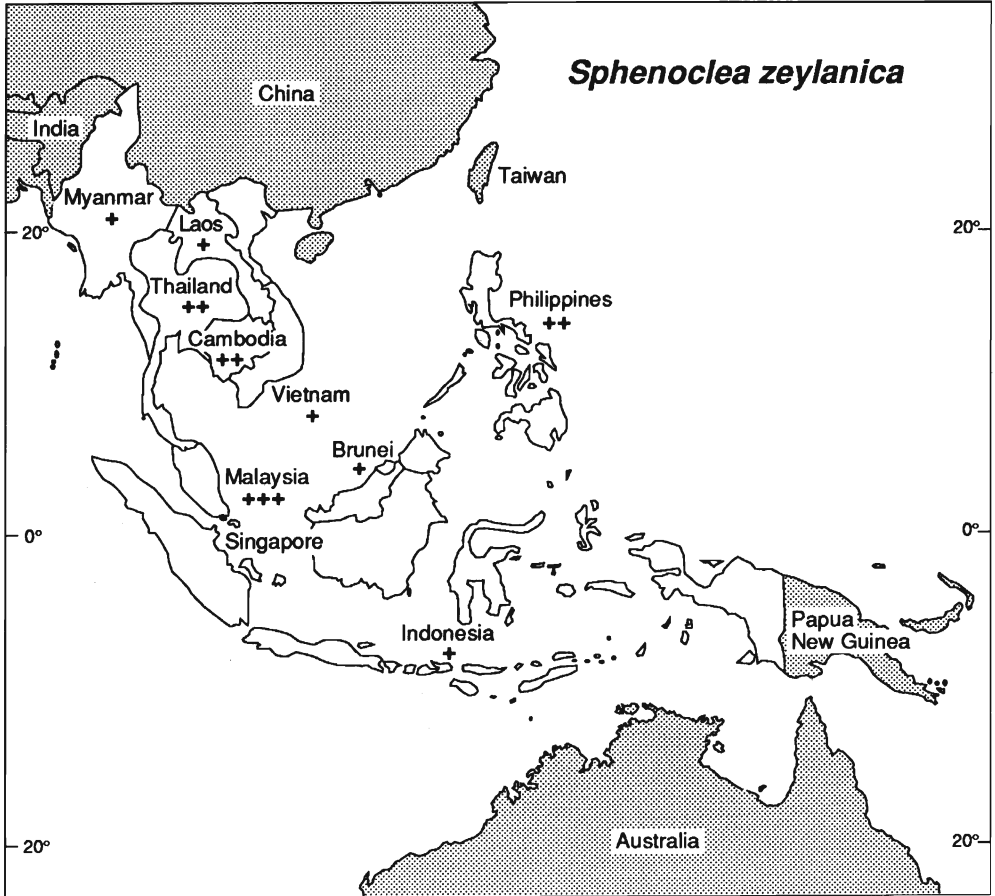
Table 4.26.4 Taxonomic position of the major exotic grass weeds (bold text) in relation to the major genera of crops in the family Poaceae (= Gramineae).

Subfamily	Tribe	Sub-tribe	Genera
Bambusoideae	Bambuseae		<i>Bambusa</i>
	Oryzeae		<i>Oryza</i>
Pooideae	Triticeae		<i>Hordeum</i> , <i>Secale</i> , <i>Triticum</i>
	Aveneae		<i>Avena</i>
Chloridoideae	Eragrostideae		<i>Eleusine</i> , <i>Eragrostis</i>
	Cynodonteae		<i>Cynodon</i>
Panicoideae	Paniceae	Setariinae	<i>Echinochloa</i> , <i>Panicum</i> , <i>Paspalum</i> , <i>Setaria</i>
		Digitariinae	<i>Digitaria</i>
		Cenchrinae	<i>Pennisetum</i>
	Andropogoneae	Saccharinae	<i>Saccharum</i>
		Sorghinae	<i>Sorghum</i>
		Rottboelliinae	<i>Rottboellia</i>
	Maydeae	Tripsacinae	<i>Zea</i>



Sphenoclea zeylanica

(after Holm *et al.* 1977)



Map 4.27 *Sphenoclea zeylanica*

Goose weed, *Sphenoclea zeylanica*, is native to Tropical Africa where it is not regarded as a weed, although there are no natural enemies recorded from it there. In Southeast Asia, where it is an important weed of rice, and in India, it is sometimes severely affected by a fungus which may have some promise as a bioherbicide.

A survey for natural enemies in its area of origin would be required to evaluate the prospects for its biological control.

4.27 *Sphenoclea zeylanica* Gaertn.

Sphenocleaceae

gooseweed; goenda (Indonesia), silisilihan (Philippines), pakpawd, phak pot (Thailand) xà bông (Vietnam)

Rating

	+++	Msia
14	++	Thai, Camb, Phil
	+	Myan, Laos, Viet, Brun, Indo

Origin

Tropical Africa

Distribution

In tropical and subtropical regions across the world. From Iran extending eastwards to Indonesia and the Philippines, also China, Japan, USA, the Caribbean, Guyana, Surinam and Madagascar. Not reported from Papua New Guinea, Australia or the oceanic Pacific.

Characteristics

S. zeylanica is an erect, fleshy, herbaceous annual, often with much branched, hollow stems, growing to 1.5 m; leaves alternate, oblong to lanceolate, tapering to both ends; flowers sessile in dense spikes, terminal, whitish; seed yellowish brown, 0.5 mm long; roots cord-like.

Importance

S. zeylanica is unusual in that it is not reported as a weed in any crop except rice (Holm et al. 1977). It thrives in damp ground at altitudes up to 350 m. In Africa it grows in the mud of tidal creeks, but does not have this habit in Malaysia. It occurs on the sides of ponds and along ditches and rivers, on dry river beds and in seasonal swamps. It prefers stagnant water sites. It reproduces continuously by seed in the Philippines. In spite of its competition with the rice plant, *S. zeylanica* can give valuable practical control (up to 99%) of populations of rice nematodes (*Hirschmaniella* spp.), with the additional benefit of increased soil nitrogen. It acts through the production of toxic plant exudates (Mohandes et al. 1981).

In Java, young plants and tips of older plants are steamed and eaten with rice.

Natural enemies

The only natural enemy encountered in the literature search is a fungus (Table 4.27.1). This was a severe infestation of the fungus *Cercosporidium helleri* on the lower surface of *S. zeylanica* leaves in India (Ponnappa 1967). The affected leaves became deformed and fell off. Similar fungi capable of causing death of the weed were observed at Los

Banos, Philippines and at Prey Phadu, Cambodia (Moody et al. 1987). If this fungus proves to be adequately specific it may have some value as a bioherbicide.

Table 4.27.1 Natural enemies of *Sphenoclea zeylanica*

Species	Location	References
NEMATODE		
<i>Meloidogyne graminicola</i>		Luc et al. 1990
FUNGUS		
<i>Cercosporidium helleri</i>	Cambodia, India, Philippines	Moody et al. 1987, Ponnappa 1967

5 References

- Abe, H. and Ui, T. 1986. Host range of *Polymyxa betae* Keskin strains in rhizomania-infested soils of sugar beet fields in Japan. *Annals of the Phytopathological Society of Japan* 52: 394–403. (*Weed Abstracts* 36: 2228, 1987).
- Abenes, M.L.P. and Khan, Z.R. 1990. Feeding and food assimilation by two species of rice leaffolders on selected weed plants. *International Rice Research Newsletter* 15(3): 31–32.
- Ablin, M.P. 1992. *Heteropsylla* sp. (Psyllidae) successfully controls pasture infestations of *Mimosa invisa* within three years of release in Australia. p. 54, Abstracts, VIII International Symposium on Biological Control of Weeds, Lincoln University, Canterbury, New Zealand, 2–7 February 1992.
- Ablin, M.P. 1993a. Insecticide exclusion with carbofuran demonstrates the effectiveness of *Heteropsylla spinulosa* as a biological control agent for *Mimosa invisa* in North Queensland. Abstract, 14 Asian Pacific Weed Science Society and 10th Australian Weed Society Conference, September 1993, Brisbane.
- Ablin, M. 1993b. Successful establishment of *Heteropsylla spinulosa* on *Mimosa invisa* in Papua New Guinea. Queensland Department of Lands, Memorandum, 1p.
- Acosta, O., Veitia, A. and Wade, J. 1986. Malezas hospedantes de *Meloidogyne* spp. en areas tabacaleras de la Preoincia de Sancti Spiritus. *Ciencia y Tecnica en la Agricultura, Proteccion de Plantas* 9(4) 31–40. (*Helminthological Abstracts, Series B*, 58: 1410, 1989).
- Adams, A. 1967. The vectors and alternate hosts of groundnut rosette virus in Central Province, Malawi. *Rhodesian, Zambian, Malawian Journal of Agricultural Research* 5: 145–151. (Holm et al. 1977).
- Agarwal, B.D. 1985. Biology of *Hypolixus truncatulus* Fabr. (Coleoptera: Curculionidae) forming galls on the stem of *Amaranthus spinosus* Linn. in India. *Cecidologia Internationale* 6(1): 83–90. (Review of Applied Entomology, Series A, 75: 1686, 1987).
- Agati, J. and Calica, C. 1950. Studies in the host range of the rice and corn leaf-gall virus. *Philippine Journal of Agriculture* 15: 249–258. (Holm et al. 1977).
- Ahmad, T.R., Pruess, K.P. and Kindler, S.P. 1984. Non-crop grasses as hosts for the chinch bug, *Blissus leucopterus leucopterus* (Say) (Hemiptera: Lygaeidae). *Journal of the Kansas Entomological Society* 57: 17–20. (Review of Applied Entomology, Series A, 72: 5850, 1984).
- Ahmad, M. and Thakur, M.L. 1991. Biology and host specificity of *Pareuchaetes pseudoinsulata* Rego Barros (Lepidoptera: Arctiidae). *Indian Forester* 117: 193–199.
- Ahmed, M.T. 1980. Preliminary field observations on the preference of stem borers to different graminous host plants. *Bulletin de la Société Entomologique d’Egypte* 63: 219–222.
- Alam, S., Alam, M.S. and Ahmed, M.S. 1980. Notes on *Athetis pectinicornis*, a pest of water lettuce and water hyacinth in Bangladesh. *International Rice Research Institute Newsletter* 5(3): 15.
- Alghali, A.M. and Domingo, J.S. 1982. Weed hosts of some pests in north western Sierra Leone. *International Rice Research Newsletter* 7(2): 10.
- Allyson, S. 1976. North American larvae of the genus *Loxostege* Hübner (Lepidoptera: Pyralidae: Pyraustinae). *Canadian Entomologist* 108: 89–104.

- Almeida, A.M.R. 1979. Experimental transmission of soybean mosaic virus by an aphid *Dactynotus* sp. occurring on *Bidens pilosa*, Paraná State, Brazil (Portuguese). *Fitopatologia Brasileira* 4: 509–510.
- Ambika, S.R. and Jayachandra 1990. The problem of *Chromolaena* weed. *Chromolaena odorata* Newsletter 3: 1–6.
- Anahosur, K.H. and Sivanesan, A. 1978. *Phyllachora sacchari* causes tar spot or black spot on leaves of *Polytoca macrophylla*, *Rottboellia exaltata*, *Saccharum*, *Sorghum*. Descriptions of Pathological Fungi and Bacteria, Commonwealth Mycological Institute, Kew, UK. 59(588) 2pp.
- Ananthakrishnan, T.N. and Thangavelu, K. 1976. The cereal thrips (*Haplothrips ganglbaueri* Schmutz) with special reference to the trends of infestation on *Oryza sativa* and the weed *Echinochloa crus-galli*. Proceedings of the Indian Academy of Science B 83: 196–201.
- Ang, O.C., Poh, T.W. and Chuan, L.Y. 1977. A whitefly-borne virus disease of *Ageratum conyzoides* (Linn.) in Malaysia. *MARDI Research Bulletin* 5: 148–152.
- Anon 1960. Index of plant diseases in the United States. Handbook 165. United States Department of Agriculture, Washington, D.C. 531pp.
- Anon 1973. Some Prospects for Aquatic Weed Management in Guyana. Workshop in Aquatic Weed Management and Utilization. National Science Research Council, Guyana, and National Academy of Science, USA. 1973. Georgetown, Guyana.
- Anon 1976. Annual Report, 1975–76. 91pp. Queensland Department of Primary Industries, Brisbane, Australia.
- Anon 1977. Hawaii pest report. Detection. *Cooperative Plant Pest Reporter* 2(3): 11.
- Anon 1979. Annual Report of the Research Branch, Department of Agriculture, Sarawak, for the year 1977. Kuching, Sarawak 257pp. (Review of Plant Pathology).
- Anon 1988. Tully insect release aimed at GSP control. *Bulletin, Bureau of Sugar Experiment Stations* 24: 8–9.
- Anon 1992. Stem-borer with promise. *Ecos* 74: 3.
- Ashton, H.I. 1973. Aquatic Plants of Australia. Melbourne University Press. Melbourne, Australia. 368pp.
- Aterrado, E.D. 1986a. *Pareuchaetes pseudoinsulata* caterpillar on *Chromolaena odorata*: a new Philippines record. *Philippines Journal of Coconut Science* 11(2): 59–60.
- Aterrado, E.D. 1986b. Notes on the presence of *Pareuchaetes pseudoinsulata* Rego Barros (Lepidoptera: Arctiidae) a potential biotic agent for the control of *Chromolaena odorata* (L.) King and Robinson, in Palawan: a new Philippine record. 17th Annual Conference of the Pest Control Council of the Philippines, Iloilo City, 8–10 May 1986, 7pp type-script.
- Aterrado, E.D. and Talatala-Sanico, R.L. 1988. Status of *Chromolaena odorata* research in the Philippines. pp. 53–55 in Proceedings of the First International Workshop on Biological Control of *Chromolaena odorata*. Agricultural Experiment Station, Mangilao, Guam.
- Awadallah, K.T., Tawfik, M.F.S. and Shalaby, F.F. 1976. Notes on the life history of *Baris arctithorax* Pic on the weed *Portulaca oleracea* L. (Coleoptera: Curculionidae). *Bulletin of the Entomological Society of Egypt* 60: 35–43.
- Ba-Angood, S.A.S. 1977. Observations on food preference and feeding habits of three important species of Acrididae in the Sudan. *Zeitschrift für Angewandte Entomologie* 83: 344–350.
- Ba-Angood, S.A.S. and Khidir, E.E. 1975. Comparative acceptability of different food plants by some species of Acrididae. *Zeitschrift für Angewandte Entomologie* 78: 291–293.

- Baer, R.G. and Quimby, P.C. 1981. Laboratory rearing and life history of *Arzama densa*, potential native biological control agent against water hyacinth. *Journal of Aquatic Plant Management* 19: 22–26.
- Baker, G.E., Sutton, D.L. and Blackburn, R.D. 1974. Feeding habits of the white amur on water hyacinth. *Hyacinth Control Journal* 12: 58–62.
- Baker, P.S. 1990. Parasitism of the mimosa psyllid (*Heteropsylla* sp.) by two parasitoids of the leucaena psyllid (*Heteropsylla cubana* Crawford). A report for ACIAR. International Institute of Biological Control, Trinidad. 8pp.
- Baki, B.B., Latief, A. and Puat, N.A. 1990. The genus *Pennisetum* in Peninsular Malaysia with particular reference to *P. setosum*, a new record for the weed flora. *Proceedings, Symposium on Weed Management. BIOTROP Special Publication* 38: 71–79.
- Bakker, W. 1974. Notes on East African plant virus diseases. VI. Virus diseases of *Passiflora* in Kenya. *East African Agricultural and Forestry Journal* 40(1): 11–23. (Review of *Plant Pathology* 54: 5499, 1975).
- Ballou, J.K., Tsai, J.H. and Center, T.D. 1986. Effect of temperature on the development, natality and longevity of *Rhopalosiphum nymphaeae* (L.) (Homoptera: Aphididae). *Environmental Entomology* 15: 1096–1099.
- Ballou, J.K., Tsai, J.H. and Wilson, S.W. 1987. Delphacid planthoppers *Sogatella kolophon* and *Delphacodes idonea* (Homoptera: Delphacidae): descriptions of immature stages and notes on biology. *Annals of the Entomological Society of America* 80: 312–319.
- Baloch, G.M., Khan, A.G. and Zafar, T. 1977. Natural enemies of *Abutilon*, *Amaranthus*, *Rumex* and *Sorghum*. Commonwealth Institute of Biological Control. Report of work carried out during 1976. pp. 61–62.
- Baloch, G.M., Zafar, T. and Khan, A.G. 1976. Natural enemies of *Abutilon*, *Amaranthus*, *Rumex* and *Sorghum* in Pakistan. Commonwealth Institute of Biological Control. Report of work carried out during 1975. pp. 69–70.
- Bandong, J.P. and Litsinger, J.A. 1984. Plant hosts of the rice caseworm. *International Rice Research Newsletter* 9(2): 20–21.
- Bardner, R. and Mathenge, W.M. 1974. First record of *Phytometra orichalcea* (F.) (Lepidoptera: Noctuidae) feeding on coffee foliage. *East African Agricultural and Forestry Journal* 40: 214. (Review of *Applied Entomology*, Series A 64: 3021, 1976).
- Barneby, R.C. 1989. Reflections on typification and application of the names *Mimosa pigra* L. and *M. asperata* L. (Mimosaceae). pp. 37–142 in *The Davies and Hedge Festschrift* (ed. Kit Tan). Edinburgh University Press.
- Barnes, D.E. and Chan, L.G. 1990. Common Weeds of Malaysia and their Control. Ancom Berhad, Persiaran Selangor, Malaysia. 349pp.
- Barnes, H.F. 1931. Gall midges (Cecidomyiidae) whose larvae prevent seed production in grasses (Gramineae). *Bulletin of Entomological Research* 22: 199–203.
- Barnes, H.F. 1946. Gall Midges of Economic Importance. Vol II Gall Midges of Fodder Crops. 160pp. Crosby Lockwood and Son, London.
- Barnes, H.F. 1954a. The sorghum midge problem. pp. 101–104 in *Report of the Sixth Commonwealth Entomological Conference 7–16 July 1954*. Commonwealth Institute of Entomology, London.
- Barnes, H.F. 1954b. Memorandum on the gall midges living on the sorghums, the *Panicum* millets and rice. pp. 155–160 in *Report of the Sixth Commonwealth Entomological Conference 7–16 July 1954*. Commonwealth Institute of Entomology, London.

- Barnes, H.F. 1956. Gall Midges of Economic Importance. Volume VII. Gall Midges of Cereal Crops. Crosby Lockwood and Son Ltd, London. 261pp.
- Barreto, J.M. 1982. Disease of coconut associated with flagellate protozoa (*Phytomonas* sp.) in the Paria peninsula, State of Sucre. (Spanish). *Agronomia Tropical* 32: 291–302 (Protozoological Abstracts 11: 2864, 1987).
- Barrett, S.C.H. and Forno, I.W. 1982. Style morph distribution in New World populations of *Eichhornia crassipes* (Mart.) Solms-Laubach (Water Hyacinth). *Aquatic Botany* 13: 299–306.
- Barrion, A.T. and Litsinger, J.A. 1980. *Euscirtus concinnus* (Orthoptera: Gryllidae)—a new rice pest in the Philippines. *International Rice Research Newsletter* 5(5): 19.
- Barrion, A.T. and Litsinger, J.A. 1986. Ephydrid flies (Diptera: Ephydriidae) of rice in the Philippines. *International Rice Research Newsletter* 11(4): 29–30.
- Barrion, A.T. and Litsinger, J.A. 1987. The bionomics, karyology and chemical control of the node-feeding black bug, *Scotinophara latiuscula* Breddin (Hemiptera: Pentatomidae) in the Philippines. *Journal of Plant Protection in the Tropics* 4: 37–54.
- Baudoin, A.B.A.M. 1986. First report of *Dichotomophthora indica* on common purslane in Virginia. *Plant Disease* 70: 352.
- Bayot, R.G., Watson, A.K. and Moody, K. 1992. Control of paddy weeds by plant pathogens in the Philippines. *Proceedings of International Symposium on Biological Control and Integrated Management of Paddy and Aquatic Weeds in Asia*. National Agricultural Research Center, Tsukuba, Japan, pp. 273–283.
- Beardsley, J.W. 1962. *Hysteroneura setariae* (Thomas). *Proceedings of the Hawaiian Entomological Society* 18: 21.
- Beardsley, J.W. 1980. Notes and exhibitions. *Agraulis vanillae* (L.). *Proceedings of the Hawaiian Entomological Society* 23: 155–157.
- Bennett, F.D. 1955. A record of an external egg parasite from Trinidad BWI. *Canadian Entomologist* 87: 406.
- Bennett, F.D. 1965. Proposals for a programme leading to the biological control of water hyacinth *Eichhornia crassipes*. 12pp. Commonwealth Institute of Biological Control, Commonwealth Agricultural Bureaux.
- Bennett, F.D. 1966. Investigations on the insects attacking the aquatic ferns, *Salvinia* spp. in Trinidad and Northern South America. *Proceedings Southern Weed Conference* 19: 497–504.
- Bennett, F.D. 1967. Notes on the possibility of biological control of the water hyacinth *Eichhornia crassipes*. *Pesticides Abstracts & News Summary, C*, 13: 304–309.
- Bennett, F.D. 1968. Insects and mites as potential controlling agents of water hyacinth (*Eichhornia crassipes* (Mart.) Solms.). pp. 832–835 in *Proceedings of the Ninth British Weed Control Conference*.
- Bennett, F.D. 1970. Insects attacking water hyacinth in the West Indies, British Honduras and the USA. *Hyacinth Control Journal* 5: 10–13.
- Bennett, F.D. 1972. Survey and assessment of the natural enemies of the water hyacinth, *Eichhornia crassipes*. *Pesticides Abstracts & News Summary, C*, 18: 310–311.
- Bennett, F.D. 1974. Biological control of aquatic weeds. *Proceedings of the Summer Institute of Biological Control, University of Mississippi*, pp. 224–237.
- Bennett, F.D. 1975. Insects and plant pathogens for the control of *Salvinia* and *Pistia*. *Proceedings of the Symposium on Water Quality Management through Biological Control*. Gainesville, Florida, January 29–31, 1975, pp 28–35.

