Cover pictures: Tackling weed problems with rust fungi.

Front cover: Rust fungi which have been, or are being, evaluated by the IIBC Weed Pathology Group as classical biological control agents. Top left: Maravalia cryptostegiae from Madagascar introduced into Australia in 1994 for control of rubber vine (Cryptostegia grandiflora). Top right: Diabole cubensis from Mexico introduced into Australia in 1996 for control of giant sensitive weed (Mimosa pigra). Bottom left: Prosopodium tuberculatum from Brazil on pink-flowered biotype of Lantana camara. Bottom right: Puccinia rotthoelliae from Kenya on different biotypes of itch grass (Rotthoellia cochinchinensis).

Back cover: Mimosa pigra invading flood plains in Northern Territory, Australia. (Photo: DPIF.)
Contents

From the Director ............................................................................................................. 1
The Organization .............................................................................................................. 3
The People .................................................................................................................... 4
Highlights of 1995 ......................................................................................................... 7
Consultancy and Advisory Visits .................................................................................. 15
Training .......................................................................................................................... 16
Conferences and Meetings ............................................................................................ 20
Information and Publications ....................................................................................... 22
Supply of Natural Enemy Cultures ................................................................................ 23
Project Summaries
  Caribbean and Latin America ...................................................................................... 24
  Europe .......................................................................................................................... 27
  Kenya .......................................................................................................................... 41
  Malaysia ...................................................................................................................... 47
  Pakistan ....................................................................................................................... 49
  UK ............................................................................................................................... 54
  Projects at Other Locations ......................................................................................... 71
Appendix 1
  Staff List ..................................................................................................................... 76
Appendix 2
  Conferences and Meetings ......................................................................................... 83
Appendix 3
  Publications and Reports ........................................................................................... 88
Glossary of Acronyms .................................................................................................. 101
Species Index ................................................................................................................ 103
From the Director

In November 1995, the FAO Council ratified a new Code of Conduct for the Import and Release of Biological Control Agents. This document attempts, for the first time, to establish an internationally acceptable protocol for the introduction of exotic biological control agents. It represents the fruition of an effort by FAO, the International Organisation for Biological Control (IOBC) and IIBC to help governments address their growing interest in biological control in a safe and effective manner. Biological control experts from countries around the world contributed to expert consultations and modification of an original draft prepared by IIBC. IIBC is currently working with FAO on practical guidelines to go with the Code, and on training and awareness raising initiatives to promote it.

The Code comes at an important time, as many countries are starting classical biological control programmes for the first time, stimulated by successes elsewhere and by the growing number of alien pest problems which trouble all countries and result from intensified world trade. It is particularly welcome for the increasing number of programmes on biological control of alien invasive species affecting conservation, as these are often supported by an environmental community which may be unfamiliar with classical biological control procedures and concerned about introducing alien organisms to control alien organisms. But the Code has relevance beyond classical biological control, as it applies to all introductions which may establish, and this includes commercial imports of predators and parasitoids for augmentation and the import of some biological pesticides. However, the Code is not intended to constrain this commercial development but to support it: it recommends clearance of new introductions as a one-off activity, such that further shipments need not go through the entire procedure, although quality control procedures are recommended.

One of the principal elements of the Code is its recommendation that importers submit to regulatory authorities dossiers on the agent to be introduced, which include assessment of potential effects on non-target species. Such dossier production accompanies a number of the many introduction programmes which are reported in the Annual Report to follow. IIBC is keen to help any government or organization with information or advice on the Code. We congratulate FAO on their achievement, and are confident that this is an important step to protecting the future and future contribution of biological control.
The Organization

The International Institute of Biological Control is a non-profit organization dedicated to supporting the development of biological control and integrated pest management world-wide, through research, training and the provision of advice and information. It was established in 1927 and remains today the only truly international service of its kind. IIBC is an institute of CAB INTERNATIONAL, an intergovernmental organization of 39 member countries providing services world-wide to agriculture, forestry, human health and the management of natural resources through provision of information and associated technical services.

IIBC achieves its aims through collaboration with national agricultural research and extension programmes, universities and international agricultural research centres. This collaboration usually involves joint research projects, supervision of post-graduate students, consultation, and training courses. In addition, IIBC produces technical and other information on biological control through its journal, Biocontrol News and Information, and other products of its TIPS group.

IIBC is supported almost entirely by contracts from sponsors, largely government institutions in the developed world, and development assistance agencies on behalf of programmes in the developing world. In 1995, IIBC undertook 101 sponsored projects, and various training programmes, with or on behalf of more than 50 countries world-wide.