- Bennett, F.D. 1979. List of natural enemies of water hyacinth *Eichhornia crassipes* and of *Tribulus cystoides* in Mexico. VII Reunion Nacional de Control Biologico. Veracruz, Mexico: 137–141.
- Bennett, F.D. 1982a. Exploration and screening of natural enemies of water hyacinth. Workshop on Biological Control of Water Hyacinth. Commonwealth Science Council, London, UK. 3–5 May 1982. Bangalore, India, pp. 27–30.
- Bennett, F.D. 1982b. Conflict of interests: Are biological control and utilization of water hyacinth compatible? Workshop on Biological Control of Water Hyacinth. Commonwealth Science Council, London. 3–5 May 1982. Bangalore, India, pp. 65–67.
- Bennett, F.D. 1984. Biological control of aquatic weeds. Proceedings of the International Conference on Water Hyacinth, Hyderabad, pp. 14–40.
- Bennett, F.D. and Cruttwell, R.E. 1972. Investigations on the insects attacking *Portulaca oleracea* L. in the Neotropics. 1. Insects recorded from *P. oleracea* and species encountered in preliminary surveys. CIBC unpublished report, 12pp.
- Bennett, F.D. and Cruttwell, R.E. 1973. Insects attacking *Eupatorium odoratum* in the Neotropics 1. *Ammalo insulata* (Walk.) (Lep.: Arctiidae), a potential biotic agent for the control of *Eupatorium odoratum* L. (Compositae). Commonwealth Institute of Biological Control. Technical Bulletin 16: 105–115.
- Bennett, F.D. and Rao, V.P. 1968. Distribution of an introduced weed *Eupatorium odoratum* Linn. (Compositae) in Asia and Africa and possibilities of its biological control. Pesticides Abstracts and News Summary, C, 14: 277–281.
- Bennett, F.D. and Yaseen, M. 1975. Control of Siam weed, *Eupatorium odoratum*. Commonwealth Institute of Biological Control. Report of work carried out during 1974, pp. 79–80.
- Bennett, F.D., Yaseen, M. and Beg, M.N. 1975. Report of work carried out during 1974. Aquatic Weeds. Commonwealth Institute of Biological Control, pp. 78–79.
- Bennett, F.D. and Zwolfer, H. 1968. Exploration for natural enemies of the water hyacinth in northern South America and Trinidad. Hyacinth Control Journal 7: 44–52.
- Bennett, F.D. and Zwolfer, H. 1969. Commonwealth Institute of Biological Control. Work carried out during 1968. Investigations on the natural enemies of *Eichhornia crassipes*. p 80.
- Benson, R.B. 1962. The affinities of the Australian Argidae (Hymenoptera). Annals and Magazine of Natural History, Series 13 (5): 631–635.
- Benson, E.W., Brown, K.S. and Gilbert, L.E. 1976. Coevolution of plants and herbivores: passion flower butterflies. Evolution 29: 659–680.
- Beshir, M.O. 1983. Water hyacinth in Sudan—early results. Biocontrol News and Information 4: 1.
- Beshir, M.O. 1984. The establishment and distribution of natural enemies of water hyacinth released in Sudan. Tropical Pest Management 30: 320–323.
- Beshir, M.O. and Bennett, F.D. 1985. Biological control of water hyacinth on the White Nile, Sudan. Proceedings of the 6th International Symposium on Biological Control of Weeds, pp. 491–496.
- Best, K.F., Bowes, G.G., Thomas, A.G. and Maw, M.G. 1980. The biology of Canadian weeds. 39. *Euphorbia esula* L. Canadian Journal of Plant Science 60: 651–663.
- Bianchi, F.A. 1955. *Ceutorhynchus* sp. Proceedings of the Hawaiian Entomological Society 15: 379–380.
- Bianchi, F. 1982. Notes and exhibitions. *Agraulis vanillae* (L.). Proceedings of the Hawaiian Entomological Society 24: 15–16.

- Bianchi, F. 1983. Notes and exhibitions. *Meteorus laphygmae* Viereck. Proceedings of the Hawaiian Entomological Society 24: 169.
- Bigot, L. and Vuattoux, R. 1979. Quelques données biologiques et écologiques sur les lepidoptères Pterophoridae de la région de Lamto (Côte d'Ivoire). Bulletin de l'Institut Fondamental d'Afrique Noire 41: 837-843. (Review of Applied Entomology, Series A, 69: 4303, 1981).
- Bill, S.M. 1969. The water weed problems in Australia. Hyacinth Control Journal 8: 1-6.
- Booker, R.A. 1964. The effect of sowing date and spacing on rosette disease of groundnut in northern Nigeria, with observations on the vector, *Aphis craccivora*. Samaru Research Bulletin 1964 (30) 7pp. (Agricola).
- Boppré, M. 1991. A non-nutritional relationship of *Zonocerus* (Orthoptera) to *Chromolaena* (Asteraceae) and general implications for weed management. Ecology and Management of *Chromolaena odorata*. Biotrop Special Publication 44: 153-161.
- Borror, D.J., DeLong, D.M. and Triplehorn, C.A. 1981. An Introduction to the Study of Insects. Saunders College Publishers, Toronto, Ontario. (Maun and Barrett 1986).
- Bradfute, O.E. and Tsai, J.H. 1990. Rapid identification of maize stripe virus. Phytopathology 80: 715-719.
- Brenan, J.P.M. 1959. *Mimosa*. Flora of Tropical East Africa. Leguminosae, Subfamily. Mimosoideae pp. 42-47.
- Brues, C.T. 1946. Insect Dietary. Harvard University Press, Cambridge, USA, 466pp.
- Brunken, J.N. 1979. Cytotaxonomy and evaluation in *Pennisetum* section Brevivalvula (Gramineae) in tropical Africa. Botanical Journal of the Linnean Society 79: 37-49.
- Brunt, A., Crabtree, K. and Gibbs, A. 1990. Viruses of Tropical Plants. CAB International and ACIAR. 707pp.
- Burikam, I. and Napompeth, B. 1980. *Gesonula punctifrons* (Stål) (Orthoptera: Acrididae) as a natural enemy of water hyacinth (*Eichhornia crassipes*). National Biological Control Research Center, Kasetsart University. Bangkok, Thailand. Technical Bulletin 8: 1-12.
- Burkill, I.H. 1935. A Dictionary of the Economic Products of the Malay Peninsula, London. Two volumes.
- Carroll, C.R. and Risch, S.J. 1984. The dynamics of seed harvesting in early successional communities by a tropical ant *Solenopsis geminata*. Oecologia 61: 388-392.
- Casañas-Arango, A., Trujillo, E.E., de Hernandez A.M. and Taniguchi, G. 1990. Field biology of *Cyanotricha necyria* Felder (Lep., Diopsideae) a pest of *Passiflora* spp. in southern Columbia's and Ecuador's Andean region. Journal of Applied Entomology 109: 93-97.
- Catindig, J.L.A., Barrion, A.T. and Litsinger, J.A. 1993. Developmental biology and host plant range of rice-feeding tiger moth *Cretonotus gangis* (L.). International Rice Research Notes 18(3): 34-35.
- Center, T.D. and Balciunas, J.K. 1982. The biological control of water hyacinth in the United States. Workshop on Biological Control of Water Hyacinth. Commonwealth Science Council, London. 3-5 May 1982. Bangalore, India, pp. 57-62.
- Center, T.D., Balciunas, J.K. and Habeck, D.H. 1982. Descriptions of *Sameodes albiguttalis* (Lepidoptera: Pyralidae) life stages with key to Lepidoptera larvae on water hyacinths. Annals of the Entomological Society of America 75: 471-479.

- Center, T.D., Cofrancesco, A.F. and Balciunas, J.K. 1989. Biological control of wetland and aquatic weeds in the south-eastern United States. Proceedings 7th International Symposium on Biological Control of Weeds 6–11 March 1988, Rome, Italy, pp. 239–262.
- Center, T.D. and Dray, F.A. 1992. Associations between water hyacinth weevils (*Neochetina eichhorniae* and *N. bruchi*) and phenological stages of *Eichhornia crassipes* in southern Florida. Florida Entomologist 75: 196–211.
- Center, T.D. and Durden, W.C. 1981. Release and establishment of *Sameodes albiguttalis* for the biological control of water hyacinth. Environmental Entomology 10: 75–80.
- Center, T.D. and Durden, W.C. 1986. Variation in water hyacinth/weevil interactions resulting from temporal differences in weed control efforts. Journal of Aquatic Plant Management 24: 28–38.
- Center, T.D., Cofrancesco, A.F. and Balciunas, J.K. 1989. Biological control of wetland and aquatic weeds in the south-eastern United States. Proceedings 7th International Symposium on Biological Control of Weeds, pp. 239–262.
- Chacko, M.J. 1988. Prospects for the biological control of *Chromolaena odorata* (L.) R.M. King and H. Robinson. Proceedings of the First International Workshop on Biological Control of *Chromolaena odorata*. Agricultural Experiment Station, Mangilao, Guam, pp. 25–33.
- Chacko, M.J. and Narasimham, A.U. 1988. Biocontrol attempts against *Chromolaena odorata* in India—a review. Proceedings of the First International Workshop on Biological Control of *Chromolaena odorata*. Agricultural Experiment Station, Mangilao, Guam, pp. 65–79.
- Chadwick, M.J. and Obeid, M. 1966. A comparative study of the growth of *Eichhornia crassipes* and *Pistia stratiotes* in water culture. Journal of Ecology 54: 563–575.
- Chandler, L.D. and Chandler, J.M. 1988. Comparative host suitability of bell pepper and selected weed species for *Liriomyza trifolii* (Burgess). Southwest Entomologist 13(2): 137–146 (Agricola).
- Chandra, R., Mital, V.P. and Goel, S.C. 1983. Consumption and utilization of different food plants by *Chrotogonus trachypterus* Blanch. (Orthoptera: Acrididae). Insect Ecology and Resource Management. ed. S.C. Goel. Sanatan Dharm College. Muzaffarnagar, India. pp. 226–231. (Review of Applied Entomology, Series A, 72: 5169–1984).
- Chandrasrikul, A. 1962. A preliminary host list of plant diseases in Thailand. Technical Bulletin 6, 23pp. Thailand Department of Agriculture, Bangkok (Holm et al. 1977).
- Chapola, G.M. 1980. Investigations into alternate hosts of tobacco bushy-top virus in Malawi. Journal of Science and Technology 1(2): 11–16.
- Charudattan, R., Freeman, T.E., Conway, K.E. and Zettler, F.W. 1974. Studies on the use of plant pathogens in biological control of aquatic weeds in Florida. Proceedings of the Fourth International Symposium on Aquatic Weeds. 17–20 September 1974. Vienna, Austria, pp. 144–149.
- Chaudhuri, H. and Janaki Ram, K. 1975. Control of aquatic weed by moth larvae. Nature 253: 40–41.
- Chaudhury, J.P. and Kapil, R.P. 1977. Record of a new host plant of *Hymenia recurvalis* (F.) and its parasites. Indian Journal of Entomology 37: 314.
- Chauhan, L.S. and Verma, S.C. 1981. Two new host records for India. Indian Journal of Mycology and Plant Pathology 11: 246–247.
- Chen, C.C., Chen, M.J., Chiu, R.J. and Hsu, H.T. 1989a. Morphological comparisons of *Echinochloa* ragged stunt and rice ragged stunt viruses by electron microscopy. Phytopathology 79: 235–241.

- Chen, C.T., Deng, T.C. and Chang, C.A. 1989b. Sugarcane mosaic in Taiwan. Serological relationships and coat protein of SCMV strains. *Taiwan Sugar* 36: 10–13 (Review *Plant Pathology* 70: 960, 1991).
- Cherian, M.C. and Kylasam, M.S. 1937. Preliminary studies on the 'freckled yellow' and 'stripe' diseases of cholam. Proceedings of the Association of Economic Biologists, Coimbatore, India 1936. (Rachie and Peters 1977).
- Chikwenhere, G.P. and Forno, I.W. 1991. Introduction of *Neohydronomus affinis* for biological control of *Pistia stratiotes* in Zimbabwe. *Journal of Aquatic Plant Management* 29: 53–55.
- Chona, B. and Rafay, S. 1950. Studies on the sugar-cane diseases in India. 1. Sugar-cane mosaic virus. 2. The phenomenon of natural transmission and recovery from mosaic of sugar-cane. *Indian Journal of Agricultural Science* 20: 39–78. (Holm et al. 1977).
- Christie, S.R., Christie, R.G. and Edwardson, J.R. 1974. Transmission of a bacilliform virus of sowthistle (*Sonchus*) and *Bidens pilosa*. *Phytopathology* 64: 840–845.
- CIBC 1972. Commonwealth Institute of Biological Control. Annual Report for 1971.
- Cilliers, C.J. 1987. First attempt at and early results on the biological control of *Pistia stratiotes* L. in South Africa. *Koedoe* 30: 35–40.
- Cilliers, C.J. 1989a. Biological control of aquatic weeds in South Africa—an interim report. Proceedings 7th International Symposium on Biological Control of Weeds. 6–11 March 1988, Rome, Italy, pp. 263–267.
- Cilliers, C.J. 1989b. Confirmation of host specificity of *Neohydronomus pulchellus* under simulated natural conditions. *Journal of the Entomological Society of Southern Africa* 52: 180.
- Cilliers, C.J. 1991a. Biological control of water hyacinth, *Eichhornia crassipes* (Pontederiaceae), in South Africa. *Agriculture, Ecosystems and Environment* 37: 207–217.
- Cilliers, C.J. 1991b. Biological control of water lettuce, *Pistia stratiotes* in South Africa. In (ed.) J.R. Hoffmann, *Biological Control of Weeds in South Africa. Agricultural Ecosystems and the Environment* 37: 225–229.
- Clark, W.E. 1984. Species of *Sibinia* Germar (Coleoptera: Curculionidae) associated with *Mimosa pigra* L. Proceedings of the Entomological Society of Washington 86: 358–367.
- Clement, S.L. and Norris, R.F. 1982. Two insects offer potential biological control of common purslane. *California Agriculture* 36(f): 16–18.
- Cock, M.J.W. 1980. Biological control of *Mikania micrantha*. Commonwealth Institute of Biological Control. Report of work carried out April 1979–March 1980, pp 53–54.
- Cock, M.J.W. 1981. An assessment of the occurrence and potential of natural enemies of *Mikania* spp. in the Neotropics. 64 pp. Final report (May 1979–March 1981). Commonwealth Institute of Biological Control, Commonwealth Agricultural Bureaux.
- Cock, M.J.W. 1982a. Potential biological control agents for *Mikania micrantha* HBK from the Neotropical region. *Tropical Pest Management* 28: 242–254.
- Cock, M.J.W. 1982b. The biology and host specificity of *Liothrips mikaniae* (Priesner) (Thysanoptera, Phlaeothripidae), a potential biological control agent of *Mikania micrantha* (Compositae). *Bulletin of Entomological Research* 72: 523–533.
- Cock, M.J.W. 1984a. Possibilities for biological control of *Chromolaena odorata*. *Tropical Pest Management* 30: 7–13.

- Cock, M.J.W. 1984b. Report on a consultancy to the Republic of Vanuatu to advise on biological control of weeds and pests, 20 November–4 December 1983. Unpublished report. 33pp. Commonwealth Institute of Biological Control, Commonwealth Agricultural Bureaux.
- Cock, M.J.W. 1985. A Review of Biological Control of Pests in the Commonwealth Caribbean and Bermuda up to 1982. Commonwealth Institute of Biological Control. Technical Communication 9, 218pp.
- Cock, M.J.W. and Holloway, J.D. 1982. The history of, and prospects for, the biological control of *Chromolaena odorata* (Compositae) by *Pareuchaetes pseudoinsulata* Rego Barros and allies (Lepidoptera: Arctiidae). Bulletin of Entomological Research 72: 193–205.
- Cofrancesco, A.F. 1984. Biological control activities in Texas and California. Proceedings 18 Annual Meeting Aquatic Plant Control Research Program, U.S. Army Corps of Engineers. Miscellaneous Paper A-84-4, pp. 57–61.
- Cofrancesco, A.F., Stewart, R.M. and Sanders, D.R. 1985. The impact of *Neochetina eichhorniae* (Coleoptera: Curculionidae) on water hyacinth in Louisiana. Proceedings of the 6th International Symposium on Biological Control of Weeds, pp. 525–535.
- Common, I.F.B. and Waterhouse, D.F. 1981. Butterflies of Australia. Angus and Robertson Sydney, 682 pp.
- Conners, I.L. 1967. An annotated index of plant diseases in Canada and fungi recorded on plants in Alaska, Canada and Greenland. Canada Department of Agriculture, Ottawa, Ontario. Publication 1251, 381pp.
- Conti, M. 1981. Wild plants in the ecology of planthopper-borne viruses of grasses and cereals. pp. 109–119 in (ed). J.M. Thresh, Pests, Pathogens and Vegetation. Pitman Publishing. Inc., Boston, Massachusetts. (Maun and Barrett 1986).
- Conway, K.E. 1976. Evaluation of *Cercospora rodmanii* as a biological control of water hyacinths. Phytopathology 66: 914–917.
- Conway, K.E. and Freeman, T.E. 1977. Host specificity of *Cercospora rodmanii*, a potential biological control of water hyacinth. Plant Disease Reporter 61: 262–266.
- Conway, K.E., Freeman, T.E. and Charudattan, R. 1974. The fungal flora of water hyacinth in Florida, Part 1. Water Resources Research Center, University of Florida, Gainesville, Florida, USA. Publication 30, 11pp.
- Conway, K.E., Freeman, T.E. and Charudattan, R. 1978. Development of *Cercospora rodmanii* as a biological control for *Eichhornia crassipes*. Proceedings of the Fifth International Symposium on Aquatic Weeds, 1978. Amsterdam, Netherlands, pp. 225–230.
- Cordo, H.A. and DeLoach, C.J. 1975. Ovipositional specificity and feeding habits of the water hyacinth mite, *Orthogalumna terebrantis*, in Argentina. Environmental Entomology 4: 561–565.
- Cordo, H.A. and DeLoach, C.J. 1976. Biology of the water hyacinth mite in Argentina. Weed Science 24: 245–249.
- Cordo, H.A. and DeLoach, C.J. 1978. Host specificity of *Sameodes albiguttalis* in Argentina, a biological control agent for water hyacinth. Environmental Entomology 7: 322–328.
- Cordo, H.A., DeLoach, C.J. and Ferrer, R. 1981. Biological studies on two weevils, *Ochetina bruchi* and *Onychylis crenatus* collected from *Pistia* and other aquatic plants in Argentina. Annals of the Entomological Society of America 74: 363–368.
- Cordo, H.A., DeLoach, C.J., Runnacles, J. and Ferrer, R. 1978. *Argentinorhynchus bruchi*, a weevil from *Pistia stratiotes* in Argentina: biological studies. Environmental Entomology 7: 329–333.

- Cruttwell, R.E. 1971a. Commonwealth Institute of Biological Control. Report of work carried out during 1970. Biological control of weeds. pp. 92–93.
- Cruttwell, R.E. 1971b. Commonwealth Institute of Biological Control. West Indian Station. Quarterly report for April–June 1971. 8pp.
- Cruttwell, R.E. 1972a. Commonwealth Institute of Biological Control. Report of work carried out during 1971. Biological control of weeds. pp. 106–107.
- Cruttwell, R.E. 1972b. *Bidens pilosa*. Commonwealth Institute of Biological Control. West Indian Station. Quarterly report for October–December 1971. 6pp.
- Cruttwell, R.E. 1973a. Insects attacking *Eupatorium odoratum* in the Neotropics. 2. Studies of the seed weevil *Apion brunneonigrum* BB and its potential use to control *E. odoratum* L. Commonwealth Institute of Biological Control. Technical Bulletin 16: 117–124.
- Cruttwell, R.E. 1973b. Insects attacking *Eupatorium odoratum* in the Neotropics 3. *Dichomeris* sp. nov. (= *Trichotaphe* sp. nr *eupatoriella*) (Lep.: Gelechiidae) a leaf-roller on *Eupatorium odoratum* L. (Compositae). Commonwealth Institute of Biological Control. Technical Bulletin 16: 125–134.
- Cruttwell, R.E. 1974. Insects and mites attacking *Eupatorium odoratum* in the Neotropics 4. An annotated list of insects and mites recorded from *Eupatorium odoratum* L., with a key to the types of damage found in Trinidad. Commonwealth Institute of Biological Control. Technical Bulletin 17: 87–125.
- Cruttwell, R.E. 1977a. Insects and mites attacking *Eupatorium odoratum* L. in the Neotropics 5. *Mescinia* sp. nr *parvula* (Zeller). Commonwealth Institute of Biological Control. Technical Bulletin 18: 49–58.
- Cruttwell, R.E. 1977b. Insects attacking *Eupatorium odoratum* in the Neotropics. 6. Two eriophyid mites, *Acalitus adoratus* Keifer and *Phyllocoptes cruttwellae* Keifer. Commonwealth Institute of Biological Control. Technical Bulletin 18: 59–63.
- Cruttwell, R.E. and Bennett, F.D. 1969. Commonwealth Institute of Biological Control. Report of work for 1968. Control of Siam weed. pp. 78–79.
- Cruttwell, R.E. and Bennett, F.D. 1972a. Investigations on the insects attacking *Portulaca oleracea* in the Neotropics. 2. Investigations on the biology and host-specificity of the leaf miner *Pegomya* sp. (Dipt., Anthomyiidae). CIBC unpublished report, 6pp.
- Cruttwell, R.E. and Bennett, F.D. 1972b. Investigations on the insects attacking *Portulaca oleracea* in the Neotropics. 3. Investigations on the biology and host-specificity of the leaf miner *Heliodine quinqueguttata* Wals. (Lep., Heliodinidae) in Trinidad. CIBC unpublished report, 6pp.
- d'Araujo e Silva, A.G., Gonçalves, C.R., Galvão, D.M., Gonçalves, A.J.L., Gomes, J., Silva, M.N. and Simoni, L. 1968a. Quarto catálogo dos insetos que vivem nas plantas do Brasil, seus parasitos e predadores. Part II. Tomo 1. Insetos hospedeiros e inimigos naturais. Ministeria da Agricultura. Departamento de Def. e Inspeção Agropecuária, Rio de Janeiro. 622pp. (Bennett and Cruttwell 1972).
- d'Araujo e Silva, A.G., Gonçalves, C.R., Galvão, D.M., Gonçalves, A.J.L., Gomes, J., Silva, M.N. and Simoni, L. 1968b. Quarto catálogo dos insetos que vivem nas plantas do Brasil, seus parasitos e predadores. Part II. Tomo 2. Indice de insetos e indice de plantas. Ministeria da Agricultura. Departamento de Def. e Inspeção Agropecuária, Rio de Janeiro. 267pp.