The facilities in the new extension include extraction vents to remove hazardous substances during weed pathology work.
IIBC operates from a headquarters in the UK and six stations around the world, in Trinidad and Tobago, Switzerland, Kenya, Malaysia, Pakistan and the UK. In 1995 IIBC staff were also based in Colombia, France, Nigeria and the Philippines.

CABI made a substantial investment in building infrastructure at IIBC in 1995.

The IIBC UK centre has been to beyond capacity for several years now, which was compromising the contribution of the UK centre. An extension to the facilities has now brought some well deserved relief. Construction began in the second half of 1995, work on the extension was completed at the beginning of January 1996 and modifications to the existing structure followed allowing the whole unit to become operational in mid-February 1996.

The facilities in the extension have enabled the IIBC UK centre to nearly double its available laboratory space and to rearrange the office and laboratory space. In the new arrangement all the pathology laboratories are in the extension, allowing work with pathogens and locusts to be isolated from office activities, which are conducted in the previously existing part of the building. The extension has also allowed the quarantine facilities to be expanded allowing more flexibility for work with exotic organisms.

Work also started to extend the Malaysia Station to more than double its size. This will enable IIBC to host collaborators from the FAO Inter-Country Rice IPM Programme (who made a contribution to the costs) by expansion of the office and laboratory space. The new facilities have been arranged in a way which creates space suitable for work with pathogens.

Plans were agreed for an extension at the IIBC Europe Station at Delémont, Switzerland, in response to the station’s growing programmes particularly on weed biological control and the increasing collaboration within Europe. The implementation of these plans should be in 1996.

The People

In December, our Deputy Director for Programme Development, Dr Ren Wang left to return to the People’s Republic of China as vice-President of the Chinese Academy of Agricultural Sciences. We look forward to an expanding programme of collaboration with one of CABI’s newest and largest member countries.

In Kenya, Dr Garry Hill spent 1995 wearing two hats: Scientist-in-charge of the IIBC Station and CABI’s Regional Representative for Africa. At the beginning of 1996 he moves to become the full time Regional Representative, and Dr Sarah Simons will take over as Scientist-in-charge. Dr Simons who is British, via New Zealand, is a crop protection plant pathologist who has also worked on biological control of plant diseases. She will be working closely with IMI as well as IIBC in her new role, as CABI’s crop protection activities become more integrated.

Dr George Phiri joined IIBC Kenya in August to work on projects for biological control of water hyacinth project in Malawi and biological control of leucaena psyllid in
Dr Sarah Simons, new Scientist in Charge at IIBC Kenya

Kenya and Tanzania. George, who is Malawian, completed his PhD on stem borer ecology at Reading University shortly before joining IIBC. Mr Jean-Claude Nsengimana, a Rwandese entomologist formerly of ISAR and a collaborator of the Regional Conifer Aphid Programme, joined IIBC in October from a refugee camp at Bukavu in Zaire.

In March, Dr Henk van den Berg (IPM Specialist) left to continue his career with the FAO Inter-Country Rice IPM Project in Indonesia. Dr van den Berg did his PhD with IIBC in Kenya on natural control of *Helicoverpa armigera* in smallholder crops in East Africa. During his one year stay with IIBC Malaysia, he coordinated the ADB-IIBC cotton IPM project covering China, India and Pakistan. Dr Janny Vos joined IIBC Malaysia in February. Her main role includes development of the vegetable IPM training curricula in the region and helping in training-of-trainers and farmers-field-schools activities. She also assists in the ADB-IIBC cotton IPM project. Dr Vos did her PhD in integrated crop management of hot pepper (*Capsicum* spp.) in Indonesia and Malaysia.

In August, the FAO Inter-Country Rice IPM Project appointed Dr S. Ramaswamy as IPM coordinator for Malaysia in addition to his IPM related work in India, Bangladesh and Sri Lanka. He was transferred from Bangladesh to be based with IIBC Malaysia, reflecting the close collaboration of IIBC with FAO in the Asian region. In addition to his FAO role, Dr Ramaswamy now coordinates the IIBC cotton IPM project.

Dr Chris Prior visited CSIRO Division of Entomology under the CSIRO McMaster Fellowship scheme to work with Dr R. Milner on selectivity of isolates of *Metarhizium*
spp. He gave seminars in Brisbane, Sydney and Melbourne and attended a meeting on control of vine pests in the Hunter Valley.