- Dabaj, K.H. and Jenser, G. 1990. Some weed host-plants of the northern root-knot nematode *Meloidogyne hapla* in Hungary. *Nematologia Mediterranea* 18: 139–140. (Weed Abstracts 40: 2868, 1991).
- Dahiya, R.S., Mangat, B.P.S. and Bhatti, D.S. 1988. Some new host records of *Meloidogyne javanica*. *International Nematology Network Newsletter* 5(3): 32–34.
- Das, B.B. and Ram, G. 1988. Incidence, damage and carry-over of cutworm (*Agrotis ypsilon*) attacking potato (*Solanum tuberosum*) crop in Bihar. *Indian Journal of Agricultural Sciences* 8: 650–651.
- Davies, J.C. 1972. Studies on the ecology of *Aphis craccivora* Koch (Aphididae) the vector of rosette disease of groundnuts in Uganda. *Bulletin of Entomological Research* 62: 169–181.
- Davis, C.J. 1955. *Hypurus bertrandi* Perris. *Proceedings of the Hawaiian Entomological Society* 16: 3.
- Davis, C.J. 1960. Recent introductions for biological control in Hawaii, V. *Proceedings of the Hawaiian Entomological Society* 17: 244–248.
- Davis, C.J. 1970. Recent introductions for biological control in Hawaii, XV. *Proceedings of the Hawaiian Entomological Society* 20: 521–525.
- Davis, C.J. and Chong, M. 1968. Recent introductions for biological control in Hawaii, XIII. *Proceedings of the Hawaiian Entomological Society* 20: 25–28.
- Davis, C.J. and Chong, M. 1969. Recent introductions for biological control in Hawaii, XIV. *Proceedings of the Hawaiian Entomological Society* 20: 317–322.
- Davis, C.J. and Krauss, N.L.H. 1962. Recent developments in the biological control of weed pests in Hawaii. *Proceedings of the Hawaiian Entomological Society* 18: 65–67.
- Davis, C.J. and Krauss, N.L.H. 1966. Recent introductions for biological control in Hawaii, XI. *Proceedings of the Hawaiian Entomological Society* 19: 201–207.
- Davis, C.J. and Krauss, N.L.H. 1967. Recent introductions for biological control in Hawaii, XII. *Proceedings of the Hawaiian Entomological Society* 19: 375–380.
- Davis, D.R. 1990. First record of a bagworm moth from Hawaii (USA): description and introduction of *Brachycyttarus griseus* De Joannis (Lepidoptera: Psychidae). *Proceedings of the Entomological Society of Washington* 92: 259–270.
- Davis, D.R., Kassulke, R.C., Harley, K.L.S. and Gillett, J.D. 1991. Systematics, morphology, biology and host specificity of *Neurostrota gunniella* (Busck) (Lepidoptera: Gracillariidae), an agent for the biological control of *Mimosa pigra* L. *Proceedings of the Entomological Society of Washington* 93: 16–44.
- Debrot, E. and Centeno, F. 1985. Occurrence of *Euphorbia* mosaic virus infecting *Euphorbia heterophylla* in Venezuela (Spanish). *Agronomia Tropical* 35(4–6): 5–12. (Review of Applied Entomology, Series A, 77: 3821, 1989).
- Delfosse, E.S. 1978a. Interaction between the mottled water hyacinth weevil, *Neochetina eichhorniae* Warner, and the water hyacinth mite, *Orthogalumna terebrantis* Wallwork. *Proceedings of the Fourth International Symposium on the Biological Control of Weeds*. 30 August–2 September 1976. Gainesville, Florida, USA, pp. 93–97.
- Delfosse, E.S. 1978b. Effect on water hyacinth of *Neochetina eichhorniae* Col.: Curculionidae, combined with *Orthogalumna terebrantis*. *Entomophaga* 23: 379–387.
- Delfosse, E.S. and Perkins, B.D. 1977. Discovery and bioassay of a kairomone from water hyacinth, *Eichhornia crassipes*. *The Florida Entomologist* 60: 217–222.

- Delfosse, E.S., Sutton, D.L. and Perkins, B.D. 1976. Combination of the mottled water hyacinth weevil and the white amur for biological control of water hyacinth. *Journal of Aquatic Plant Management* 14: 64–67.
- DeLoach, C.J. 1975. Evaluation of candidate arthropods for biological control of water hyacinth: studies in Argentina. *Proceedings of the Symposium on Water Quality Management through Biological Control*. 23–30 January 1975. Gainesville, Florida, USA, pp. 44–50.
- DeLoach, C.J. 1976. *Neochetina bruchi*, a biological control agent of water hyacinth: host specificity in Argentina. *Annals of the Entomological Society of America* 69: 635–642.
- DeLoach, C.J. 1977. Identification and biological notes on the species of *Neochetina* that attack Pontederiaceae in Argentina (Coleoptera: Curculionidae: Bagoiini). *Coleopterists' Bulletin* 29: 257–263.
- DeLoach, C.J. and Cordo, H.A. 1976a. Ecological studies of *Neochetina bruchi* and *N. eichhorniae* on water hyacinth in Argentina. *Journal of Aquatic Plant Management* 14: 53–59.
- DeLoach, C.J. and Cordo, H.A. 1976b. Life cycle and biology of *Neochetina bruchi*, a weevil attacking water hyacinth in Argentina, with notes on *N. eichhorniae*. *Annals of the Entomological Society of America* 69: 643–652.
- DeLoach, C.J. and Cordo, H.A. 1978. Life history and ecology of the moth *Sameodes albiguttalis*, a candidate for biological control of water hyacinth. *Environmental Entomology* 7: 309–321.
- DeLoach, C.J., Cordo, H.A., Ferrer, R., Runnacles, J. and DeSantis, L. 1980. *Acigona infusella*, a potential biological control agent for water hyacinth: observations in Argentina (with descriptions of two new species of *Apanteles* by L. DeSantis). *Annals of the Entomological Society of America* 73: 138–146.
- DeLoach, C.J., DeLoach, A.D. and Cordo, H.A. 1976. *Neohydronomus pulchellus*, a weevil attacking *Pistia stratiotes* in South America: biology and host specificity. *Annals of the Entomological Society of America* 69: 830–834.
- DeLoach, C.J., DeLoach, D.J. and Cordo, H.A. 1979. Observations on the biology of the moth, *Samea multiplicalis* on water lettuce in Argentina. *Journal of Aquatic Plant Management* 17: 42–44.
- Den Doop, J.E.A. 1918. De Verspreiding van *Trichogramma*, den Eiparasiet van *Heliothis obsoleta* F., ter Oostkust van Sumatra. *Meded. del Proelstation, Medan* 10(9): 213–220. (Pemberton 1983).
- Desai, S.A., Siddaramaiah, A.L. and Hegde, R.K. 1980. Three additional hosts to *Sclerotium rolfsii*. *Current Research* 9(9): 151–152.
- Dethier, V.G. 1940. Life histories of Cuban Lepidoptera. *Psyche* 47: 14–26.
- De Waele, D., Jordaen, E.M. and Basson, S. 1990. Host status of seven weed species and their effects on *Ditylenchus destructor* infestation of peanut. *Journal of Nematology* 22: 292–296.
- De Wijs, J.J. 1974. A virus causing ringspot of *Passiflora edulis* in the Ivory Coast. *Annals of Applied Biology* 77: 33–40.
- Dhaliwal, G.S. 1979. Some new weed hosts of the rice hispa recorded in India. *International Rice Research Newsletter* 4: 19.
- Dharmadhikari, P.R., Perera, P.A.C.R. and Hassen, T.M.F. 1977. The introduction of *Ammalo insulata* for the control of *Eupatorium odoratum* in Sri Lanka. *Commonwealth Institute of Biological Control. Technical Bulletin* 18: 129–135.
- Dhiman, S.C. 1986. New host plants of *Haplothrips longisetosus* Ananthkrishnan. *Entomon* 11: 262.

- Dias, M.M. 1979. Morphology and biology of *Eryphanis polyxena polyxena* (Meerburgh 1775), Lepidoptera, Satyridae, Brassolinae. (Portuguese). *Revista Brasileira de Entomologia* 23: 267–274.
- Dikova, D. 1989. Wild-growing hosts of the cucumber mosaic virus. (Bulgarian). *Rasteniev dni Nauki* 26(7): 57–64 (Weed Abstracts 39: 842, 1990).
- Divakar, B.J. and Manoharan, V. 1978. A review on water hyacinth, *Eichhornia crassipes* (Mart.) Solms. and its control by natural enemies. *Plant Protection Gleanings* 9: 23pp.
- Dodds, J.A. and Taylor, G.S. (1980). Cucumber mosaic virus infection of tobacco transplants and purslane (*Portulaca oleracea*). *Plant Disease* 64: 294–296.
- Dong, H.F., Guo, Y.J. and Niu, L.P. 1986. Biological control of the two spotted spider mite with *Phytoseiulus persimilis* on four ornamental plants in greenhouses (Chinese). *Chinese Journal of Biological Control* 2: 59–62.
- Drake, C.J. and Poor, M.E. 1938. Los Tingitidae (Hemiptera) de la coleccion Carlos Berg. Instituto del Museo de la Universidad Nacional de la Plata. *Notas del Museo la Plata* 2: 103–109.
- Drake, C.J. and Ruhoff, F.A. 1965. Lacebugs of the world. A catalog (Hemiptera: Tingidae). United States National Museum Bulletin 243. 634pp.
- Dray, F.A. and Center, T.D. 1992. Biological control of *Pistia stratiotes* L. (waterlettuce) using *Neohydronomus affinis* Hustache (Coleoptera: Curculionidae). U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. Technical Report A-92-1, 27 pp.
- Dray, F.A., Center, T.D. and Habeck, D.H. 1989. Immature stage of the aquatic moth *Petrophila drumalis* (Lepidoptera: Pyralidae: Nymphulinae) from *Pistia stratiotes* (water lettuce). *Florida Entomologist* 72: 711–714.
- Dray, F.A., Center, T.D., Habeck, D.H., Thompson, C.R., Cofrancesco, A.F. and Balciunas, J.K. 1990. Release and establishment in the southeastern United States of *Neohydronomus affinis* (Coleoptera: Curculionidae), an herbivore of water lettuce. *Environmental Entomology* 19: 799–802.
- Dray, F.A., Thompson, C.R., Habeck, D.H., Balciunas, J.K. and Center, T.D. 1988. A survey of the fauna associated with *Pistia stratiotes* (water lettuce) in Florida. U.S. Army Engineers, Waterways Experiment Station, Technical Report A-86-6, 32pp.
- Duatin, C.J.Y. and Pedro, L.B.de 1986. Biology and host range of the taro planthopper, *Tarophagus proserpina* Kirk. *Annals of Tropical Research* 8: 72–80.
- Duatin, C.J.Y., Pedro, L.B.de and De Pedro, L.B. 1986. Biology and host range of the taro planthopper, *Tarophagus proserpina* Kirk. *Annals of Tropical Research* 8: 72–80. (Review of Applied Entomology, Series A, 75: 794, 1987).
- Ekukole, G., Ansa, O.A., Ajaye, O. and Sundaram, N.V. 1989. Some grasses showing streak virus symptoms in Zaria, Nigeria. *Samaru Journal of Agricultural Research* 6(6): 29–33 (Review of Plant Pathology 69: 8439, 1990).
- El-Banhawy, E.M. 1979. Description of some unknown phytoseiid mites from Brazil (Mesostigmata: Phytoseiidae). *Acarologia* 20: 477–484.
- Ellison, C.A. 1992. Mycoherbicidal control of *Rottboellia cochinchinensis*: a viable alternative? *Plant Protection Quarterly* 7: 163–165.
- Ellison, C.A. and Evans, H.C. 1990. Preliminary assessment of fungal pathogens as biological control agents for *Rottboellia cochinchinensis* (Gramineae). *Proceedings of the VII International Symposium on Biological Control of Weeds*. 6–11 March 1988, Rome, Italy, pp. 477–482.

- Ellison, C.A. and Evans, H.C. 1993. Present status of the biological control programme for the graminaceous weed *Rottboellia cochinchinensis*. Proceedings of the VIII International Symposium on Biological Control of Weeds, 2–7 February 1992, Lincoln University, Canterbury, New Zealand.
- Elshafie, M. 1976. *Nysius vinitor* Berg. (Hemiptera: Lygaeidae) infesting pigweed, *Portulaca oleracea* L. Journal of the Entomological Society of Australia 9: 54.
- Esguerra, N.M., William, W.S. and Smith, J.R. 1991. Status of biological control of the Siam weed *Chromolaena odorata* (L.) R.M. King and H. Robinson on Pohnpei, Federated States of Micronesia. Ecology and Management of *Chromolaena odorata*. Biotrop Special Publication 44: 99–104.
- Esguerra, N.M., William, W.S. and Smith, J.R. 1994. Establishment of *Pareuchaetes pseudoinsulata* Rego Barros introduced to control the Siam weed, *Chromolaena odorata* (L.) R.M. King and H. Robinson in the Eastern Caroline Islands. Proceedings 3rd International Workshop on Biological Control of *Chromolaena odorata*. Ivory Coast, November 1993. Preprint 4pp.
- Espósito, M.C., Medeiros, L., Righetti, S.M. and Garcia, M.A. 1985. Efeito de insetos fitófagos em populações de *Bidens pilosa*. Resumos, XII Congresso Brasileiro de Zoologia 27 de Janeiro a 1 de Fevereiro, Universidade Estadual de Campinas, p. 114.
- Eugenio, C. and del Rosario, M. 1962. Host range of tobacco mosaic virus in the Philippines. Philippine Agriculturist 46: 175–197. (Holm et al. 1977).
- Evans, H.C. 1987. Fungal pathogens of some subtropical and tropical weeds and possibilities for biological control. Biocontrol News and Information 8: 7–30.
- Evans, H.C. 1988. Preliminary survey of fungal pathogens of *Mimosa pigra* in Mexico, 21 February–2 March 1988. Project PIG 760. 4pp. CIBC, Silwood Park. UK.
- Evans, H.C. 1990. The potential of fungal pathogens as biological control agents of *Mimosa pigra*: a preliminary assessment. Unpublished report, 19pp. CAB International Institute of Biological Control.
- Evans, H.C. 1991. Biological control of tropical grassy weeds. pp. 52–72 in Tropical Grassy Weeds, (eds) F.W.G. Baker and P.J. Terry.
- Evans, H.C., Carrion, G. and Guzman, G. 1993. A new species of *Sphaerulina* and its *Phloeospora* anamorph, with potential for biological control of *Mimosa pigra*. Mycological Research 97: 59–67.
- Evans, H.C. and Seier, M.K. 1991. Project PIG 760 Progress Report, October 1990–September 1991. CAB International Institute of Biological Control, Silwood Park, UK.
- Everist, S.L. 1974. Poisonous Plants of Australia. Angus and Robertson, Sydney. 684pp.
- Felt, E.P. 1911. Hosts and galls of American gall midges. Journal of Economic Entomology 4: 451–475.
- Felt, E.P. 1916. New western gall midges. Journal of the New York Entomological Society 24: 175–196.
- Felt, E.P. 1918. Key to American insect galls. Bulletin of the New York State Museum 200: 5–310.
- Felt, E.P. 1920. New Indian gall midges (Diptera). Memoirs of the Department of Agriculture in India, Entomology 7(1–2): 1–11.
- Felt, E.P. 1921. New Indian gall midges (Itonididae). Memoirs of the Department of Agriculture in India, Entomology 7(4): 23–28.

- Fernandez, M. and Ortega, J. 1982. Plantas indeseables como hospedantes de nematodos parasitos del arroz (Spanish). *Ciencias de la Agricultura* 12: 114–116. (Helminthological Abstracts, Series B, 53: 955, 1984).
- Ferreira, D.I.C., Garrido, M.J. and Trujillo, G.E. 1989. Maize hoja blanca virus infecting sorghum (*Sorghum bicolor* (L.) Moench) in Maracay, Aragua (Spanish). *Fitopatologia Venezolana* 2: 23 (Review of Agricultural Entomology 79: 4587, 1991).
- Ferronato, E.M.O. 1986. Preliminary observations on the host plants of the immature stages of the principal chrysomelids (Coleoptera: Chrysomelidae) occurring in cacao plantations. *Revista Theobroma* 16: 107–110. (Portuguese). (Review of Applied Entomology, Series A, 76: 3499, 1988).
- Field, S.P. 1991. *Chromolaena odorata*: friend or foe for resource poor farmers. *Chromolaena odorata* Newsletter 4: 4–7.
- Figliola, S.S., Camper, N.D. and Ridings, W.H. 1988. Potential biological control agents for goosegrass (*Eleusine indica*). *Weed Science* 36: 830–835.
- Fischer, G.W. 1953. Manual of North American smut fungi. Ronald Press, New York. (Maun and Barrett 1986).
- Fisher, H.H., Menendez, R.A., Daley, L.S., Robb-Spencer, D. and Crabtree, G.D. 1987. Biochemical characterization of itch grass (*Rottboellia exaltata*) biotypes. *Weed Science* 35: 333–338.
- Flanagan, G.J., Wilson, C.G. and Gillett, J.D. 1990. The abundance of native insects on the introduced weed *Mimosa pigra* in Northern Australia. *Journal of Tropical Ecology* 6: 219–230.
- Fontes, E.G., Teixeira, C.A.D., Pires, C.S.S. and Sujii, E.R. 1992. Current status of the biological control of weeds in Brazil. Abstracts, VIII International Symposium on Biological Control of Weeds, Lincoln University, Canterbury, New Zealand, 2–7 February 1992, p. 84.
- Force, D.C. 1965. The purslane sawfly in central California. California Department of Agriculture, Bulletin 54: 157–160.
- Forno, I.W. 1981. Effects of *Neochetina eichhorniae* on the growth of water hyacinth. *Journal of Aquatic Plant Management* 19: 27–31.
- Forno, I.W. 1983. Life history and biology of a water hyacinth moth, *Argyrectis subornata* (Lepidoptera: Pyralidae, Nymphulinae). *Annals of the Entomological Society of America* 76: 624–627.
- Forno, I.W. 1987. Biological control of the floating fern *Salvinia molesta* in north-eastern Australia: plant herbivore interactions. *Bulletin of Entomological Research* 77: 9–17.
- Forno, I.W. 1992. Biological control of *Mimosa pigra*: research undertaken and prospects for effective control. (ed.) K.L.S. Harley, A Guide to the Management of *Mimosa pigra*, CSIRO, Canberra, pp. 38–42.
- Forno, I.W. and Harley, K.L.S. 1992. Host testing of biological control agents for *Mimosa pigra*. (ed.) K.L.S. Harley, A Guide to the Management of *Mimosa pigra*, CSIRO, Canberra, pp. 43–62.
- Forno, W., Heard, T.A. and Day, M.D. 1994. Host-specificity and aspects of the biology of *Coelocephalapion aculeatum* (Coleoptera: Apionidae), a potential biological control agent of *Mimosa pigra* (Mimosaceae). *Environmental Entomology* 24: (in press).
- Forno, I.W., Kassulke, R.C. and Day, M.D. 1991a. Life-cycle and host testing procedures for *Carmenta mimosa*, Eichlin and Passoa (Lepidoptera: Sesiidae), a biological control agent for *Mimosa pigra* L. (Mimosaceae) in Australia. *Biological Control* 1: 309–315.

- Forno, I.W., Kassulke, R.C. and Harley, K.L.S. 1989a. *Neurostrota gunniella* (Busck) (Order Lepidoptera, Family Gracillariidae), a potential agent for biological control of the weed, *Mimosa pigra* L. (Family Leguminosae) in the Northern Territory. CSIRO Division of Entomology, unpublished report, 9pp.
- Forno, I.W., Miller, I.L., Napompeth, B. and Thamasara, S. 1991b. Management of *Mimosa pigra* in Southeast Asia and Australia. pp. 265–271. Proceedings of the 3rd International Conference on Plant Protection in the Tropics.
- Forno, I.W., Napompeth, B. and Buranapanichpan, S. 1989b. Is biological control of *Mimosa pigra* possible? Proceedings of The 1st Asia-Pacific Conference of Entomology, November 1989. Chiangmai, pp. 785–799.
- Forno, I.W. and Wright, A.D. 1981. The biology of Australian weeds. 5. *Eichhornia crassipes* (Mart.) Solms. Journal of the Australian Institute of Agricultural Science 47: 21–28.
- Fortuner, R. 1976. *Pratylenchus zaeae*. Commonwealth Institute of Helminthology. Descriptions of Plant-Parasitic Nematodes, Set 6, No. 77.
- Freeman, T.E. 1977. Biological control of aquatic weeds with plant pathogens. Aquatic Botany 3: 175–184.
- Freitas, A.V.L. 1991. Variation, life cycle and systematics of *Tegosa claudina* (Eschscholtz) (Lepidoptera, Nymphalidae, Melitaeinae) in São Paulo State, Brazil. (Portuguese). Revista Brasileira de Entomologia 35: 301–306.
- Frick, K.E. 1956. Revision of the North American *Calycomyza* species north of Mexico (*Phytobia*: Agromyzidae, Diptera). Annals of the Entomological Society of America 49: 284–300.
- Fullerton, R.A. 1977. New plant disease record in New Zealand: two smuts (*Ustilago tricophora*, *Tolyposporium bullatum*) of barnyard grass (*Echinochloa crus-galli*). New Zealand Journal of Agricultural Research 20: 113.
- Gagné, R.J. 1968. A catalogue of the Diptera of the Americas south of the United States. 23. Family Cecidomyiidae. 62pp. (Bennett and Cruttwell 1972).
- Gagné, R.J. 1985. A taxonomic revision of the Asian rice gall midge, *Orseolia oryzae* (Wood-Mason), and its relatives (Diptera: Cecidomyiidae) Entomography 3: 127–162.
- Ganga-Vislakshy, P.N. and Jayanth, K.P. 1991. Studies on the life history and development of *Orthogalumna terebrantis* Wallwork (Acarina: Galumnidae), an exotic oribatid mite of *Eichhornia crassipes*. Entomon 16: 53–58.
- Garcia, C.A. 1982a. Preliminary report on the natural enemies and distribution of *Mimosa invisa* in Brazil. Queensland Department of Lands Report. 4pp.
- Garcia, C.A. 1982b. A survey of the insects attacking giant sensitive plant (*M. invisa*) in Brazil with notes on its distribution. Queensland Department of Lands Report. 15pp.
- Garcia, C.A. 1983. Preliminary host specificity testing of *Psilopygida walkeri* for the biological control of *Mimosa invisa*. Queensland Department of Lands Report. 11pp.
- Garcia, C.A. 1984. A preliminary report on the host specificity of *Scamurius* sp. (Hemiptera, Heteroptera: Coreidae) a potential agent for the biological control of *Mimosa invisa* (giant sensitive plant in Queensland Australia). Queensland Department of Lands Report. 10pp.
- Garcia, C.A. 1985. A preliminary report on the host specificity of *Heteropsylla* sp. (Hemiptera, Homoptera: Psyllidae), a potential agent for the biological control of *Mimosa invisa* (giant sensitive plant) in Queensland, Australia. Queensland Department of Lands Report. 12pp.

- Gardner, D.E. 1989. Pathogenicity of *Fusarium oxysporum* f.sp. *passiflorae* to banana poka and other *Passiflora* spp. in Hawaii. *Plant Disease* 73: 476–478.
- Gardner, D.E., Smith, C.W. and Markin, G.P. 1992. Biological control of alien plants in natural areas of Hawaii. Abstracts, VIII International Symposium on Biological Control of Weeds. Lincoln University, Canterbury, New Zealand, p 11.
- Garlick, W.G. 1922. Concerning the feeding habits of the purslane sawfly larva. *The Canadian Entomologist* 54: 240.
- Gast, R.E., Wilson, R.G. and Kerr, E.D. 1984. Lesion nematode (*Pratylenchus* spp.) infection of weed species and fieldbeans (*Phaseolus vulgaris*). *Weed Science* 32: 616–620.
- Gazziero, D.L.P., Ulbrich, A.V., Yorinori, J.T. and Voll, E. 1988. Weeds: biological control (Portuguese). Documentos-Centro Nacional de Pesquisa de Soja, EMBRAPA 36: 299–303.
- Geering, Q.A. 1953. The sorghum midge, *Contarinia sorghicola* (Coq.) in East Africa. *Bulletin of Entomological Research* 44: 363–366.
- George, M.J. 1963. Studies on infestation of *Pistia stratiotes* Linn. by the caterpillar of *Namangana pectinicornis* Hems., a noctuid moth, and its effects on *Mansonioides* breeding. *Indian Journal of Malariology* 17: 149–155.
- Ghani, M.A. 1965. Studies on the insect enemies of noxious weeds in Pakistan. Commonwealth Institute of Biological Control, Rawalpindi, Pakistan. 171pp.
- Ghosh, A.K., Basu, R.C. and Raychaudhuri, D.N. 1971. On collection of aphids (Homoptera: Aphididae) from Bhutan with descriptions of two new species. *Kontyû* 39(2): 120–125.
- Gillespie, A.G. and Koike, H. 1973. Sugarcane mosaic virus and maize dwarf mosaic in mixed infections of sugarcane and other grasses. *Phytopathology* 63: 1300–1307.
- Gillett, J.D., Dunlop, C.R. and Miller, I.L. 1988. Occurrence, origin, weed status and control of water lettuce (*Pistia stratiotes*) in the Northern Territory. *Plant Protection Quarterly* 3(4): 144–148.
- Gingery, R.E., Nault, L.R. and Bradfute, O.E. 195. *Nosema pilicornis* sp. n. of the purslane sawfly. *Schizocerella pilicornis*. *Journal of Invertebrate Pathology* 32: 235–243.
- Goto, M. 1992. The relationship between *Emmalocera* sp. and barnyard grass and its potential as a biological control. Proceedings of an International Symposium on Biological Control and Integrated Management of Paddy and Aquatic Weeds in Asia. National Agriculture Research Center, Tsukuba, Japan, pp. 229–247.
- Grazia, J., Vecchio, M.C. del., Hildebrand, R. and Ramiro, Z.A. 1982. Study of the nymphs of pentatomids (Heteroptera) that infest soyabeans (*Glycine max* (L.) Merrill) III. *Thyanta perditor* (Fabricius 1794). *Anais da Sociedade Entomologica do Brasil* 11: 139–146. (Portuguese). (Review of Applied Entomology, Series A 73: 7093, 1983).
- Greber, R.S. 1979. Cereal chlorotic mottle virus—a rhabdovirus of Graminae in Australia transmitted by *Nesoclutha pallida* (Evans). *Australian Journal of Agricultural Research* 30: 433–443.
- Gruezo, W.S. 1990. The genus *Kordyana* Rac. new record (Exobasidiaceae) in the Philippines. *Natural History Bulletin of the Siam Society* 38: 89–92 (Biological Abstracts, July to December 1991).
- Guo, Y.Y., Zhou, N.S., Wu, T.T. and Qiu, H.L. 1984. An investigation and study on rice root-knot nematode on Hainan Island (Chinese). *Guangdong Agricultural Science, Guangdong Nongye Kexue* 1984(4) 32–34. (Helminthological Abstracts Series B, 54: 598, 1985).

- Gürsoy, O.V. 1989. Arthropod and phytopathogen natural enemies of several weeds in Turkey. Proceedings, VII Symposium on Biological Control of Weeds, 6–11 March 1988, Rome, Italy. Istituto Sperimentale per la Patologia Vegetale. Ministero dell'Agricoltura e delle Foreste, Rome, Italy, pp. 609–611.
- Habeck, D.H. 1974. *Arzama densa* as a pest of dasheen. The Florida Entomologist 57: 409–410.
- Habeck, D.H. and Passoa, S. 1982. Potential for biological control of *Mimosa pigra*. Proceedings of an International Symposium on *Mimosa pigra* Management, 1982 Chaing Mai, Thailand. International Plant Protection Center Document No 48–A–83. Oregon State University, USA, pp. 115–120.
- Haller, W.T. and Sutton, D.L. 1973. Effects of pH and high phosphorus concentrations on the growth of water hyacinth. Hyacinth Control Journal 11:59–67.
- Hamdoun, A.M. and Tigani, K.B.El. 1977. Weed problems in the Sudan. Pesticides Abstracts & News Summary 23: 190–194.
- Handayani, T. and Syed, R.A. 1976. *Nymphula responsalis* attacking *Salvinia* spp. in Indonesia. BIOTROP Newsletter 15: 14.
- Hanlin, R.T. and Tortolero, O. 1990. Icones Ascomycetum Venezuelae: *Myriogenospora atramentosa*. Mycotaxon 39: 237–244.
- Harley, K.L.S. 1982. Release and evaluation of natural enemies of water hyacinth. Proceedings, Workshop on Biological Control of Water Hyacinth. Commonwealth Science Council, London. 3–5 May 1982. Bangalore, India, pp. 24–30.
- Harley, K.L.S. 1984. Implementing a program for biological control of water hyacinth, *Eichhornia crassipes*. Proceedings of the International Conference on Water Hyacinth. United Nations Environment Programme. 7–11 February 1983. Hyderabad, India, pp. 58–69.
- Harley, K.L.S. 1989. The management of water hyacinth with emphasis on biological control. Commonwealth Science Council, London, 44pp.
- Harley, K.L.S. 1990. The role of biological control in the management of water hyacinth, *Eichhornia crassipes*. Biocontrol News and Information 11:11–22.
- Harley, K.L.S., Forno, I.W., Kassulke, R.C. and Sands, D.P.A. 1984. Biological control of water lettuce. Journal of Aquatic Plant Management 22: 101–102.
- Harley, K.L.S. and Kassulke, R.C. 1975. The suitability of *Teleonemia prolixa* (Stål) for biological control of *Lantana camara* in Australia. Journal of the Australian Entomological Society 14: 225–228.
- Harley, K.L.S., Kassulke, R.C., Sands, D.P.A. and Day, M.D. 1990. Biological control of water lettuce, *Pistia stratiotes* (Araceae) by *Neohydronomus affinis* (Coleoptera: Curculionidae). Entomophaga 35: 363–374.
- Harley, K.L.S., Winder, J.A., Kassulke, R.C. and Sands, D.P.A. 1983. Prospects for biological control of *Mimosa pigra* L. in Australia. Proceedings of the International Symposium on *Mimosa pigra* management. Chaing Mai 1982, pp. 113–114.
- Harley, K.L.S., Miller, I.L., Napompeth, B. and Thamasara, S. 1985. An integrated approach to the management of *Mimosa pigra* L. in Australia and Thailand. Proceedings of the 10th Asian-Pacific Weed Society Conference, pp. 209–215.
- Harley, K.L.S. and Wright, A.D. 1984. Implementing a program for biological control of water hyacinth, *Eichhornia crassipes*. Proceedings of the International Conference on Water Hyacinth, Hyderabad, India. (ed.) G. Thyagarajan. 7–11 February 1983. United Nations Environment Program Reports and Proceedings 7: 55–69.
- Haseler, W.H. 1984. The Alan Fletcher Research Station Annual Report 1983–1984. Queensland Department of Lands. 15pp.

- Hashioka, Y. 1973. Notes on *Pyricularia*. II. Four species and one variety parasitic to Cyperaceae, Gramineae and Commelinaceae. Transactions of the Mycological Society of Japan 14: 256–265 (Review of Plant Pathology 53: 3373, 1974).
- Heald, C.M., Menges, R.M. and Wayland, J.R. 1974. Efficacy of ultra-high frequency (UHF) electromagnetic energy and soil fumigation on the control of the reniform nematode (*Rotylenchus reniformis*) and common purslane (*Portulaca oleracea*) among southern peas. Plant Disease Reporter 58: 985–987.
- Heard, T.A. 1992. Resource use by *Apion aculeatum*, a herbivore of inflorescences of *Mimosa pigra*. p. 73, Abstracts, VIII International Symposium on Biological Control of Weeds, Lincoln University, Canterbury, New Zealand, 2–7 February 1992.
- Heath, M.C., Valent, B., Howard, R.J. and Chumley, F.G. 1990. Interactions of two strains of *Magnaporthe grisea* with rice, goosegrass and weeping lovegrass. Canadian Journal of Botany 68: 1627–1637.
- Heath, M.C., Howard, R.J., Valent, B. and Chumley, F.G. 1992. Ultrastructural interactions of one strain of *Magnaporthe grisea* with goosegrass and weeping lovegrass. Canadian Journal of Botany 70: 779–787.
- Hegdekatti, R.M. 1927. The rice gall midge in north Kanara. Agricultural Journal of India 22: 461–463.
- Herren-Gemmill, B. 1991. The ecological role of the exotic asteraceous *Chromolaena odorata* in the bush fallow farming system of West Africa. Ecology and management of *Chromolaena odorata*. BIOTROP Special Publication 44: 11–24.
- Hilda, A. and Suranarayanan, S. 1976. Cross-protection in the blast disease of *Panicum repens* L. Proceedings of the Indian Academy of Science Section B. 84: 215–225.
- Hillebrand, W.F. 1888. Flora of the Hawaiian Islands. Williams and Norgate, London. 673pp.
- Hilu, K.W. and Johnson, J.L. 1992. Ribosomal DNA variation in finger millet and wild species of *Eleusine* (Poaceae). Theoretical and Applied Genetics 83: 895–902.
- Hilu, K.W. and de Wet, J.M.J. 1976. Domestication of *Eleusine coracana*. Economic Botany 30: 199–208.
- Hilu, K.W., de Wet, J.M.J. and Harlan, J.R. 1979. Archaeobotany and the origin of finger millet. American Journal of Botany 16: 330–333.
- Hinckley, A.D. 1963. Trophic records of some insects, mites and ticks in Fiji. Fiji Department of Agriculture Bulletin 45. 116pp.
- Hiremath, S.C. and Salimath, S.S. 1992. The 'A' genome donor of *Eleusine coracana* (L.) Gaertn. (Gramineae). Theoretical and Applied Genetics 84: 747–754.
- Hiremath, P.C. and Sulladmath, V.V. 1985. Zonate leaf blight—a new disease of finger millet. Current Science 54: 935.
- Hodkinson, I.D. and White, I.M. 1981. The neotropical Psylloidea (Homoptera: Insecta): an annotated check list. Journal of Natural History 15: 491–523.
- Hoffmann, A. and Tempère, G. 1944. Note sur *Hypurus bertrandi* Perris. Bulletin de la Société Entomologique de France 49: 100–104.
- Holcomb, G.E., Jones, J.P. and Wells, D.W. 1989. Blight of prostrate spurge and cultivated poinsettia caused by *Amphobotrys ricini*. Plant Disease 73: 74–75.
- Holm, L.G., Plucknett, D.L., Pancho, J.V. and Herberger, J.P. 1977. The World's Worst Weeds. Distribution and Biology. University Press of Hawaii, Honolulu, Hawaii. 609pp.

- Huang, C.W., Feng, B.C., Wang, H.D., Yao, J. and Song, L.J. 1985. The host plants of whitebacked planthopper and its tolerance to starvation (Chinese). *Insect Knowledge (Kunchong Zhishi)* 22(5): 193–194. (Review of Applied Entomology, Series A, 75: 3954, 1987).
- Igarashi, K. 1985. Ecological studies of *Triops cancriformis* (Bosc) inhabiting Shonai district, Japan (Japanese). *Journal of the Yamagata Agriculture and Forestry Society* 42: 35–42. (Review of Applied Entomology, Series A, 75: 1079, 1987).
- IMI 1992. Unpublished report of the International Mycological Institute, CAB International, UK.
- Inserra, R.N., Dunn, R.A., McSorley, R., Langdon, K.R. and Richmer, A.Y. 1989. Weed hosts of *Rotylenchus reniformis* in ornamental nurseries in southern Florida. *Nematology Circular*, Gainesville, No 171, 4pp. (Nematological Abstracts 59: 1404, 1990).
- Irving, N.S. and Beshir, M.O. 1982. Introduction of some natural enemies of water hyacinth to the White Nile, Sudan. *Tropical Pest Management* 28: 20–26.
- Itoh, K. 1991a. Life Cycles of Rice Field Weeds and their Management in Malaysia. Tropical Agriculture Research Center, Tsukuba, Japan. 89pp.
- Itoh, K. 1991b. Integrated weed management of direct seeded wet rice fields in Southeast Asia and Pacific regions, with special reference to Malaysia. Proceedings of the 13th Asian Pacific Weed Science Society Conference, Jakarta, Indonesia, October 15–18, 1991. 18pp.
- Izquierdo, J.E., Huepp, G. and Chacon, L. 1987. Detection of nematodes of the genus *Meloidogyne* in weeds associated with coffee plantations (Spanish). *Sciencia y Tecnica en la Agricultura, Cafe y Cacao* 9 (1): 47–54. (Weed Abstracts 39: 581, 1990).
- Jacobsen, W.B.C. 1983. Ferns and Fern Allies of Southern Africa. Durban, Butterworths. 542pp.
- Jairajpuri, M.S., Khan, W.U., Setty, K.G.H. and Govindu, H.C. 1979. *Heterodera delvii* n. sp. (Nematoda: Heteroderidae) a parasite of ragi (*Eleusine coracana*) in Bangalore, India. *Revue Nematologie* 2: 3–9.
- Janardhanan, K.K., Singh, H.N. and Husain, A. 1982. Studies on *Claviceps* parasitic on *Panicum* species in India. *Folia Microbiologica* 27: 121–125.
- Jayanth, K.P. 1987. Biological control of water hyacinth in India. Indian Institute of Horticultural Research Technical Bulletin No. 3, 28pp.
- Jayanth, K.P. 1988. Biological control of water hyacinth in India by release of the exotic weevil *Neochetina bruchi*. *Current Science* 17: 968–970.
- Jayanth, K.P. and Visalakshi, P.N.G. 1989. Establishment of the exotic mite *Orthogalumna terebrantis* Wallwork on water hyacinth in Bangalore, India. *Journal of Biological Control* 3: 75–76.
- Jeritta, A.L.R. and David, B.V. 1986. Some insects associated with euphorbiaceous weeds. *Pest management* 1: 21–26. (Review of Applied Entomology, Series A, 75: 6270, 1987).
- Jeyarajan, R., Doraiswamy, S., Sivaprakasam, K., Venkata-Rao, A. and Ramakrishnan, L. 1988. Incidence of whitefly transmitted viruses in Tamil Nadu. *Madras Agricultural Journal* 75: 212–213.
- Jimenez, J.M., Bustamante, E., Gomez, R. and Pareja, M. 1990. Spike rot disease of itchgrass, *Rottboellia cochinchinensis*, its etiology and possible use in biological control (Spanish). *Manejo Integrado de Plagas* 15: 13–23.
- Jordaan, E.M., Waele, D.de. and De Waele, D. 1988. Host status of five weed species and their effects on *Pratylenchus zae* infestation of maize. *Journal of Nematology* 20: 620–624.

- Joshi, P.M. 1972. *Pseudocephalobus indicus* n.gen, n.sp. (Rhabditida: Cephalobidae) from Marathwada, India. Marathwada University Journal of Science Section B (Biological Science) 11: 155–158. (Helminthological Abstracts, Series B. 47:1363, 1978).
- Joshi, R.D. and Prakash, J. 1977. *Ageratum conyzoides*—a weed reservoir of potato virus Y. Journal of the Indian Potato Association 4(1): 22 (Agricola).
- Joy, P.J. 1978. On the occurrence of *Nisia atrovonosa* Lethierry (Homoptera: Menoplidae) on *Pistia stratiotes* L. (Fam. Araceae) in India. Agricultural Research Journal of Kerala 16: 93–94.
- Joy, P.J., Lyla, K.R. and Satheesan, N.V. 1993. Biological control of *Chromolaena odorata* in Kerala, India. *Chromolaena odorata* Newsletter 7: 1–3.
- Julien, M.H. 1992. Biological control of weeds. A world catalogue of agents and their target weeds. 3rd edition. 186pp. CAB International in association with ACIAR.
- Kalshoven, L.G.E. 1981. The pests of crops in Indonesia. Revised and translated by P.A. Van Der Laan and G.H.L. Rothschild. P.T. Ichtiar Baru-Van Hoeve, Jakarta, Indonesia. 701pp.
- Kamarudin, K.A. and Shah, A.A. 1978. The potential of *Haltica cyanea* Weber (Col.: Chrysomelidae) as a biological control agent of *Melastoma malabathricum* Linn. MARDI Research Bulletin 6: 15–24.
- Kamath, M.K. 1979. A review of biological control of insect pests and noxious weeds in Fiji (1969–1978). Fiji Agricultural Journal 41: 55–72.
- Kanagaratnam, P. 1976. Report of the Crop Protection Division—1975. Ceylon Coconut Quarterly 27: 36–41.
- Kar, A.K. and Ashok-Das 1988. New records of fungi from India. Indian Phytopathology 41: 505. (Review of Plant Pathology 70: 6367, 1991).
- Kasno, A.K.A. and Soerjani, M. 1979. Prospects for biological control of weeds in Indonesia. Proceedings of the Seventh Asian-Pacific Weed Science Society Conference. Australia; Asian-Pacific Weed Science Societies. 26–30 November 1979. Orange, Australia, Supplement 2: 35–38.
- Kassulke, R.C., Harley, K.L.S. and Maynard, G.V. 1990. Host specificity of *Acanthoscelides quadridentatus* and *A. puniceus* (Col.: Bruchidae) for biological control of *Mimosa pigra* (with preliminary data on their biology). Entomophaga 35: 85–97.
- Kativu, S. and Mithen, R. 1988. *Pennisetum* in southern Africa. Plant Genetic Resources Newsletter 73/74: 1–8.
- Keifer, H.H. 1979. Eriophyid studies. C-16, California Department of Agriculture. Sacramento, California. USA.
- Kenfield, D., Hallock, Y., Clardy, J. and Strobel, G. 1989. Curvulin and O-ethyl-curvulinic acid: phytotoxic metabolites of *Drechslera indica* which cause necroses on purslane and spiny amaranth. Plant Science 60: 123–128.
- Khan, A.G., Baloch, G.M. and Ghani, M.A. 1978. Natural enemies of *Abutilon*, *Amaranthus*, *Rumex* and *Sorghum*. Commonwealth Institute of Biological Control. Report of work carried out January 1977–March 1978. pp. 42–43.
- Khan, M.A., Hibino, H., Aguiro, V.M., Daquioag, R.D. and Opina, O.S. 1991. Rice and weed hosts of rice tungro associated viruses and leafhopper vectors. Plant Disease 75: 926–930.
- Khan, R.M. and Khan, M.W. 1985. *Portulaca oleracea* hitherto unrecorded host of *Rotylenchulus reniformis* from India. Acta Botanica Indica 13: 286–295.
- Kholod, N.A. 1983. Plant hosts of the strawberry stem nematode. (Russian). Materialy Simpoziuma Voronezh, 27–29 Sentyabrya 1983, 104–111 (Helminthological Abstracts, Series B, 55: 110, 1986).