An insect pathologist, Ms Sue Smith, was recruited in 1995, and spent several months towards the end of the year working on the LUBILOSA project in Benin, but at the beginning of 1996 will transfer to IIBC Kenya to work on biological control of sugar cane white grubs and storage pests using pathogens.

Mr Ulrich Kuhlmann completed his PhD thesis Measuring and understanding the impact of insect predators and parasitoids on populations of the apple ermine moth, Yponomeuta malinellus (Lepidoptera: Yponomeutidae) which was accepted at the University of Kiel, Germany; and Ms Nina Jenkins submitted her PhD thesis entitled Studies on mass production and field efficacy of Metarhizium flavoviride for biological control of locusts and grasshoppers to the University of Cranfield, this was accepted in 1996.

### IIBC staff receiving training

<table>
<thead>
<tr>
<th>Name</th>
<th>Station</th>
<th>Training</th>
<th>Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y.J. Abraham</td>
<td>UK</td>
<td>PhD</td>
<td>conifer aphids</td>
</tr>
<tr>
<td>B. Ahmad</td>
<td>Pakistan</td>
<td>special techniques</td>
<td>IPM of fruit pests</td>
</tr>
<tr>
<td>S.E. Barnes</td>
<td>UK</td>
<td>MSc</td>
<td>microbiology</td>
</tr>
<tr>
<td>H.-M. Bürki</td>
<td>Europe</td>
<td>PhD</td>
<td>pigweeds</td>
</tr>
<tr>
<td>M.L. Carey</td>
<td>UK</td>
<td>BSc</td>
<td>applied biology</td>
</tr>
<tr>
<td>G. Grosskopf</td>
<td>Europe</td>
<td>DiplBiol</td>
<td>Hieracium insects</td>
</tr>
<tr>
<td>H. Hinz</td>
<td>Europe</td>
<td>PhD</td>
<td>Tripleurospermum</td>
</tr>
<tr>
<td>S.L. Huddison</td>
<td>UK</td>
<td>BTechNatCert</td>
<td>business finance</td>
</tr>
<tr>
<td>N. Jenkins</td>
<td>UK</td>
<td>PhD</td>
<td>mycoinsecticide development</td>
</tr>
<tr>
<td>M.K.T. Kairo</td>
<td>UK</td>
<td>PhD</td>
<td>conifer aphids</td>
</tr>
<tr>
<td>A.N. Khan</td>
<td>Pakistan</td>
<td>MSc</td>
<td>brown peach aphid</td>
</tr>
<tr>
<td>U. Kuhlmann</td>
<td>Europe</td>
<td>PhD</td>
<td>apple ermine moth</td>
</tr>
<tr>
<td>B. Nyambo</td>
<td>Kenya</td>
<td>study tour</td>
<td>IIBC programme on IPM of vegetables and farmer training through Farmers Field Schools in Philippines</td>
</tr>
<tr>
<td>M.A. Poswal</td>
<td>Pakistan</td>
<td>study tour</td>
<td>IIBC programme on IPM of vegetables and farmer training through Farmers Field Schools in Philippines</td>
</tr>
<tr>
<td>M.A. Poswal</td>
<td>Pakistan</td>
<td>training course</td>
<td>project management</td>
</tr>
<tr>
<td>M. Schwarzlender</td>
<td>Europe</td>
<td>PhD</td>
<td>Cynoglossum insects</td>
</tr>
<tr>
<td>M. Seier</td>
<td>UK</td>
<td>PhD</td>
<td>weed pathology</td>
</tr>
<tr>
<td>R.H. Shaw</td>
<td>UK</td>
<td>MSc</td>
<td>applied biology</td>
</tr>
<tr>
<td>J.G.M. Vos</td>
<td>Malaysia</td>
<td>study tour</td>
<td>IIBC programme on IPM of vegetables and farmer training through Farmers Field Schools in Philippines</td>
</tr>
<tr>
<td>S. Williamson</td>
<td>UK</td>
<td>study tour</td>
<td>IIBC programme on IPM of vegetables and farmer training through Farmers Field Schools in Philippines</td>
</tr>
<tr>
<td>R. Wittenberg</td>
<td>Europe</td>
<td>PhD</td>
<td>Clematis insects</td>
</tr>
</tbody>
</table>
Highlights of 1995

Gorse thrips release experiment in New Zealand

One of the year's most interesting studies was carried out as part of the link between IIBC and Imperial College through the Leverhulme Unit.

Many biological control agents fail to establish in the field. Field experience from New Zealand and elsewhere has demonstrated that the probability of establishment increases with the size of release. However, there is usually a limit to the number of biological control agents available for release into the field so biological control workers often face a dilemma: should they make a limited number of large releases or a large number of small releases?

Field experiments with gorse thrips (Sericothrips staphylinus) in New Zealand have shown that the latter strategy may be the more effective one. Thus, while each of the smaller releases has a relatively low chance of establishment, because a large number of releases can be made the overall success rate is higher. This research, which is a collaborative venture between IIBC, Imperial College, Landcare Research (New Zealand) and the University of Bristol, is continuing and will examine the causes of extinctions of small, released populations including environmental and demographic variability, and genetic founder effects.

Progress with control of leafy spurge and knapweed biological control in North America

During 1995, many positive records of effective suppression of leafy spurge (Euphorbia esula s.l.) have been received from the north-western USA and Canada. Greatest impact is reported for the flea beetles Aphthona nigriscutis, A. cyparissiae and, for the first time, A. lacertosa of which 20 million beetles were collected for redistribution at a site in North Dakota where 77 beetles had been released in 1988. In several states research is under way to further enhance the effect of Aphthona spp. by sheep grazing, application of herbicides and increasing grass competition by seeding Bozoisky Russian wild rye and Luna pubescent wheatgrass.

After numerous unsuccessful trials, the first 185 adults of the knapweed root-mining moth Pelochrista medullana were recovered from field cages at Corvallis, Montana. It will now be possible to mass rear this important control agent for open field releases.
DPIF scientist spraying *Phloeospora mimosae-pigrae* inoculum at a release site for control of *Mimosa pigra*, Finess river, Northern Territory, Australia.
Continued progress on the use of pathogens for biological control of tropical weeds

The spiny leguminous shrub, *Mimosa pigra*, or giant sensitive plant, has caused a major ecological disaster in the Northern Territory, Australia, forming dense, impenetrable thorn thickets which cover thousands of square kilometres, altering the flora and fauna, and threatening unique conservation areas, such as the Kakadu National Park. In its neotropical habitats, it is a relatively inconspicuous plant of river banks and marshes. A whole suite of natural enemies has been found suppressing it and, in addition to insect control agents, two fungal pathogens from Mexico have been screened at IIBC for CSIRO. One of these, *Phloeospora mimosae-pigrae*, which causes stem cankers and die-back, has been released recently and is beginning to spread into the weed population, whilst a leaf rust, *Diabole cubensis*, has just been approved for release. It is envisaged that the impact of these two pathogens will be synergistic and, combined with the insect biocontrol agents, that significant control of weed populations will be achievable within 2–3 years.

Another ecological disaster is the rubber-vine weed, *Cryptostegia grandiflora*, a perennial, asclepiad climbing shrub native to Madagascar, which has been described recently as the greatest single threat to the national parks of tropical Australia. This weed disrupts agricultural and natural ecosystems in Queensland, smothering and destroying indigenous riverine flora. In a project funded by Queensland Department of Lands, IIBC undertook surveys for fungal pathogens in Madagascar and, on the basis of studies of host damage and specificity, a rust fungus, *Maravalia cryptostegiae*, was introduced in 1994. Because of the vast and remote areas involved, helicopters have been used to transport fungal inoculum to pre-designated release sites, reports are that the rust is spreading rapidly such that yellow rusted areas can clearly be seen from the air amongst the green, canopy-smothering weed monoculture. Hopefully, it will only be a matter of time before there is a significant impact on the weed which should allow the indigenous flora to recover and out-compete the alien.

Results with a new biological control agent for leucaena psyllid look promising

*Tamarixia leucaenae*, the Neotropical eulophid parasitoid of leucaena psyllid has not been successfully introduced in earlier programmes in south east Asia, but initial results from Africa look promising. In 1995, *T. leucaenae* was the first leucaena psyllid natural enemy released in Africa, and it seems to have become established at its release site near the coast in northern Tanzania. By the end of 1995 it had survived for nearly 6 months and spread over 10 km from the original release area. Thus, prospects for its establishment are good. If this can be confirmed, it opens up new opportunities for leucaena psyllid control in Africa and elsewhere.
IIBC co-ordinates South-South collaboration to control Eucalyptus borer in Zambia

Under the regional Africa forestry IPM programme the first release of a biological control agent against the eucalyptus borers *Phoracantha semipunctata* and *P. recureva* was made in Zambia. An egg parasitoid, *Avetianella longoi*, was used which although originally from Australia had been successfully introduced into South Africa. The Plant Protection Research Institute provided parasitoids to Zambia in January 1995 and they were released in Chipata, Eastern Province. The parasitoid rapidly became established in the field and within ten months had dispersed approximately 70 km from the original release site. IIBC and the Zambia National Programme ran a Training Course for national scientists. These scientists will now monitor the spread of the parasitoid which will be redistributed within the country to the Copperbelt Province, using supplementary funding from CIDA to be administered by the IIBC project. The prospects for a successful completion of this biological control programme are most encouraging.