- Kim, K.S. and Flores, E.M. 1979. Nuclear changes associated with *Euphorbia* mosaic virus transmitted by the whitefly. *Phytopathology* 69: 980–984.
- Kim, K.S. and Fulton, R.W. 1984. Ultrastructure of *Datura stramonium* infected with *Euphorbia* virus suggestive of a whitefly-transmitted geminivirus. *Phytopathology* 74: 236–241.
- Klein, M. and Raccah, B. 1991. Separation of two leafhopper populations of *Circulifer haematoceps* complex on different host plants in Israel. *Phytoparasitica* 19: 153–155. (Review of *Agricultural Entomology* 79: 9784, 1991).
- Kleinschmidt, R.P. 1960. New species of Agromyzidae from Queensland. *Queensland Journal of Agricultural Science* 17: 321–337.
- Kleinschmidt, R.P. 1970. Studies of some Agromyzidae in Queensland. *Queensland Journal of Agriculture and Animal Science* 27: 341–384.
- Klisiewicz, J.M. 1985. Growth and reproduction of *Dichotomophthora portulacae* and its biological activity on purslane. *Plant Disease* 69: 761–762.
- Klisiewicz, J.M., Clement, S.L. and Norris, R.F. 1983. Black stem: a fungal disease of common purslane in California. *Plant Disease* 64: 1162.
- Klots, A.B. 1951. *A Field Guide to the Butterflies of North America East of the Great Plains*. Houghton Mifflin, Boston. 349pp.
- Kluge, R.L. 1991. Biological control of trifid weed, *Chromolaena odorata* (Asteraceae), in South Africa. *Agriculture, Ecosystems and Environment* 37: 193–197.
- Kluge, R.L. and Caldwell, P.M. 1991. *Chromolaena odorata* in South Africa. *Chromolaena odorata* Newsletter 4: 7.
- Kluge, R.L. and Caldwell, P.M. 1993. The biology and host specificity of *Pareuchaetes aurata aurata* (Lepidoptera: Arctiidae), a 'new association' biological control agent for *Chromolaena odorata* (Compositae). *Bulletin of Entomological Research* 83: 87–94.
- Kluge, R.L. and Morris, M.J. 1992. The bio-control of *Chromolaena odorata* in South Africa: a progress report. Abstracts of the IX International Symposium on Biological Control of Weeds, New Zealand, p. 59.
- Knipling, E.B., West, S.H. and Haller, W.T. 1970. Growth characteristics, yield potential and nutritive content of water hyacinths. *Proceedings of the Soil Science Society, Florida* 30: 51–63.
- Knopf, K.W. and Habeck, D.H. 1976. Life history and biology of *Samea multiplicalis*. *Environmental Entomology* 5: 539–542.
- Koike, H. 1977. Transmission by *Dactynotus ambrosiae* from mixed infections with sugarcane mosaic and maize dwarf mosaic virus strains. *Plant Disease Reporter* 61: 724–727.
- Kooner, B.S. and Deol, G.S. 1982. Comparative rate of development of *Orosius albicinctus* Distant (Cicadellidae: Homoptera) on different host plants. *Journal of Agricultural Science, Cambridge* 98: 613–614.
- Krauss, N.L.H. 1965. Investigations on biological control of melastoma (*Melastoma malabathricum* L.). *Proceedings of the Hawaiian Entomological Society* 19: 97–101.
- Krombein, K.V. and Burks, B.D. 1967. Hymenoptera of America north of Mexico. *Synoptic Catalogue, Agriculture Monograph* 2. Second Supplement. 584pp. USDA, US Government Printing Office, Washington.
- Kuhn, G.B., Lin, M.T. and Kitajima, E.W. 1982. Some properties of bidens mosaic virus. (Portuguese). *Fitopatologia Brasileira* 7: 185–195.

- Kulkarni, S.N. and Sharma, O.P. 1976. Evaluation of some systemic and non-systemic fungicides against two plant pathogenic fungi. *Pesticides* 10(8): 32.
- Lal, A., Yadav, B.S. and Nandwana, R.P. 1978. A record of some new and known weed hosts of *Rotylenchulus reniformis* Linford and Oliveira, 1940 from Rajasthan. *Indian Journal of Nematology* 6: 94–95 (*Helminthological Abstracts*, B, 48: 932, 1979).
- Lallana, V.H., Sabattini, R.A. and Lallana, M.C. 1987. Evapotranspiration from *Eichhornia crassipes*, *Pistia stratiotes*, *Salvinia herzogii* and *Azolla caroliniana* during summer in Argentina. *Journal of Aquatic Plant Management* 25: 48–50.
- Latiza, A.S. 1980. Host range of *Ustilago scitaminea* Syd. in the Philippines. *Sugarcane Pathologists' Newsletter* 24: 11–13.
- Laup, S. 1987a. Biological control of water hyacinth: early observations. *Harvest* 12: 35–40.
- Laup, S. 1987b. Biological control of water lettuce: early observations. *Harvest* 12: 41–43.
- Lee, O. 1964. Weeds may host dwarf mosaic. *Proceedings of the 20th North Central Weed Control Conference*. Purdue University, Lafayette, pp. 44–47. (Holm et al. 1977).
- Leeuwangh, J. and Leuamsang, P. 1967. Observations on the ecology of *Thaia oryzivora*, a leafhopper found on rice in Thailand. *FAO Plant Protection Bulletin* 15(2): 30–31.
- Leggat, F.W. and Teakle, D.S. 1975. *Passiflora foetida*, a widespread host of passionfruit woodiness virus in Queensland. *APPS Newsletter* 4(3): 22–23.
- Lei, H.Z., Liu, G.Q. and Li, W.J. 1983. Studies of planthopper species and their population fluctuation on cocksbur in rice fields. *Plant Protection* 9: 11–12.
- Liau, S.S., Ooi, P.A.C. Ismail, M.R., Tay, B.L., Lee, S.A., Chung, G.F. and Ho, C.T. 1991. Biological control of *Mikania*—early experiences in Malaysia. *Proceedings, International Conference on Biological Control in Tropical Agriculture*, 27–30 August, 1991, Malaysia. Preprint 10 pp.
- Liau, S.S., Tan, C.L., Chung, G.F., Ooi, P.A.C., Lee, S.A. and Tay, B.L. 1993. Field releases of *Liothrips mikaniae* (Priesner)—experiences in Malaysia. *Workshop on Biological Control of Mimosa pigra and Mikania micrantha*, February 2, 1993. ASEAN PLANTI, Serdang, Malaysia, 1 p. abstract.
- Lin 1968. Weeds Found on Cultivated Land in Taiwan. Volumes 1 and 2. College of Agriculture, National Taiwan University, Taipei. 950pp. (Holm et al. 1977).
- Linford, M., Oliveira, J. and Ishii, M. 1949. *Paratylenchus minutus* n.sp., a nematode parasitic on roots. *Pacific Science* 3: 111–119.
- Linford, M. and Yap, F. 1940. Some hosts of the reniform nematode in Hawaii. *Proceedings of the Helminthological Society of Washington* 7: 42–44. (Holm et al. 1977).
- Little, E.C.S. 1968. The control of water weeds. *Weed Research* 8: 79–105.
- Logan, A.E. and Zettler, F.W. 1984. Susceptibility of *Rudbeckia*, *Zinnia*, *Ageratum* and other bedding plants to *Bidens* mottle virus. *Plant Disease* 68: 260–262.
- Lonsdale, W.M. 1992. The biology of *Mimosa pigra*. (ed.) K.L.S. Harley, *A Guide to the Management of Mimosa pigra*. CSIRO Canberra, pp. 8–32.
- Lonsdale, W.M., Miller, I.L. and Forno, I.W. 1989. The biology of Australian weeds 20. *Mimosa pigra* L. *Plant Protection Quarterly* 4: 119–131.

- Lonsdale, W.M. and Segura, R. 1987. A demographic study of native and introduced populations of *Mimosa pigra*. (eds) D. Lemerle and A.R. Leys. Proceedings of the 8th Australian Weeds Conference, Sydney. Weed Society of N.S.W., Sydney, pp. 163–166.
- Lordello, R.R.A., Lordello, A.I.L. and Paulo, E.M. 1988. Multiplicao de *Meloidogyne javanica* em plantas daninbas. *Nematologia Braziliera* 12: 84–92 (Weed Abstracts 38: 2165, 1989).
- Lourencao, A.L., Filho, E.B. and Ferraz, M.C.V.D. 1982. Natural enemies of *Mocis latipes* (Guenée 1852). (Portuguese). *Bragantia* 41: 237–240 (Review of Applied Entomology, Series A, 71: 7909, 1983).
- Loyal, D.S. and Kumar, K. 1977. Utilization of *Marsilea* sporocarps as sham seeds by a weevil. *American Fern Journal* 67(3): 95.
- Lubigan, R. and Vega, M. 1971. The effect of different densities and durations of competition of *Echinochloa crusgalli* (L.) Beauv. and *Monochoria vaginalis* (Burm.f.) Presl. on the yield of lowland rice. *Weed Science Report*, 1970–71. Department of Agricultural Botany, University of the Philippines, College of Agriculture, Los Banós, pp. 19–23. (Holm et al. 1977).
- Luc, M., Sikora, R.A. and Bridge, J. 1990. Plant Parasitic Nematodes in Subtropical and Tropical Agriculture. CAB International Institute of Parasitology, U.K., 629 pp.
- Lyla, K.R. and Joy, P.J. 1992. Biology of *Aphis spiraecola* Patch infesting *Chromolaena odorata* in Kerala, India. *Chromolaena odorata* Newsletter 5: 2–3.
- Lyla, K.R., Joy, P.J. and Abraham, C.C. 1987. Insect pests of *Chromolaena odorata* (= *Eupatorium odoratum*). *Agricultural Research Journal of Kerala* 25: 302–304.
- Lynch, R.E., Some, S., Dicko, I., Wells, H.D. and Monson, W.G. 1987. Chinch bug damage to bermuda grass. *Journal of Entomological Science* 22: 153–158.
- Maas, P.W.T., Sanders, H. and Dede, J. 1978. *Meloidogyne oryzae* n.sp. (Nematoda, Meloidogynidae) infesting irrigated rice in Surinam (South America). *Nematologica* 24: 305–311.
- Mabberley, D.J. 1987. *The Plant Book*. Cambridge University Press, 706pp.
- McConnell, J., Marutani, M. and Muniappan, R. 1992. Insect induced changes in *Chromolaena odorata*. Ecology and Management of *Chromolaena odorata*. SEAMEO BIOTROP, Bogor, Indonesia, BIOTROP Special Publication 44: 159–161.
- McFadyen, R.E.C. 1988a. Phytophagous insects recorded from *C. odorata*. *Chromolaena odorata* Newsletter 2: 5–23.
- McFadyen, R.E.C. 1988b. History and distribution of *Chromolaena odorata* (L.) R.M. King and H. Robinson. Proceedings of the First International Workshop on Biological Control of *Chromolaena odorata*. Agricultural Experiment Station, Mangilao, Guam, pp. 7–12.
- McFadyen, R.E.C. 1988c. Ecology of *Chromolaena odorata* in the Neotropics. Proceedings of the First International Workshop on Biological Control of *Chromolaena odorata*. Agricultural Experiment Station. Mangilao, Guam, pp. 13–20.
- McFadyen, R.E.C. 1989. Siam weed: a new threat to Australia's north. *Plant Protection Quarterly* 4: 3–7.
- McFadyen, R.E.C. 1991a. The ecology of *Chromolaena odorata* in the Neotropics. Ecology and management of *Chromolaena odorata*. BIOTROP Special Publication 44: 1–9.
- McFadyen, R. 1991b. The accidental introduction of the *Chromolaena* mite *Acalitus adoratus* into Southeast Asia. *Chromolaena odorata* Newsletter 4: 8.
- McFadyen, R.E.C. 1991c. New approaches to the biological control of *Chromolaena odorata* in Southeast Asia. Ecology and Management of *Chromolaena odorata*. SEAMEO BIOTROP, Bogor, Indonesia, Biotrop Special Publication 44: 135–141

- McFadyen, R. 1992. A critique of the paper "Chromolaena odorata: friend or foe for resources poor farmers" by S.P. Field, published in the *Chromolaena odorata* newsletter 4. *Chromolaena odorata* Newsletter 5: 6.
- McFadyen, R.E.C. 1993. The accidental introduction of the *Chromolaena* mite *Acalitus adoratus* into Southeast Asia. Proceedings of the Eighth International Symposium on Biological Control of Weeds. 2-7 February 1992 Lincoln University, Canterbury New Zealand, 9pp.
- Macfarlane, R. 1984. Report of the entomologist 1981 and 1982. Solomon Islands, Ministry of Home Affairs and National Development. (Review of Applied Entomology, Series A 72: 8235, 1984).
- MacGowan, J.B. 1989. Bureau of Nematology-nematode detections of special interest. Triology Technical Report 28(12): 1-3. (Nematological Abstracts, Series B. 59: 1413, 1990).
- McSorley, R., Parrado, J.L. and Goldweber, S. 1981. Plant-parasitic nematodes associated with mango and relationship to tree condition. *Nematropica* 11: 1-9.
- Maehler, K.L. 1954. Recent beetle captures. Proceedings of the Hawaiian Entomological Society 15: 269.
- Mahindapala, R., Kirthisinghe, J.K.F. and Pinto, J.L.J.G. 1980. Some studies on the biological control of *Chromolaena odorata* (*Eupatorium odoratum*). *Ceylon Coconut Quarterly* 31: 98-104.
- Malleswaria-Rao, Y. and Narayana-Rao, A. 1981. Sporulation of *Pyricularia* spp.: stimulation by detached leaves and leaf extracts of *Commelina benghalensis* L. Proceedings of the Indian Academy of Science. *Plant Science* 90: 389-393.
- Mallikarjunaiah, R.R. and Rao, V.G. 1972. A new leaf-spot disease of passion flower from Maharashtra. *Current Science* 41: 686.
- Mamaril, E.C. and Alberto, R.T. 1989. Root-knot nematodes infecting some common weeds in vegetable growing areas in Sicsican. *International Nematology Network Newsletter* 6(3): 37-39. (Nematological Abstracts 59: 389, 1990).
- Mangodihardjo, S. 1975. Prospects of biological control of weeds in Indonesia. Proceedings, 3rd Indonesian Weed Science Conference, Bandung, Indonesia, pp 33-41.
- Mangoendihardjo, S. and Nasroh, A. 1976. *Proxenus* sp. (Lepidoptera: Noctuidae), a promising natural enemy of water lettuce (*Pistia stratiotes*). Proceedings of the Fifth Asian-Pacific Weed Science Society Conference October 5-11, 1975 Tokyo, pp. 444-446.
- Mangoendihardjo, S., Nasroh, A., Kasno and Subagyo, T. 1976. Studies of natural enemies associated with important weed species in Indonesia. BIOTROP Annual Report, 1975-1976 p. 22.
- Mangoendihardjo, S., Setyawati, O., Syed, R.A. and Sosromarsono, S. (1977). Insects and fungi associated with some aquatic weeds in Indonesia. Proceedings, Sixth Asian Pacific Weed Science Society Conference July 11-17, 1977. 2:440-446.
- Mangoendihardjo, S. and Syed, R.A. 1974. Studies of natural enemies of *Eichhornia crassipes* and *Pistia stratiotes* L. Southeast Asian Workshop on Aquatic Weeds. Malang. Paper 7b. 3. 19pp.
- Mani, M.S. and Jayaraman, P. 1987. On some plant galls from the Fiji islands. Proceedings of the Indian Academy of Science: *Animal Science* 96: 81-115.
- Maqbool, M.A., Hashmi, S. and Ghaffar, A. 1986. Eleven new hosts of root-knot nematodes and identification of physiological races in Pakistan. *Pakistan Journal of Nematology* 4: 11-14.

- Markin, G.P. and Nagata, R.F. 1989. Host preference and potential climatic range of *Cyanotricha necyria* (Lepidoptera: Diptidae), a potential biological control agent of the weed *Passiflora mollissima* in Hawaiian forests. Cooperative National Park Resources Studies Unit. Technical Report 67. 35pp.
- Markin, G.P., Nagata, R.F. and Taniquchi, G. 1989. Biology and behaviour of the South American moth, *Cyanotricha necyria* (Felder and Rogenhofer) (Lepidoptera: Notodontidae), a potential biocontrol agent in Hawaii of the forest weed *Passiflora mollissima* (HBK) Bailey. Proceedings of the Hawaiian Entomological Society 29: 115–123.
- Marshall, G.K. 1911. On a new species of *Baris* from the Sudan. The Entomologists' Monthly Magazine 22: 207–208.
- Marshall, G.K. 1916. Some injurious Indian weevils (Curculionidae) 2. Bulletin of Entomological Research 26: 565–569.
- Marshall, G.K. 1935. New injurious Curculionidae (Col.) from Malaya. Bulletin of Entomological Research 26: 565–569.
- Martin, G.C., James, G.L., Bissett, J.L. and Way, J.I. 1969. New records of infection by the burrowing nematode. FAO Plant Protection Bulletin 17: 116.
- Marutani, M. and Muniappan, R. 1990. A new natural enemy of *Chromolaena odorata* in Micronesia. *Chromolaena odorata* Newsletter 3: 7.
- Marutani, M. and Muniappan, R. 1991a. Re-establishment of *Pareuchaetes pseudoinsulata* in Yap. *Chromolaena odorata* Newsletter 4: 3.
- Marutani, M. and Muniappan, R. 1991b. Interactions between *Chromolaena odorata* (Asteraceae) and *Pareuchaetes pseudoinsulata* (Lepidoptera: Arctiidae). Annals of Applied Biology 119: 227–238.
- Mathur, V.K. and Prasad, S.K. 1973. Survival and host range of the rice root nematode, *Hirschmaniella oryzae*. Indian Journal of Nematology 3: 88–93 (Helminthological Abstracts B, 44: 1259, 1975).
- Maun, M.A. and Barrett, S.C.H. 1986. The biology of Canadian weeds. 77. *Echinochloa crus-galli* (L.) Beauv. Canadian Journal of Plant Science 66: 739–759.
- Mehrlisch, F.P. and Fitzpatrick, H.M. 1935. *Dichotomophthora portulacae*, a pathogene of *Portulaca oleracea*. Mycologica 27: 543–550.
- Menon, R. and Ponnappa, K.M. 1964. Commonwealth Institute of Biological Control. Report of work carried out during 1963. Plant Pathogens, pp. 39–40.
- Mew, T.W., Fabellar, N.G. and Elazegui, F.A. 1980. Ecology of the rice sheath blight pathogen: parasitic survival. International Rice Research Newsletter 5(4): 16.
- Migliori, A. and Lastra, R. 1980. Etude d'une maladie de type viral présente sur maïs en Guadeloupe et transmise par le delphacide *Peregrinus maidis*. Annals de Phytopathologie 12: 277–294.
- Migliori, A. and Lastra, R. 1981. Mise en évidence du maïs mosaic virus chez le maïs en Guadeloupe et en Guyane. Agronomie 7: 195–198.
- Miller, I.L. and Lonsdale, W.M. 1987. Early records of *Mimosa pigra* in the Northern Territory. Plant Protection Quarterly 2: 140–142.
- Mintz, A.S. and Weidemann, G.J. 1992. Evaluation of *Aposphaeria amaranthi* as a potential bioherbicide for *Amaranthus*. p.68. Abstracts, VIII International Symposium on Biological Control of Weeds. Lincoln University, Canterbury, New Zealand.
- Misra, M.P., Pawar, A.D., Samujh, R. and Srivastava, C.M. 1992. Use of *Neochetina eichhorniae* Warner and *N. bruchi* Hustache (Coleoptera, Curculionidae) for the biological control of water hyacinth in north India. Journal of Advanced Zoology 13: 49–52.