Pheromone monitoring shows crash in larger grain borer populations following release of predator

Numbers of the larger grain borer monitored in pheromone traps at the KARI/IIBC long-term monitoring site in East Province, Kenya, have continued to decline, and have been at extremely low levels throughout 1995. This follows the release in 1992 and subsequent establishment of the predatory histerid beetle *Teretriosoma nigrescens*. Meanwhile, levels of the pest in pheromone traps at locations which have not received predator releases continue to be high. This work will be presented at an East African regional workshop being organized by IIBC and KARI in early 1996 to evaluate existing knowledge and future needs in research and extension. Monitoring and predator evaluation will continue as a joint KARI/IIBC activity in 1996.

Pink mealybug devastates the Isle of Spice!

The pink or hibiscus mealybug, *Maconellicoccus hirsutus*, is a minor pest in Asia, Australia, the Middle East and most of tropical Africa. During 1993–94 it was accidentally introduced into the Caribbean island of Grenada and has since spread to the islands of Trinidad and St Kitts. In Grenada the mealybug rapidly became a devastating pest attacking fruit, vegetables, shrubs and fruit and forest trees, wrecking local and international trade. Reports from the Caribbean have put the number of affected plant species at over 200.

In May 1995 IIBC began an FAO sponsored Technical Co-operation Project for the government of Grenada to find a suitable biological control agent. *Anagyrus kamali* was chosen as the most promising agent for introduction, and obtained from China in collaboration with the Guangdong Entomological Institute. It was quarantined at IIBC
Pink mealybug is causing devastating damage to a wide variety of crops (such as this soursop fruit), but biological control releases have now started.

UK. The first batch of live parasitoids was hand carried to Grenada in October; some were used to initiate cultures at the facilities of the Pest Management Unit, and the rest were used to begin a series of sleeved cage releases in the field. Once mass open releases begin early in 1996 the parasitoid should become established and is expected, in time, to provide substantial control.

The problem and the project generated a great deal of media interest both locally and in the UK. The coverage has considerably raised national public awareness of biological control, and rejuvenated regional interests in safe, sustainable methods of pest control.

**IIBC and AAFC launch global initiative for biological control based IPM of apple pests**

During the International Conference on Integrated Fruit Production held last August-September in Cedzyna, Poland, IIBC and AAFC organized a meeting with the objective of evoking interest in biological control of apple pests, develop a global collaborative network among scientists, and eventually develop co-operative projects. It was an overwhelming success. Twenty leading scientists from Europe, Canada and the USA were invited, but over 40 participated. There was general agreement that currently biological control in apple IPM is underdeveloped, new native pests will develop as a
result of resistance and the more restrictive use of broad-spectrum pesticides, alien pests will continue to be introduced that are particularly promising targets for biological control, there must be more intensive studies on natural enemies to determine and make use of their potential as biological control agents, by conservation, augmentation and introduction elsewhere; Central and East Asia as the evolutionary centres of pome fruits and several major pests are of particular relevance, they are now open to co-operative research programmes and the exchange of natural enemies.

A steering committee was set up that formulated a questionnaire to find out about the general interest, who would want to participate and which topics are of particular interest. Over 80% of the questionnaires sent out so far have been positively answered. If you are interested, please write to IIBC European Station.

**IIBC Malaysia extends its vegetable IPM implementation programme**

In February, FAO contracted the IPM Sub-Programme of the Farmer-centered Agricultural Resource Management Programme (FARM) to IIBC. The overall objective of FARM is to improve conservation, management and utilization of natural agricultural resources in rainfed lowlands and upland farming systems. The IPM Sub-Programme concentrates on farming systems in which pesticides pose a serious threat to the environment in Indonesia, Vietnam and India. The project follows the 'farmers first' approach and focuses on the design and evaluation of technical training exercises for vegetable IPM field schools. With the assistance of some external part-time staff, evaluation of new exercises is partly executed in the screenhouse facility at IIBC Malaysia.