- Mitchell, D.S. 1978. Aquatic Weeds in Australian Inland Waters. Australian Government Printing Service. Canberra, Australia. 189pp.
- Mitchell, J.K. 1986. *Dichotomophthora portulacae* causing black stem rot on common purslane in Texas. *Plant Disease* 70: 603.
- Miyagawa, H., Ozaki, K. and Kimura, T. 1988. Pathogenicity of *Psuedomonas glumae* and *P. plantarii* to the ears and leaves of graminaceous plants. *Bulletin of the Chugoku National Agricultural Experiment Station* 3: 31–43. (*Weed Abstracts* 38: 3926, 1989).
- Miyaniishi, K. and Cavers, P.B. 1980. The biology of Canadian weeds. 40. *Portulaca oleracea* L. *Canadian Journal of Plant Sciences* 60: 953–963.
- Moffett, M.L. and McCarthy, G.J.P. 1973. *Xanthomonas translucens* on Japanese millet (*Echinochloa crus-galli* var. *frumentacea*). *Australian Journal of Experimental Agriculture and Animal Husbandry* 13: 452–454.
- Mohamed, A.Z., Lee, B.S. and Lum, K.Y. 1992. Developing a biological control initiative in Malaysia. (eds) P.A.C. Ooi, G.S. Lim and P.S. Teng. *Biological Control: Issues in the Tropics*, pp. 59–62.
- Mohanasundaram, M. 1984. Some tarsonemid mites from Tamilnadu, India (Acari: Tarsonemidae). *Oriental Insects* 18: 79–85.
- Mohandes, C., Rao, Y.S. and Sahu, S.C. 1981. Cultural control of rice root nematodes (*Hirschmaniella* spp.) with *Sphenoclea zeylanica*. *Proceedings of the Indian Academy of Sciences (Animal Sciences)* 90:373–376.
- Monte, O. 1939. Lista preliminar do tingitideos de Minas Gerais. (Portuguese). *Revista Sociedade Brasileira de Agronomia* 2: 63–87.
- Moody, K. 1989. Weeds reported in rice in South and Southeast Asia. International Rice Research Institute. Los Banos, Philippines. 442pp.
- Moody, K., Castin, E.M. and Estorninos, L.E. 1987. Natural enemies of some weeds in the Philippines. Typescript 17pp.
- Morrill, W.L., Penelec, L. and Almazon, L.P. 1990. Effects of weeds on fecundity and survival of *Leptocorisa oratorius* (Hemiptera: Alydidae). *Environmental Entomology* 19: 1469–1472.
- Muchovej, J.J. 1987. *Drechslera gigantea* on *Eleusine indica* in Brazil. (Portuguese). *Fitopatologia Brasileira* 12: 405–406. (Review of *Plant Pathology*, 67: 5494, 1988).
- Muchovej, J.J. and Muchovej, R.M.C. 1987. *Physarum cinereum* on turfgrass in Brazil. *Fitopatologia Brasileira* 12: 402–403.
- Muchovej, J.J. and Nesio, M.L.R. 1987. A new *Exserohilum* from Brazil. *Transactions of the British Mycological Society* 89: 126–128.
- Muddiman, S.B., Hodkinson, I.D. and Hollis, D. 1992. Legume-feeding psyllids of the genus *Heteropsylla* (Homoptera: Psylloidea). *Bulletin of Entomological Research* 82: 73–117.
- Muesebeck, C.F.W., Krombein, K.V. and Townes, H.K. 1951. Hymenoptera of America north of Mexico. Synoptic Catalogue, Agriculture Monograph 21. 1420pp. USDA, US Government Printing Office, Washington.
- Mundkur, B.B. 1939. A contribution towards a knowledge of Indian Ustilaginales. *Transactions of the British Mycological Society* 23: 105 (Rachie and Peters 1977).
- Mune, T.L. and Parham, J.W. 1967. The declared noxious weeds of Fiji and their control. Fiji Department of Agriculture. *Bulletin* 48. 74pp.
- Muniappan, R. 1988a. *Chromolaena odorata* newsletter No 1, 15pp. Agricultural Experiment Station, University of Guam. Mangilao, Guam.
- Muniappan, R. 1988b. *Chromolaena odorata* newsletter No 2, 23pp. Agricultural Experiment Station, University of Guam, Mangilao, Guam.

- Muniappan, R. 1988c. *Pareuchaetes* establishment. *Chromolaena odorata* Newsletter 1: 2.
- Muniappan, R., Marutani, M. and Denton, G.R.W. 1988b. Introduction and establishment of *Pareuchaetes pseudoinsulata* Rego Barros (Arctiidae) against *Chromolaena odorata* in the Western Caroline Islands. *Journal of Biological Control* 2: 141–142.
- Muniappan, R. and Marutani, M. 1992. Coevolution of the Siam weed and its natural enemy. p. 74. Abstracts VIII International Symposium on Biological Control of Weeds, Lincoln University, Canterbury, New Zealand, 2–7 February 1992.
- Muniappan, R., Marutani, M. and McConnell, J. 1988a. A bibliography of *Chromolaena odorata*. *Chromolaena odorata* Newsletter 1: 3–15.
- Muniappan, R., Sundaramurthy, V.T. and Viraktamath, C.A. 1989. Distribution of *Chromolaena odorata* (Asteraceae) and bionomics and consumption and utilization of food by *Pareuchaetes pseudoinsulata* (Lepidoptera: Arctiidae) in India. *Proceedings of the VII International Symposium on Biological Control of Weeds*. Italy, pp. 401–409.
- Muniappan, R. and Viraktamath 1986. Insects and mites associated with *Chromolaena odorata* (L.) R.M. King and H. Robinson (Asteraceae) in Karnataka and Tamil Nadu. *Entomon* 11: 285–287.
- Nachapong, M. and Mabbett, T. 1979. A survey of some wild hosts of *Bemisia tabaci* Genn. around cotton fields in Thailand. *Thai Journal of Agricultural Science* 12: 217–222.
- Nafus, D. and Schreiner, I. 1989. Biological control activities in the Mariana Islands from 1911 to 1988. *Micronesica* 22: 65–106.
- Nag Raj, T.R. and Ponnappa, K.M. 1966. Commonwealth Institute of Biological Control. Report of work carried out during 1965. *Plant pathogens*. pp. 43–44.
- Nagarkatti, S. 1982. Biological control efforts in India with special reference to water hyacinth (*Eichhornia crassipes*). Workshop on Biological Control of Water Hyacinth. Commonwealth Science Council, London. 3–5 May 1982. Bangalore, India, pp. 43–44.
- Nakahara, L.M. 1977. Possible new State pest, *Agraulis* (= *Dione*) *vanillae* Linnaeus. Memorandum, Hawaii Department of Agriculture, January 17. 2pp.
- Napompeth, B. 1981. Approaches to the biological control of *Mimosa pigra* L. in Thailand. (Thai). National Biological Control Research Centre Kasetsart University, Bangkok, Thailand. Extension Leaflet 12. 11pp.
- Napompeth, B. 1982. Biological control research and development in Thailand. *Proceedings of the International Conference on Plant Protection in the Tropics*. 1–4 March 1982. Kuala Lumpur, Malaysia, pp. 301–323.
- Napompeth, B. 1983. Preliminary screening of insects for biological control of *Mimosa pigra* in Thailand. *Proceedings of an International Symposium on Mimosa pigra Management, 1982*, Chiang Mai, Thailand. International Plant Protection Center Document No 48–A–83. Oregon State University, USA, pp. 121–128.
- Napompeth, B. 1984. Biological control of water hyacinth in Thailand. *Proceedings, International Conference on Water Hyacinth, Hyderabad, India*. 7–11 February 1983. (ed.) G. Thyagarajan. United Nations Environment Program Reports and Proceedings Series 7: 811–822.
- Napompeth, B. 1989. Biological control of insect pests and weeds in Thailand. *Biological control of pests*. BIOTROP Special Publication 36: 51–68.
- Napompeth, B. 1990a. Country report: Thailand. *Biological control of weeds in Thailand*. BIOTROP Special Publication 38: 23–36.

- Napompeth, B. 1990b. *Hypolixus trunculatus* F. found feeding on *C. odorata* in Thailand. *Chromolaena odorata* Newsletter 3: 6.
- Napompeth, B. 1992a. Brief review of biological control activities in Thailand. ed. Y. Hirose, Biological Control in South and East Asia. Kyushu University Press, Japan, pp. 51–68.
- Napompeth, B. 1992b. Biological control of paddy and aquatic weeds in Thailand. Biological Control and Integrated Management of Paddy and Aquatic Weeds in Asia. National Agriculture Research Center, Tsukuba, Japan, pp. 249–258.
- Napompeth, B., Charernsom, K., Suasa-Ard, W. and Pongsupradit, D. 1977. Insects of biological control importance for aquatic weeds in Thailand. *Environment News* 5: 47–56.
- Napompeth, B. and Hai, T.N. 1988. *Chromolaena odorata* in Vietnam. Proceedings of the First International Workshop on Biological Control of *Chromolaena odorata*. Agricultural Experiment Station, Mangilao, Guam, p. 63.
- Napompeth, B., Hai, T.N. and Winotai, A. 1988. Attempts on biological control of Siam weed *Chromolaena odorata* in Thailand. Proceedings of the First International Workshop on Biological Control of *Chromolaena odorata*. Agricultural Experiment Station, Mangilao, Guam, pp. 57–62.
- Napompeth, B. and Winotai, A. 1991. Progress on biological control of Siam weed, *Chromolaena odorata* in Thailand. Ecology and management of *Chromolaena odorata*. BIOTROP Special Publication 44:91–97.
- Narendra, D.V. and Rao, V.G. 1973. A new leaf-spot disease of *Commelina*. *Current Science* 42(5): 180.
- Nasser, M.A.K. and Basky, Z. 1988. Research on some weeds as reservoirs of cucumber mosaic virus. (Hungarian). *Zoldsegtermesztesi Kutato Intezet Bulletinje* 21: 83–88. (Weed Abstracts 39: 3424, 1990).
- Natural Resources Institute 1992. Control of *Rottboellia cochinchinensis* with mycoherbicides. *Natural Resources Institute Newsletter* 5(10): 8–9.
- Nault, L.R., Gingery, R.E. and Gordon, D.T. 1980. Leafhopper transmission and host range of maize rayado fino virus. *Phytopathology* 70: 709–712.
- Nayar, B.K. and Bajpai, N. 1976. Morphology in relation to phylogeny of the davalloid oleandroid group of ferns. *Phytomorphology* 26: 333–354.
- Neal, M.C. 1965. In Gardens of Hawaii. B.P. Bishop Museum Special Publication 50, Bishop Museum Press, Honolulu, HI.
- Needham, J.G. 1946. An insect community which lives in flowerheads. *National Geographic* 90: 340–356.
- Nguyen Van Vuong, 1973. Weed flora in rice field in South Vietnam. The Second Indonesian Weed Science Conference, Yogyakarta, April 2–5, 1973, pp. 155–161.
- Noda, K., Teerawatsakul, M., Prakongvongs, C. and Chaiwiratnukul, L. 1985. Major Weeds in Thailand. National Weed Science Research Institute Project, Thailand. 142pp.
- Norman, K., Liao, S.S. and Ooi, P.A.C. 1992. The introduction of *Liothrips mikaniae* for the biocontrol of *Mikania* in Malaysia. Proceedings of the National IRPA (Intensification of Research in Priority Areas) Seminar (Agricultural Sector) Kuala Lumpur, 6–11 January 1992. 1 p abstract.

- Norris, R.F. 1985. Biological weed control with endemic organisms, with emphasis on common purslane (*Portulaca oleracea*). Proceedings 37 Annual California Weed Conference. El Macero, California, USA, pp. 67–69.
- Noyes, J.S. 1990. A new encyrtid (Hymenoptera) parasitoid of the leucaena psyllid (Homoptera: Psyllidae) from Mexico, Central America and the Caribbean. Bulletin of Entomological Research 80: 37–41.
- O'Brien, C.W. 1976. A taxonomic revision of the New World subaquatic genus *Neochetina* (Coleoptera: Curculionidae: Bagoini). Annals of the Entomological Society of America 69: 165–174.
- O'Brien, C.W. and Wibmer, G.J. 1989a. Revision of the neotropical weevil genus *Argentinorhynchus* Brethes (Coleoptera: Curculionidae). Annals of the Entomological Society of America 82: 267–278.
- O'Brien, C.W. and Wibmer, G.J. 1989b. Two new South American species of the weevil genus *Argentinorhynchus* Brethes. Southwestern Entomologist 14: 213–223. (Review of Agricultural Entomology 78: 7552, 1990).
- O'Brien, C.W. and Wibmer, G.J. 1989c. Revision of the neotropical genus *Neohydronomus* Hustache (Coleoptera: Curculionidae). Coleopterists' Bulletin 43: 291–304.
- Ofuya, T.I. 1988. Occurrence, growth and survival of *Aphis craccivora* (Homoptera: Aphididae) on some weeds in a rainforest area of Nigeria. Annals of Applied Biology 113: 229–233.
- Ogwaro, K. 1978. Ovipositional behaviour and host-plant preference of the sorghum shoot fly, *Atherigona soccata* (Diptera: Anthomyiidae). Entomologia Experimentalis et Applicata 23: 189–199.
- Ohtsu, Y. and Gomi, T. 1985. Strain A of sugarcane mosaic virus isolated from sourgrass in Ishigaki Island, Okinawa, Japan. (Japanese). Annals of the Phytopathological Society of Japan 51: 616–622.
- Okali, D.U.U. and Hall, J.B. 1974. Die-back of *Pistia stratiotes* on Volta Lake, Ghana. Nature 248: 452–453.
- Okioma, S.N.M., Muchoki, R.N. and Gathuru, E.M. 1983. Alternate hosts of rice yellow mottle virus in the Lake Victoria basin of Kenya. Tropical Pest Management 29: 295–296. (Review of Plant Pathology 63: 1258, 1984).
- Olaoye, S.O.A. 1974. Studies on the biological control of *Eupatorium odoratum* in Nigeria. Proceedings of the Fourth Nigerian Weed Science Group Meeting, pp. 1–8. (Weed Abstracts 25: 836, 1976).
- Ong, C.A. and Ting, W.P. 1973. Two virus diseases of passion fruit (*Passiflora edulis* f. *flavicarpa*). MARDI Research Bulletin 1: 33–50.
- Ooi, P.A.C. 1993. Biological control of *Mikania micrantha*. International Institute of Biological Control, Annual Report 1992, p. 48.
- Ooi, P.A.C., Holden, A.N.G. and Baker, P.S. 1991. Arthropods and pathogens for biological control of *Chromolaena odorata*. Ecology and Management of *Chromolaena odorata*. BIOTROP Special Publication 44: 127–132.
- Ooi, P.A.C., Ravindran, C.P. and Liau, S.S. 1993. Biology and production of *Liothrips mikaniae* Priesner. Workshop on Biological Control of *Mimosa pigra* and *Mikania micrantha*, February 2, 1993. ASEAN PLANTI, Serdang, Malaysia, 1 p. abstract.
- Ooi, P.A.C., Sim, C.H. and Tay, E.B. 1988a. Status of the arctiid moth introduced to control Siam weed in Sabah, Malaysia. Planter 64: 298–304.

- Ooi, P.A.C., Sim, C.H. and Tay, E.B. 1988b. Irregular recovery of *Pareuchaetes pseudoinsulata* in Sabah, Malaysia. Proceedings of the First International Workshop on Biological Control of *Chromolaena odorata*. Agricultural Experiment Station, Mangilao, Guam, p. 56.
- Oritsejafor, J.J. 1986. Weed hosts of *Fusarium oxysporum* f.sp. *elaeidis*. Oleagineux 41: 1-7. (Review of Plant Pathology 65: 3667, 1986).
- Ortiz, M.S. 1981. Aphididae from the forest edge: Tingo Maria (Huanuco-Peru) (Spanish). Revista Peruana de Entomologia 23: 119-120.
- Paje, E.P., Exconde, O.R. and Raymundo, S.A. 1964. Host range of *Piricularia oryzae* in the Philippines. Philippine Agriculturist 48: 35-48.
- Pande, A. 1980. *Haplosporella passifloridia* n.sp. from Maharashtra. New taxa on *Passiflora foetida*. Indian Journal of Mycology and Plant Pathology 10: 75.
- Parbery, D.G. 1967. Studies on graminicolous species of *Phyllachora* Nks. in Fckl. V. A taxonomic monograph. Australian Journal of Botany 15: 271-375.
- Parejarearn, A., Chettanachit, D., Balaveang, W. and Disthaporn, S. 1988. Rice ragged stunt virus (RSV) in aquatic weed *Monochoria vaginalis*. International Rice Research Newsletter 13(2): 22.
- Parenzan, P. 1985. Damage to jojoba (*Simmondsia chinensis*) by *Nysius (Macroparius) cymoides* Spin. (Rhynchota-Heteroptera-Lygaeidae) in Apulia. (Italian). Entomologica 20: 99-108. (Review of Applied Entomology A 76: 1203, 1988).
- Parker, C. 1972. The *Mikania* problem. Pesticides Abstracts & News Summary, A. 18: 312-315.
- Parris, S.D. 1980. Aquatic plant control activity in the Panama Canal zone. Miscellaneous Paper, United States Army Waterways Experimental Station A-80-3, pp. 384-389.
- Parsons, W.T. 1963. Water hyacinth, a pest of world water-ways. Victorian Journal of Agriculture 61: 23-27.
- Patch, E.M. 1939. Food-plant catalogue of the aphids of the world. Maine Agricultural Experiment Station. Bulletin 393: 35-430.
- Patil, M.S. 1975. Some *Cercospora* species from Kolhapur India Part 2. Botanique (Nagpur) 6: 219-226. (BIOSIS).
- Patnaik, N.C., Mohanty, B. and Parida, A.K. 1987. *Nisaga simplex* caterpillar on rice in western Orissa. International Rice Research Newsletter 12: 44.
- Pawar, A.D. and Gupta, M. 1984. Importation of exotic phytophagous insects for the control of water hyacinth in India. Plant Protection Bulletin 36: 79-82.
- Pemberton, R.W. 1983. Exploration for natural enemies of *Passiflora mollissima* in the Andes. USDA Biological Control of Weeds Laboratory Albany, California. Unpublished report 125pp.
- Pencoe, N.L. and Martin, P.B. 1982. Grass hosts of fall armyworm: larval preference and methods of determination. Journal of the Georgia Entomological Society 17: 126-132. (Agricola).
- Penfound, W.T. and Earle, T.T. 1948. The biology of the water hyacinth. Ecological Monographs 18: 448-472.
- Peregrine, W.T.H. and Ahmad, K. 1982. Brunei: a first annotated list of plant diseases and associated organisms. Commonwealth Mycological Institute. Phytopathological Papers 27: 1-87.
- Perera, K.A.D.N., Chandrasena, J.P.N.R. and Tillekeratne, L.M.V. 1989. Further studies on allelopathic effects of torpedograss (*Panicum repens* L.). Proceedings, 12th Asian-Pacific Weed Science Society Conference 2: 433-439 (Weed Abstracts 41: 1652, 1992).
- Perera, P.A.C.R. 1981. Predation studies on *Pareuchaetes pseudoinsulata* (Lep: Arctiidae) using ³²P labelled immatures. Ceylon Coconut Quarterly 32: 105-110.

- Perez, A.Z. and Lopez, E. 1980. Two new hosts of *Elasmopalpus lignosellus* Zeller in Cuba. *Ciencias Agrícolas* 6: 106. (Maun and Barrett 1986).
- Perez, E., Orta, R. and Martinez, M.A. 1988. Influence of *Hemiargus hanno filenus* (Poey) on the reproductive potential of *Mimosa pudica* L. (Spanish). *Revista Biología Habana* 11(2): 65–68.
- Perez, M., Palenzuela, I., Ramirez, L.A. and Jackson, A. 1987. New hosts of *Tetranychus urticae* (Acari: Tetranychidae). (Spanish). *Revista de Protección Vegetal* 2: 63–65 (Review of *Agricultural Entomology* 78: 8426, 1990).
- Perju, T. 1989. Biological control of weeds in Romania. *Proceedings of the VII International Symposium on Biological Control of Weeds*, 6–11 March 1988, Rome, Italy, pp. 659–661.
- Perkins, B.D. 1973a. Potential for water hyacinth management with biological agents. *Proceedings Tall Timbers Conference on Ecological Animal Control by Habitat Management* 4. 24–25 February 1972. Tallahassee, Florida, USA, pp. 53–64.
- Perkins, B.D. 1973b. Preliminary studies of a strain of the water hyacinth mite from Argentina. *Proceedings of the Second International Symposium on Biological Control of Weeds*. October 1971. Rome, Italy. *Miscellaneous Publication* 6: 179–184. Commonwealth Institute of Biological Control, Commonwealth Agricultural Bureaux.
- Perkins, B.D. 1974. Arthropods that stress water hyacinth. *Pesticides Abstracts & News Summary*, A, 20: 304–314.
- Perkins, B.D. 1977a. Enhancement of effect of *Neochetina eichhorniae* for biological control of water hyacinth. *Proceedings of the IV International Symposium on Biological Control of Weeds*. Center for Environmental Programs. Institute of Food and Agricultural Sciences, Florida University 1977. Gainesville, Florida, USA, pp. 87–92.
- Perkins, B.D. 1977b. Preliminary results of integrating chemical and biological controls to combat water hyacinth.
- Perkins, B.D., Lovarco, M.M. and Durden, W.C.I. 1976. A technique for collecting adult *Neochetina eichhorniae* Warner (Coleoptera: Curculionidae) for water hyacinth control. (Note). *The Florida Entomologist* 59: 352.
- Perkins, B.D. and Maddox, D.H. 1976. Host specificity of *Neochetina bruchi* Hustache (Coleoptera: Curculionidae), a biological control agent for water hyacinth. *Journal of Aquatic Plant Management* 14: 59–64.
- Persley, G.J. 1973. Naturally occurring alternative hosts of *Xanthomonas albilineans* in Queensland. *Plant Disease Reporter* 57: 1040–1042.
- Pettett, A. and Pettett, S.J. 1970. Biological control of *Pistia stratiotes* in Western State, Nigeria. *Nature* 226: 282.
- Phillips, S.M. 1972. A survey of the genus *Eleusine* Gaertn. (Gramineae) in Africa. *Kew Bulletin* 27: 251–270.
- Pillai, K.S. and Nair, M.R.G.K. 1979. Biology and habits of the rice case worm *Nymphula depunctalis* in Kerala, India. *Entomon* 4: 13–16.
- Pitre, H.N. and Boyd, F.J. 1970. A study of the role of weeds in corn fields in the epidemiology of corn stunt disease. *Journal of Economic Entomology* 63: 195–197.
- Plana, L., Palenzuela, I., Perez, M., Diaz, L.E., Meza, P. and Gonzalez, J.L. 1986. Reporte de cuatro malezas hospedantes de *Monecphora bicincta fraterna* Uhler (Homoptera: Cercopidae). *Documentos de Ciencia y Técnica, Instituto Superior de Ciencias Agropecuarias de la Habana, Ciencias Agropecuarias* 5: 85–91. (Review of *Applied Entomology*, Series A, 76: 4049, 1988).
- Ponnappa, K. 1967. *Cercosporidium helleri* on *Sphenoclea zeylanica*—a new record from India. *Current Science* 10: 273.

- Ponnappa, K.M. 1976. Evaluation of *Alternaria eichhorniae* Nag Raj and Ponnappa as an agent of biological control of water hyacinth, *Eichhornia crassipes*, and some aspects of biology of the fungus. Technical Bulletin 17: 161–168. Commonwealth Institute of Biological Control, Commonwealth Agricultural Bureaux.
- Prabhu, A.S., Filippi, M.C. and Castro, N. 1992. Pathogenic variation among isolates of *Pyricularia oryzae* affecting rice, wheat and grasses in Brazil. Tropical Pest Management 38: 367–371.
- Puckdeedindan, P. 1966. A supplementary host list of plant diseases in Thailand. Technical Bulletin 7. Department of Agriculture, Bangkok. 24pp. (Holm et al. 1977).
- Purseglove, J.W. 1968. Tropical Crops. Dicotyledons 1 and 2 (1–719). Longman, London.
- Puttaswamy and Channabasavanna, G.P. 1981. Influence of three *Amaranthus* species on the development, fecundity and longevity of *Tetranychus novocaledonicus* (Acari: Tetranychidae). Colemania 1: 35–36. (Review of Applied Entomology, Series A, 70: 2612, 1982).
- Puttaswamy, Reddy, D.N.R. and Naik, L.K. 1981. Redgram bud weevil *Ceuthorhynchus asperulus* Faust (Coleoptera: Curculionidae) a pest on *Amaranthus*. Current Research 10(2): 33–35. (Review of Applied Entomology, Series A, 70: 966, 1982).
- Quintero, J., Rebellon, A. and De Agudelo, F.V. 1988. Distribution and identification of host species of *Heterodera glycines* Ichinoke race 3 in Valle del Cauca (Colombia). (Spanish). Acta Agronomica (Palmira) 38(1): 41–52
- Raabe, R. 1965. Checklist of some parasitic phanerogams and some of their hosts on the island of Hawaii in 1963. Plant Disease Reporter 49: 583–585.
- Rachie, K.O. and Peters, L.V. 1977. The Eleusines (a review of the world literature). International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, India. 179pp.
- Rader, W.E. 1948. *Helminthosporium portulacae* a new pathogen of *Portulaca oleracea* L. Mycologica 40: 342–346.
- Rahman, R. and Khan, M.W. 1986. Population growth of some ectoparasitic nematodes on vegetables and associated weeds. International Nematology Network Newsletter 3(3): 11–22. (Helminthological Abstracts Series B, 56: 261, 1987).
- Rajapakse, R.H.S., Ashley, T.R., Waddill, H. van and Van-Waddill, H. 1988. Interspecific competition of fall armyworm parasites. Brighton Crop Protection Conference. Pests and Diseases 1988, Vol 3: 1137–1141. (Review of Agricultural Entomology 79: 2457, 1991).
- Ramakrishnan, T.S. 1963. Diseases of Millets. Indian Council of Agricultural Research, New Delhi, 152pp. (Wapshere 1990b).
- Ramesh, P. and Laughlin, R. 1984. Dispersal of nymphs of *Nysius vinitor* Berg. and its importance in the management of sunflower crops. Proceedings of the Fourth Australian Applied Entomological Research Conference, Adelaide 1984, pp. 35–42.
- Rao, D.G., Varma, P.M. and Kapoor, S.P. 1965. Studies of mosaic disease of *Eleusine* in the Deccan. Indian Phytopathology 18: 139–150.
- Rao, P.N. 1966. A new species of *Dichotomophthora* on *Portulaca oleracea* from Hyderabad, India. Mycopathologia et Mycologia Applicata 28: 137–140.
- Rao, Y.S., Israel, P. and Biswas, H. 1970. Weed and rotation crop plants as hosts for the rice root-knot nematode *Meloidogyne graminicola* (Golden and Birchfield). *Oryza* 7: 137–142. (Helminthological Abstracts B, 46: 25, 1977).
- Raychaudhuri, D.N. 1983. Food Plant Catalogue of Indian Aphididae. University of Calcutta. 203pp.

- Raychaudhuri, D.N., Pal, P.K. and Ghosh, M.R. 1978. Root-infesting aphids (Homoptera: Aphididae: Pemphiginae) from north east India. *Entomon* 3: 234-264.
- Reddy, C.N. 1983. Seed mycoflora of finger millet (*Eleusine coracana*) and its effect on seed viability. *Current Science* 52: 488-490.
- Reddy, K.S., Yaraguntaiah, R.C. and Sastry, K.S. 1981. Strains of leaf curl virus of tomato in India. *Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz* 88: 400-404.
- Reis, E.M. 1982. Survey of cultivated, native and weed plants, hosts of fungi that cause root rots on winter cereals and other crops. *Summa Phytopathology* 8: 134-140. (Maun and Barrett 1986).
- Reyes, T.T. and Beguico, E.D. 1978. Nematodes in sugarcane. *NSDB Technology Journal, Philippines* 3(3): 25-30. (Helminthological Abstracts B, 49: 1609, 1980).
- Ribeiro, J.H.C. 1953. Sobre um inimigo do *Bidens pilosus*. *Agronomia* 12: 51-53.
- Rifai, M.A. 1980. The identity of *Ustilago amadelpha* var. *glabriuscula* (considered conspecific with *Ustilago overeemii* which is reclassified as *Sporisorium overeemii*, cause of smut on *Panicum repens* in Java). *Reinwardtia* 9: 399-401.
- Rochecouste, E. and Vaughan, R. 1959. Weeds of Mauritius. *Bidens pilosa* L. Leaflet Series 1. Mauritius Sugar Industry Research Institute, Reduit. (Holm et al. 1977).
- Romm, H.J. 1937. The insect predators of purslane (*Portulaca oleracea* L.). *Florida Entomologist* 20: 43-47 and 51-61.
- Room, P.M. 1993. Biological control of floating weeds in the Pacific: history and status. *Micronesica*, Supplement 4: 41-47.
- Room, P.M. and Fernando, I.V.S. 1992. Weed invasions countered by biological control: *Salvinia molesta* and *Eichhornia crassipes* in Sri Lanka. *Aquatic Botany* 42: 99-107.
- Room, P.M., Forno, I.W. and Taylor, M.F.J. 1984. Establishment in Australia of two insects for the biological control of the floating weed *Salvinia molesta*. *Bulletin of Entomological Research* 74: 505-516.
- Rossel, H.W., Nabukenya, R., Thottapilly, G. and Zagre, M'B.B. 1984. Maize. *Virology. International Institute of Tropical Agriculture, 1983 Annual Report* pp. 42-43.
- Roy, A.K. 1973. Natural occurrence of *Corticium sasakii* on some weeds. *Current Science* 42: 842-843.
- Russo, V.M. 1985. Leaf spot disease of *Chromolaena odorata* caused by *Septoria* sp. in Guam. *Plant Disease* 69: 1101.
- Sabrosky, C.W. 1950. The genus *Dicraeus* in North America (Diptera, Chloropidae). *Proceedings of the Entomological Society of Washington* 52(2): 53-62.
- Sadana, G.L., Gupta, B.K. and Chopra, R. 1983. Mites associated with the crops and weeds in the Punjab, India. *Science and Culture* 49: 184-186.
- Safeulla, K.M. 1976. Biology and Control of the Downy Mildews of Pearl Millet, Sorghum and Finger Millet. Mysore University, Mysore, 304pp. (Wapshere 1990b).
- Sakimura, K. 1937. A survey of host ranges of thrips in and around Hawaiian pineapple fields. *Proceedings of the Hawaiian Entomological Society* 9: 415-427.
- Salamat, G.Z., Parejarearn, A. and Hibino, H. 1987. Weed hosts of ragged stunt virus. *International Rice Research Newsletter* 12(4): 30.
- Salawu, E.O., Ambursa, A.S. and Managa, Y.B. 1991. Weed and crop hosts of root-knot nematode, *Meloidogyne javanica* (Treub 1885) Chitwood 1949 in north west Nigeria. *Pakistan Journal of Nematology* 9: 109-118.
- Salgado, M.L.M. 1972. *Tephrosia purpurea* (Pila) for the control of *Eupatorium* and as a green manure on coconut estates. *Ceylon Coconut Planters Review* 6: 160-174.

- Sampson, M.A. and Kumar, R. 1986. Alternative host plants of sugar-cane stem-borers in southern Ghana. *Insect Science and its Application* 7: 539-541.
- Sands, D.P.A. and Kassulke, R.C. 1983. *Acigona infusella* (Walker) (Lepidoptera: Pyralidae), an agent for biological control of water hyacinth (*Eichhornia crassipes*) in Australia. *Bulletin of Entomological Research* 73: 625-632.
- Sands, D.P.A. and Kassulke, R.C. 1984. *Samea multiplicalis* (Lep.: Pyralidae) for biological control of two water weeds *Salvinia molesta* and *Pistia stratiotes* in Australia. *Entomophaga* 29: 267-273.
- Sankaran, T. 1974. Evaluation of natural enemies associated with witchweed, nutsedge and several other aquatic weeds occurring in India. Final Report P.L. 480 Project. India Station, CIBC, Bangalore. 56pp.
- Sankaran, T. and Ramaseshiah, G. 1974. Prospects for biological control of some major aquatic weeds in Southeast Asia. CIBC Indian Station. Mimeographed Report. 15pp.
- Sankaran, T. and Rao, V.P. 1972. An annotated list of insects attacking some terrestrial and aquatic weeds in India, with records of some parasites of the phytophagous insects. CIBC Technical Bulletin 15: 131-157.
- Sankaran, T. and Sugathan, G. 1974. Host-specificity tests and field trials with *Ammalo insulata* (Wlk.) (Lep.: Arctiidae) in India. Commonwealth Institute of Biological Control. Unpublished report. 11pp.
- Sankaran, T., Rao, V.P., Rao, H.D. and Narayanan 1964. Commonwealth Institute of Biological Control. Report of work carried out during 1963. *Insects*. pp. 36-39.
- Sankaran, T., Srinath, D. and Krishna, K. 1966. Studies on *Gesonula punctifrons* Stal. (Orthoptera: Acrididae: Cyrtacanthacridinae) attacking water hyacinth in India. *Entomophaga* 11: 433-440.
- Sastroutomo, S.S., Ikusima, I and Numata, M. 1978. Ecological studies of water hyacinth (*Eichhornia crassipes* Mart. Solms) with special emphasis on their growth. *Japanese Journal of Ecology* 28: 191-197.
- Sastry, K.S. 1984. Strains of tomato leaf curl virus and its perpetuation under field conditions. *Journal of Turkish Phytopathology* 13: 87-90. (Review of *Plant Pathology* 64: 3189, 1985).
- Satheesan, N.V., Lyla, K.R., Joy, P.J. and Joseph, D. 1987. Establishment of *Pareuchaetes pseudoinsulata* Rego Barros (= *Ammalo insulata* Walk.), an arctiid caterpillar, for the biological control of *Chromolaena odorata*. *Agricultural Research Journal of Kerala* 25: 142-143.
- Sathiarajan, P.K. and Sasikumar, S. 1977. *Ageratum conyzoides* Linn; a weed host of *Psuedomonas solanacearum*, E.F. Smith. *Agricultural Research Journal of Kerala* 14: 188 (Agricola).
- Sauer, M.R. and Alexander, D.M. 1979. Root-knot resistance in *Passiflora foetida*. *Australasian Plant Pathology* 8(4): 50-51.
- Savoie, K.L. 1988. Selective feeding by species of *Spodoptera* (Lepidoptera: Noctuidae) in a bean field with minimum tillage (Spanish). *Turrialba* 38: 67-70. (Review of *Agricultural Entomology* 78: 4848, 1990).
- Saxena, A.K., Jain, S.K. and Saksena, S.B. 1981. Additions to the host range of *Macrophomina phaseolina*. *Indian National Academy of Sciences, Letters* 4: 357.
- Scheepens, P.C. 1987. Joint action of *Cochliobolus lunatus* and atrazine on *Echinochloa crus-galli* (L.) Beauv. *Weed Research* 27: 43-47.
- Schmutz, E., Preenan, B. and Reed, R. 1968. The livestock poisoning plants of Arizona. University of Arizona Press, Tucson. 176pp. (Holm et al. 1977).

- Schreiner, I.H., Nafus, D.M. and Dumaliang, N. 1990. Growth and survival of the Asian corn borer *Ostrinia furnacalis* Guenée (Lep: Pyralidae) on alternative hosts in Guam. *Tropical Pest Management* 36: 93–96.
- Seibert, T.F. 1989. Biological control of the weed, *Chromolaena odorata* (Asteraceae), by *Pareuchaetes pseudoinsulata* (Lepidoptera: Arctiidae) on Guam and the Northern Mariana Islands. *Entomophaga* 34: 531–539.
- Seier, M.K. and Evans, H.C. 1993. Proposal to import the fungus *Sphaerulina mimosae-pigrae* (*Phloeospora mimosae-pigrae*) into Australia for the biological control of the giant sensitive plant, *Mimosa pigra*. CAB Institute of Biological Control, Ascot, UK. 131pp.
- Sher, S.A. 1954. Observations on plant-parasitic nematodes in Hawaii. *Plant Disease Reporter* 38: 687–689.
- Shetty, H.S., Gopinath, A. and Rajashekar, K. 1985. Relationship of seed-borne inoculum of *Pyricularia grisea* to the incidence of blast of finger millet in the field. *Indian Phytopathology* 38: 154–156.
- Shinkai, A. 1956. Host range of rice stripe disease (further report) (Japanese). *Annals of the Phytopathological Society of Japan* 21: 47 (Holm et al. 1977).
- Shoemaker, R.A. 1962. *Drechslera* Ito. *Canadian Journal of Botany* 40: 809–836.
- Shreni, V.C.D., Srivastava, K.M. and Singh, B.P. 1979. Vein yellowing of *Ageratum conyzoides*—a whitefly transmitted disease from India. *New Botanist* 6: 97–102. (Review of *Plant Pathology* 60: 4163, 1981).
- Silveira-Guido, A. 1971. Datos preliminares de biología y especificidad de *Acigona ignitalis* Hamps. (Lep., Pyralidae) sobre el hospedero *Eichhornia crassipes* (Mart.) Solms-Laubach (Pontederiaceae). *Revista de la Sociedad Entomologica Argentina* 33: 137–145.
- Simmonds, J.H. 1966. Host Index of Plant Diseases in Queensland. Queensland Department of Primary Industries, Brisbane. pp. 22–37.
- Singh, K.G. 1980. A check list of host and disease in Malaysia. Ministry of Agriculture, Malaysia. *Bulletin* 154: 1–280.
- Singh, N.D. 1974. Some host plants of the reniform nematode in Trinidad. (eds) C.W.D. Braithwaite, R.H. Phelps and F.D. Bennett. Proceedings of a symposium on the protection of horticultural crops in the Caribbean held at the University of the West Indies, St Augustine, Trinidad, 8–11 April 1974, pp. 119–124.
- Singh, N., Gill, J.S. and Krishnanada, N. 1979. Prevalence of root-knot nematode in Nilgiri hills. *Indian Phytopathology* 32: 499–501.
- Singh, R.A. and Misra, A.P. 1978. Some new hosts for *Helminthosporium holmii* leaf spot from India. *Indian Phytopathology* 31: 264–266. (Agricola).
- Singh, S. and Beri, S.K. 1973. Studies on the immature stages of Agromyzidae (Diptera) from India. Part III. Notes on the biology and description of immature stages of three species of *Melanagromyza* Hendel. *Journal of Natural History* 7: 23–32.
- Singh, S., Verma, V.S. and Padma, R. 1975. A mosaic disease of *Digera arvensis* Forsk. *Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz* 82: 180–182.
- Singh, S.R., Kamath, M.K., Kumar, K., Autar, M.L. and Lal, S.L. 1981. Fiji Department of Agriculture Annual Research Report for 1979: 77–78.
- Singh, S.R., Prasad, R.S. and Solly, R.K. 1982. The status of *Neochetina eichhorniae* Warner (Coleoptera, Curculionidae) as biological control agent for water hyacinth *Eichhornia crassipes* (Mart) Solms (Fam: Pontederiaceae) in Fiji. Report of the Regional Workshop on Biological Control of Water Hyacinth. 3–5 May 1982, Bangalore, India. Commonwealth Science Council, pp. 35–38.

- Sisounthone, C. and Sisombat, L. 1973. Brief information on weeds in rice fields in Laos. The Second Indonesian Weed Science Conference, Yogyakarta, April 2-5, 1973, pp. 151-153.
- Sivapragasam, A. 1983. Weed hosts for *Cyrtorhinus lividipennis* (Reuter) a brown planthopper predator. International Rice Research Newsletter 8(6): 19-20.
- Smith, C.S. and Wilson, C.G. 1992. Use of an artificial diet for rearing the *Mimosa* clearwing moth, *Carmenta mimosa*. Abstracts, VIII International Symposium on Biological Control of Weeds, Lincoln University, Canterbury, New Zealand, 2-7 February 1992, p. 80.
- Soerjani, M., Kostermans, A.J.G.H. and Tjitrosoepomo, G. 1987. Weeds of Rice in Indonesia. Balai Pustaka, Jakarta. 732pp.
- Spencer, K.A. 1961. A synopsis of the oriental Agromyzidae (Diptera). Transactions of the Royal Entomological Society of London 113: 55-100.
- Spencer, K.A. 1973. Agromyzidae (Diptera) of economic importance. Series Entomologica. 9. Dr W. Junk, The Hague. 405pp.
- Spencer, K.A. 1990. Host Specialization in the World Agromyzidae. Series Entomologica. 45, Kluwer Academic Publishers. 445pp.
- Spencer, K.A. and Steyskal, G.C. 1986. Manual of the Agromyzidae (Diptera) of the United States. United States Department of Agriculture. Agriculture Handbook No 638. 478pp.
- Srivastava, K.M. Singh, B.P., Dwadash Shreni, V.C. and Srivastava, B.N. 1977. Zinnia yellow net disease-transmission, host range and agent-vector relationship. Plant Disease Reporter 61: 550-554.
- Srivastava, R.C. 1981. Fungi causing plant disease at Jaunpur (U.P.). IV. Indian Phytopathology 33: 221-224.
- Stevens, F. 1925. Hawaiian fungi. Bernice P. Bishop Museum, Honolulu, Bulletin 19, 189pp. (Holm et al. 1977).
- Steyskal, G.C. 1972. The dipterous fauna of the heads of *Bidens pilosa* re-examined. Florida Entomologist 55: 87-88.
- Stoyanov, D. 1972. *Heterodera amaranthi* n.sp. (Tylenchida: Heteroderidae); un nématodo formador de quistes en Cuba. Poeyana 97:1.
- Strider, D.L. and Chi, T.T.L. 1984. Damping-off of portulaca caused by *Helminthosporium (Bipolaris) portulacae* in North Carolina. Plant Disease 68: 826.
- Suasa-Ard, W. 1976. Ecological investigation on *Namangana pectinicornis* Hampson (Lepidoptera: Noctuidae), as a potential biological control agent of the water lettuce, *Pistia stratiotes* L. (Araceae). M.S. Thesis Kasetsart University, Bangkok. 59pp.
- Suasa-Ard, W. and Napompeth, B. 1978. Investigation on *Episammia pectinicornis* (Hampson) (Lepidoptera: Noctuidae) for biological control of the water lettuce in Thailand. (Thai). National Biological Control Research Centre, Kasetsart University, Bangkok Technical Bulletin 3. 10pp.
- Subagyo, T. 1975. Some aspects of the biology of *Nymphula responsalis* Wlk. attacking *Salvinia* spp. BIOTROP Newsletter 12: 14.
- Sulochana, K.K., Wilson, K.I. and Nair, M.C. 1982. Some new host records for *Cylindrocladium quinqueseptatum* from India. Agricultural Research Journal of Kerala 20: 106-108. (Review of Plant Pathology 64: 4207, 1985).
- Sunaina, V., Kishore, V. and Shekhawat, G.S. 1989. Latent survival of *Pseudomonas solanacearum* in potato tubers and weeds. Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz 96: 361-363. (Review of Plant Pathology 39: 2327, 1990).
- Suriapermana, S. 1977. Weed competition in transplanted rice. International Rice Research Newsletter 2(3): 9-10.

- Suteri, B.D., Joshi, C.C. and Bala, S. 1980. Some ornamentals and weeds as reservoirs of potato virus Y and cucumber mosaic virus in Kumaon. *Indian Phytopathology* 32: 640.
- Swarbrick, J.T. 1981. Weeds of Australia. 3. Passifloraceae—the passion flowers. *Australian Weeds* 1(2): 20–22.
- Syed, R.A. 1973. Report on biological control of *Eupatorium odoratum* for Sabah. Commonwealth Institute of Biological Control. Unpublished report. 10pp.
- Syed, R.A. 1975. Commonwealth Institute of Biological Control. Report of work carried out during 1974. Biological control of *Eupatorium odoratum*. pp. 83–84.
- Syed, R.A. 1979a. An attempt on biological control of *Eupatorium odoratum* L. f. in Sabah, Malaysia. (ed.) Soerjani. Proceedings of the Sixth Asian-Pacific Weed Science Society, 1977, Jakarta Indonesia 2: 459–466. (Cock 1984).
- Syed, R.A. 1979b. Some aspects of biological control of weeds in Southeast Asia. Second Indonesian Weed Science Conference, Yogyakarta, April 2–5, 1973. *BIOTROP Bulletin* 11: 311–318.
- Syed, R.A., Setywati, O. and Kasno 1977. Commonwealth Institute of Biological Control. Report of work carried out during 1976. Biological control of some important aquatic weeds. pp. 87–89.
- Tawfik, M.F.S., Awadallah, K.T. and Shalaby, F.F. 1976. Survey of insects found on common weeds in Giza region, Egypt. *Bulletin of the Entomological Society of Egypt* 60: 7–14.
- Tedford, E.C. and Fortnum, B.A. 1988. Weed hosts of *Meloidogyne arenaria* and *M. incognita* common in tobacco fields in South Carolina. *Annals of Applied Nematology* 2: 102–105. (Weed Abstracts 38: 2559, 1989).
- Tempère, G. 1943. Observations sur *Hypurus bertrandi* Perris, Coléoptère, Curculionidae nuisible au pourpier. *Revue de Zoologie Agricole et Appliquée* 42 (9–10): 49–55. (Review of Applied Entomology A, 34: 349, 1946).
- Tempère, G. 1944. Remarques sur *Hypurus bertrandi* Perris. *Bulletin de la Société Linnéenne de Lyon* 13: 78–80.
- Tempère, G. 1950. L'éthologie des Hypurini (Col. Curculionidae) (Note préliminaire). *Bulletin de la Société Entomologique de France* 55: 57–61.
- Teng, S. 1932. Fungi of Nanking II. Contribution from the biological laboratory of the Science Society of China. *Botanical Series* 8: 5–48. (Holm et al. 1977).
- Teoh, C.H., Chung, G.F., Liau, S.S., Ghani, I., Tan, A.M., Lee, S.A. and Mariati, M. 1985. Prospects for biological control of *Mikania micrantha* HBK in Malaysia. *Planter* 61: 515–530.
- Thangavelu, K. 1978. First record of host plants and additional distribution of *Nysius inconspicuus* Distant. *Current Science* 47: 249.
- Thite, A.N. and Chavan, P.D. 1977. A new leaf spot disease of *Pennisetum* spp. caused by *Helminthosporium rostratum*. *Maharashtra Vidnyan Mandir Patrika* 12(2): 63–65. (Review of Plant Pathology 57: 277, 1978).
- Thomas, P.A. and Room, P.M. 1986. Taxonomy and control of *Salvinia molesta*. *Nature* 320: 581–584.
- Thompson, C.R. and Habeck, D.H. 1988. Host specificity and biology of the weevil *Neohydronomus pulchellus* Hustache, biological control agent of water lettuce (*Pistia stratiotes* L.). U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. Technical Report A-83-10, 23 pp.

- Thompson, C.R. and Habeck, D.H. 1989. Host specificity and biology of the weevil *Neohydronomus affinis* (Coleoptera: Curculionidae) a biological control agent of *Pistia stratiotes*. *Entomophaga* 34: 299–306.
- Thottappilly, G., Lent, J.W.M. van, Rossel, H.W. and Sehgal, O.P. 1992. *Rottboellia* yellow mottle virus, a new solemovirus affecting *Rottboellia cochinchinensis* (itch grass) in Nigeria. *Annals of Applied Biology* 120: 405–415.
- Tjitrosoedirdjo, S. 1990. *Pennisetum polystachion* (L.) Schult. SEAMEO BIOTROP, Bogor, Indonesia. *Weed Info Sheet* 3, 2pp.
- Tjitrosoedirdjo, S. 1991. *Chromolaena odorata* (L.) R.M. King and H. Robinson. SEAMEO, BIOTROP, Bogor, Indonesia. *Weed Info Sheet* 5, 4pp.
- Tjitrosoedirdjo, S., Tjitrosoedirdjo, S.S. and Umaly, R.C. 1991. The status of *Chromolaena odorata* (L.) R.M. King and H. Robinson in Indonesia. *Ecology and Management of Chromolaena odorata*. BIOTROP Special Publication 44: 57–66.
- Togashi, K. 1942. A survey of the plant diseases of cultivated plants in Iwate Prefecture in 1941. *Bulletin* 8. Iwate Agricultural Experiment Station, Morioka. 25pp. (Holm et al. 1977).
- Torres, D.O. 1986. Potential insect biocontrol agents against the weed *Chromolaena odorata* R.M. King and H. Robinson in the Philippines. *Philippine Entomologist* 6: 535–536.
- Torres, D.O. 1988. Infestation of *Chromolaena odorata* R.M. King and H. Robinson in the Philippines and search for local insects with potential as biological control agents. *Weedwatcher* 849: 12.
- Torres, D.O. and Paller, E.C. 1989. The devil weed (*Chromolaena odorata* R.M. King and H. Robinson) and its management. *SEAWIC Weed Leaflet* 4. 6pp.
- Toye, S.A. 1974. Feeding and locomotory activities of *Zonocerus variegatus* (L.) (Orthoptera, Acridoidea). *Revue de Zoologie Africaine* 88: 205–212.
- Trujillo, G.E., Acosta, J.M. and Pinero, A. 1974. A new corn virus found in Venezuela. *Plant Disease Reporter* 58: 122–126.
- Tryon, R.M. and Tryon, A.F. 1982. *Ferns and Allied Plants with Special Reference to Tropical America*. Springer-Verlag, New York, 537 pp.
- Ueki, K. and Oki, Y. 1979. Seed production and germination of *Eichhornia crassipes* in Japan. *Proceedings of the Seventh Asian-Pacific Weed Science Society Conference*. Australia; Asian-Pacific Weed Science Societies. 26–30 November 1979. Orange, Australia, 25 pp.
- Ukwela, M.U. and Ewete, F.K. 1989. Studies on the biology and population assessment of *Cletus fuscescens* Walk. (Heteroptera: Coreidae) on *Amaranthus* in western Nigeria. National Horticultural Research Institute, Ibadan. *Occasional Paper* 24. 15pp. (Review of *Agricultural Entomology* 79: 4760, 1991).
- Ullstrup, A.J. 1955. Crazy top of some wild grasses and the occurrence of the sporangial stage of the pathogen. *Plant Diseases Reporter* 39: 839–841.
- Umraht, K., Thaler, I. and Steiner, G. 1979. Reduced quantity of excitatory substance and morphological changes in virus infested *Mimosa pudica* (German). *Phyton Annales Rei Botanicae* 19: 247–251.
- Valdez, R. 1968. Survey, identification and host-parasite relationships of root-knot nematodes occurring in some parts of the Philippines. *Philippine Agriculturist* 51: 802–824. (Holm et al. 1977).
- Valent, B., Crawford, M.S., Weaver, C.G. and Chumley, F.G. 1986. Genetic studies of fertility and pathogenicity in *Magnaporthe grisea* (*Pyricularia oryzae*). *Iowa State Journal of Research* 60: 569–594. (Review of *Plant Pathology*, 65: 4921, 1986).
- Van Velsen, R.J. 1961. Chlorotic spot, a virus disease of *Passiflora foetida* in New Guinea. *Papua and New Guinea Agricultural Journal* 13: 160–166.

- Vega, J., Almeida, A.M.R. and Costa, A.S. 1981. A mycoplasma-like organism associated with witches' broom disease of *Bidens pilosa* L. (Portuguese). *Fitopatologia Brasileira* 6: 29–33.
- Vegh, I. and Le Berre, A. 1984. Presence in France of two new diseases in purslane and tarragon. (French). *Revue Horticole* 249: 15–17 (Review of Plant Pathology 63: 5064, 1984).
- Vengris, J., Palacz, A.K., Shaw, F.R. and Ziener, W.H. 1963. Weevil affects barnyard grass in Massachusetts. *Weeds* 11: 321–322.
- Venkataramaiah, G.H. 1974. A note on *Dialeurodes vulgaris* on coffee. *Journal of Coffee Research* 1: 13–14.
- Venturi, F. 1960. Insetti e aragnidi delle piante Comuni del Venezuela segnalati nel periodo 1938–1963. *Relazione Monografiche Agarie Subtropicale. Tropicale* 86: 149–150 (Pemberton 1983).
- Viraktamath, C.A. and Muniappan, R. 1992. New records of insects on *Chromolaena odorata* in India. *Chromolaena odorata Newsletter* 5: 1, 4.
- Vodianiaia, L.A., Maglakelidze, A.I., Lebedev, V.B., Kozlova, L.F. and Iakushevich, M.I. 1986. Role of the completed stage of the life cycle of the fungus *Pyricularia grisea* (Russian). *Bulletin, Academy of Sciences Georgia USSR* 122: 401–404. (Agricola).
- Vogel, E. and Oliver, A.D. 1969. Life history and some factors affecting the population of *Arzama densa* in Louisiana. *Annals of the Entomological Society of America* 62: 749–752.
- Vogt G.B. and Cordo, H.A. 1976. Recent South American field studies of prospective biocontrol agents of weeds. *Proceedings Research Planning Conference on the Aquatic Plant Control Program. 22–24 October 1975. Charleston, South Carolina, USA. U.S. Army Engineer Waterways Experiment Station, Missouri, Miscellaneous Paper A-76-1: 36–55.*
- Vrbanov, V.M. and Krumov, K.I. 1989. Spreading and hosts of *Polymyxa betae* parasite of sugar beet and vector of rhizomal pathogen. (Bulgarian). *Rasteniev 'dn Nauki* 26(8): 80–85.
- Waage, J.T., Smiley, J.T. and Gilbert, L.E. 1981. The *Passiflora* problem in Hawaii: prospects and problems of controlling the forest weed *P. mollissima* (Passifloraceae) with heliconiinae butterflies. *Entomophaga* 26: 275–284.
- Wagner, W.L., Herbst, D.R. and Sohmer, S.H. 1990. *Manual of the Flowering Plants of Hawaii*. Bishop Museum Special Publication 83. Volume II. University of Hawaii Press.
- Walker, H.L. and White, J.C. 1979. *Curvularia cymbopogonis*, a pathogen of itchgrass (*Rottboellia exaltata*) in southern Louisiana. *Plant Disease Reporter* 63: 642–644.
- Wapshere, A.J. 1990a. Biological control options for some grass weeds in Australia. (eds) C. Bassett, L.J. Whitehouse and J.A. Zabkiewicz. *Alternatives to the Chemical Control of Weeds. Proceedings of an International Conference, Rotorua, New Zealand, July 1989. Ministry of Forestry, FRI Bulletin* 155: 80–84.
- Wapshere, A.J. 1990b. Discussion of the biological control of crowfoot grass (*Eleusine indica*) in India, Africa and Australia. *Proceedings of the 9th Australian Weeds Conference, Adelaide, South Australia, August 6–10, 1990*, pp. 484–489.
- Wapshere, A.J. 1990c. Biological control of grass weeds in Australia: an appraisal. *Plant Protection Quarterly* 5: 62–75.
- Wara-Aswapati, O. 1983. Seed production and germination of *Mimosa pigra* L. in Chiangmai, Thailand. (eds) G.L. Robert and D.H. Habeck. *Proceedings, International Symposium on Mimosa pigra Management, Chiang Mai, Thailand. International Plant Protection Center, Corvallis, Document 48-A-83: 81–83.*

- Watanakul, L. 1964. A study on the host range of tungro and orange leaf virus of rice. M.S. Thesis, College of Agriculture, University of the Philippines, Los Baños. (Holm et al. 1977).
- Waterhouse, D.F. 1992. Prospects for biological control of paddy weeds in Southeast Asia and some recent successes in the biological control of aquatic weeds. Proceedings of International Symposium on Biological Control and Integrated Pest Management of Paddy and Aquatic Weeds in Asia, pp. 21–42. National Agricultural Research Centre, Kannondai 3–1–1. Tsukuba, Ibaraki 305, Japan, October 1992.
- Waterhouse, D.F. 1993a. The major arthropod pests and weeds of agriculture in Southeast Asia: distribution, importance and origin. Australian Centre for International Agricultural Research, Canberra, Australia. 141pp.
- Waterhouse, D.F. 1993b. Biological Control: Pacific Prospects. Supplement 2. Australian Centre for International Agricultural Research, Canberra. 138 pp.
- Waterhouse, D.F. and Norris, K.R. 1987. Biological Control: Pacific Prospects. Inkata Press, Melbourne, 454pp.
- Way, M.O., Grigarick, A.A. and Mahr, S.E. 1983. Effects of rice plant density, rice water weevil (Coleoptera: Curculionidae) damage to rice and aquatic weeds on aster leafhopper (Homoptera: Cicadellidae) density. Environmental Entomology 12: 949–952.
- Webster, F.M. and Mally, C.W. 1900. The purslane sawfly—*Schizocerus zabriskei* Ashm. Canadian Entomologist 32: 51–54.
- Wee, Y.C. 1974. Viable seeds and spores of weed species in peat soil under pineapple cultivation. Weed Research 14: 193–196.
- West, J.G. 1990. Portulacaceae. pp. 178–185, (ed.) G.J. Harden, Flora of NSW, NSW University Press Volume 1, 601pp.
- Wibmer, G.J. and O'Brien, C.W. 1989. Two new neotropical genera in the weevil tribe Stenopelmini. Southwestern Entomologist 14: 395–408. (Review of Agricultural Entomology 78: 9497, 1990).
- Wild, C.H. 1986. Host specificity report on *Scamurius* sp. (Hemiptera, Heteroptera: Coreidae) an agent for the biological control of giant sensitive plant (*Mimosa invisa* Mart.: Mimosaceae) in Queensland. Queensland Department of Lands Report. 15pp.
- Wild, C.H. 1987. Supplement to host specificity report on *Scamurius* sp. (Hemiptera, Heteroptera: Coreidae) an agent for the biological control of giant sensitive plant (*Mimosa invisa* Mart.: Mimosaceae) in Queensland. Queensland Department of Lands Report. 4pp.
- Williams, C., Vagalo, M., Tsatsia, F. and Pauku, R. 1990. Entomology Section Report. Research Division Internal Report, Ministry of Agriculture and Lands. Solomon Islands. Chapter 13: 1–9.
- Willson, B.W. 1987. Host specificity report on *Heteropsylla* sp. (Hemiptera, Homoptera: Psyllidae) an agent for the biological control of giant sensitive plant (*Mimosa invisa* Mart.: Mimosaceae) in Queensland. Queensland Department of Lands Report. 12pp.
- Willson, B.W. and Ablin, M.P. 1991. Biological control of *Mimosa invisa*—Western Samoa. Progress Report—ACIAR Project 8801, June 1991. 7pp. Queensland Department of Lands.
- Willson, B.W. and Garcia, C.A. 1992. Host specificity and biology of *Heteropsylla spinulosa* (Hom.: Psyllidae) introduced into Australia and Western Samoa for the biological control of *Mimosa invisa*. Entomophaga 37: 293–299.
- Wilson, A.K. 1981. *Euphorbia heterophylla*: a review of distribution, importance and control. Tropical Pest Management 27: 32–38.

- Wilson, C.G. 1992. The biological control programme against *Mimosa pigra* in Australia's Northern Territory. Abstracts VIII International Symposium on Biological Control of Weeds, Lincoln University, Canterbury, New Zealand, 2-7 February 1992, p. 13.
- Wilson, C.G. and Flanagan, G.J. 1990. Establishment and spread of *Neurostrotta gunniella* on *Mimosa pigra* in the Northern Territory. Proceedings of the Ninth Australian Weeds Conference, Adelaide, South Australia, pp. 505-507
- Wilson, C.G. and Flanagan, G.J. 1991. Establishment of *Acanthoscelides quadridentatus* (Schaeffer) and *A. puniceus* Johnson (Coleoptera: Bruchidae) on *Mimosa pigra* L. in northern Australia. Journal of the Australian Entomological Society 30: 279-280.
- Wilson, C.G., Flanagan, G.J. and Gillett, J.D. 1990. The phytophagous insect fauna of the introduced shrub, *Mimosa pigra* in Northern Australia and its relevance to biological control. Environmental Entomology 19: 776-784.
- Wilson, C.G., Forno, I.W., Smith, C.S. and Napompeth, B. 1992. Rearing and release methods for biological control agents. (ed.) K.L.S. Harley, A Guide to the Management of *Mimosa pigra*, CSIRO, Canberra, pp. 49-62.
- Wilson, F. 1964. The biological control of weeds. Annual Review of Entomology 9: 225-244.
- Wolcott, G.N. 1948. The insects of Puerto Rico. Journal of Agriculture, University of Puerto Rico 32: 1-975. (Bennett and Cruttwell 1972).
- Wong, P.W. 1964. Evidence for the presence of growth inhibitory substances in *Mikania cordata* (Burm. f.) B.L. Robinson. Journal of the Rubber Research Institute of Malaya 18: 231-241.
- Wright, A.D. 1979. Preliminary report on damage to *Eichhornia crassipes* by an introduced weevil at a central Queensland liberation site. Proceedings of the Seventh Asian-Pacific Weed Science Society Conference. Australia; Asian-Pacific Weed Science Societies. 26-30 November 1979. Orange, Australia, pp. 227-229.
- Wright, A.D. 1981. Biological control of water hyacinth in Australia. Proceedings of the 5th International Symposium on Biological Control of Weeds, pp. 529-535.
- Wright, A.D. 1982. Progress towards biological control of water hyacinth in Australia. Proceedings, Workshop on Biological Control of Water Hyacinth. Commonwealth Science Council. London. 3-5 May 1982. Bangalore, India, pp. 31-33.
- Wright, A.D. 1984. Effect of biological control agents on water hyacinth in Australia. Proceedings of the International Conference on Water Hyacinth. United Nations Environment Programme. 7-11 February 1983. Hyderabad, India, pp. 823-833.
- Wright, A.D. 1987. A basis for integrating biological and chemical control of water hyacinth (*Eichhornia crassipes* (Mart.) Solms). Master of Philosophy Thesis, School of Environmental Studies, Griffith University.
- Wright, A.D. and Bourne, A.S. 1986. Effect of leaf hardness on penetration of water hyacinth by *Sameodes albipunctalis*. Journal of Aquatic Plant Management 24: 90-91.
- Wright, A.D. and Bourne, A.S. 1990. Effect of 2, 4-D on the quality of water hyacinth as food for insects. Plant Protection Quarterly 5: 139-141.
- Wright, A.D. and Stegeman, D.A. 1990. The weevil, *Neochetina bruchi*, could help control water hyacinth in Australia. Proceedings of the 9th Australian Weeds Conference, Adelaide, South Australia, August 6-10, pp. 508-510.
- Wu, Q.N. and Liang, K.G. 1984. Host range of *Helminthosporium maydis* Nish and Miyake. (Chinese). Acta Phytopathologica Sinica 14: 79-86. (Review of Plant Pathology 64: 1088, 1985).

- Xie, L.H., Lin, Q.Y. and Wang, S.F. 1984. On the preparation and use of an antiserum to rice ragged stunt virus. (Chinese). *Acta Phytopathologica Sinica* 14: 147–151. (Review of Applied Pathology 64: 2513, 1985).
- Yadav, A.S. and Tripathi, R.S. 1982. A study on seed population dynamics of three weedy species of *Eupatorium odorata*. *Weed Research* 22: 69–76.
- Yaseen, M. 1971. *Mimosa pudica*. Report on work carried out during 1970. Commonwealth Institute of Biological Control. Commonwealth Agricultural Bureaux, p. 92.
- Yaseen, M. 1972. *Mimosa pudica*. Report on work carried out during 1971. Commonwealth Institute of Biological Control. Commonwealth Agricultural Bureaux, p. 107.
- Yaseen, M. and Bennett, F.D. 1977. Commonwealth Institute of Biological Control. Report of work carried out during 1976. Control of Siam weed, *Eupatorium odoratum*, pp. 75–76.
- Yonaha, T., Tamori, M., Yamanoha, S. and Nakasone, T. 1979. Studies on passion fruit virus diseases in Okinawa. 1. Cucumber mosaic virus isolated from diseased *Passiflora edulis* and *Passiflora foetida* plants (Japanese). *Science Bulletin of the College of Agriculture, University of the Ryukyus* 1979 (No 26): 29–38. (Review of Plant Pathology 60: 1553, 1981).
- Yorinori, J.T. 1985. Biological control of milk weed (*Euphorbia heterophylla*) with pathogenic fungi. Proceedings of the VI International Symposium on Biological Control of Weeds. Agriculture Canada 1985, pp. 677–681.
- Zaka-ur-rab, M. 1991. Leaf mining Coleoptera of the Indian subcontinent. *Journal of Entomological Research (New Delhi)* 15: 20–30.
- Zehr, E.I., Aitken, J.B., Scott, J.M. and Meyer, J.R. 1990. Additional hosts for the ring nematode *Criconebella xenoplax*. *Journal of Nematology* 22: 86–89.
- Zeigler, R.S. and Lozano, J.C. 1983. The relationship of some *Elsinoe* and *Sphaceloma* species pathogenic on cassava and other Euphorbiaceae in Central and South America. *Phytopathology* 73: 293–300.
- Zem, A.C. and Lordello, L.G.E. 1983. Studies on hosts of *Radopholus similis* and *Helicotylenchus multicinctus* (Portuguese). Trabalhos apresentados a VII Reuniao Brasileira de Nematologia, Brasilia, D.F. 21–25 de fevereiro de 1983. *Publicacao* 7: 175–187. (*Weed Abstracts* 34: 100, 1985).
- Zhang, S., Shu, X., Zhou, G., Fu, C., Li, Z. and Wang, L. 1981. Preliminary studies on the host range of wheat rosette disease caused by northern cereal mosaic virus. (Chinese). *Acta Phytopathologica Sinica* 11: 7–10.
- Zimmerman, E.C. 1957. The portulaca leafmining weevil, *Hypurus bertrandi*, in Hawaii (Coleoptera: Curculionidae: Ceutorhynchinae). *Annals of the Entomological Society of America* 50: 221–222.
- Zundel, G.L. 1953. The Ustilaginales of the World. Contribution 176. Department of Botany, School of Agriculture, State College, Pennsylvania. 410pp.

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