**LUBILOSA carries out a successful field trial in Niger**

Scientists in IIBC and the Leverhulme Unit participated in LUBILOSA trials that have demonstrated that 'Green Muscle' can reduce locust and grasshopper populations on an operational scale. A total of 150 ha was sprayed near Maine Soroa, in south east Niger, infested with high populations of grasshoppers (approximately 40 per m², of which 80% were *Oedaleus senegalensis*). A population reduction of >75% was shown in treated plots in comparison with the controls. This was not only a success from a biological point of view, but also demonstrated that LUBILOSA has the ability to produce spores and carry out such trials using operational locust control equipment.

**Successful control of Orthezia insignis ... gumwoods saved in St Helena!!!**

The latest news from St Helena concerning the scale insect *Orthezia insignis* is that the coccinellid predator (*Hyperaspis pantherina*) introduced by IIBC in 1993 has saved the
Although some gumwoods died, most are now recovering as the *Orthezia* population is brought under biological control.
last remaining stands of the island's national tree, the endemic gumwood
(Commidendrum robustum, Compositae), which were being destroyed rapidly by this
alien pest. During a visit to the island in 1995 it was clear that the predator had built
up very large populations on the infested gumwoods, and was found wherever small
colonies of the scale still remained. Although about 10% of the remaining gumwood
trees were killed by the scale, and many more damaged, the survivors are showing
excellent signs of recovery with fresh, uninfested green shoots developing on plants
that were otherwise completely blackened after massive infestations from the scale. It
was clear that the successful biological control came only just in time to save the
majority of the trees, and that the policy of the St Helena Government to set up a large
scale laboratory rearing programme for the predator to allow mass releases played an
important role in this rapid success. The predator has now spread all over the island
and can be found wherever local infestations of the scale occur. The laboratory cultur-
ing of the predator has now become unnecessary, but it has also become impossible to
locate sufficient numbers of the scale to maintain the culture. Programmes to restore
some of the native habitats on St Helena, where the gumwood and its relatives were
once dominant components of the vegetation, can now continue. Many other alien
pests and weeds exist on the island, and IIBC is currently developing an agricultural
IPM programme with NRI which will involve a substantial component of classical
biological control to help to control these alien invaders.

**Promising developments in the biological control of purple
loosestrife in North American wetlands**

The biological control of purple loosestrife (*Lythrum salicaria*), an invasive weed prob-
lem that has plagued wetland habitats across the USA and eastern Canada for much
of the latter part of this century, is expected to become a major success.

In 1995, 24 USA states and three Canadian provinces were actively involved in the
release, rearing and redistribution of the four European control agents so far estab-
lished. The leaf beetles, *Galerucella calmariensis* and *G. pusilla*, and the root-boring
weevil, *Hyllobius transversovittatus*, have been established since 1992. The flower-feeding
weevil *Nanophyes marmoratus* overwintered successfully and reproduced in all three
USA states where it had been released in 1994.
**Consultancy and Advisory Visits**

**Consultancies by IIBC staff members**

<table>
<thead>
<tr>
<th>Consultant</th>
<th>Country</th>
<th>Date</th>
<th>Sponsor</th>
<th>Purpose/Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Cock</td>
<td>Trinidad</td>
<td>27 February–11 March</td>
<td>CABI PF</td>
<td>Governing Board study team</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6–13 October</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr Cock</td>
<td>Nevis, Trinidad &amp;</td>
<td>7–18 November</td>
<td>FAO</td>
<td>coconut pests</td>
</tr>
<tr>
<td></td>
<td>Barbados</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr Cock</td>
<td>Indonesia, Philippines</td>
<td>10 November–5 December</td>
<td>ACIAR</td>
<td>Chromolaena odorata</td>
</tr>
<tr>
<td>Mr Cross</td>
<td>Grenada</td>
<td>16–23 July, 26 October–3</td>
<td>FAO</td>
<td>training in rearing pink mealybug parasitoids and field monitoring</td>
</tr>
<tr>
<td></td>
<td>November</td>
<td>3 November</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr Fowler</td>
<td>Togo</td>
<td>30 January–3 February</td>
<td>FAO</td>
<td>advising on the potential biocontrol of spiralling whitefly</td>
</tr>
<tr>
<td>Dr Fowler</td>
<td>St Helena</td>
<td>6 February–17 March</td>
<td>ODA</td>
<td>development of IPM programmes and classical biocontrol</td>
</tr>
<tr>
<td>Dr Fowler</td>
<td>Seychelles, Mauritius &amp;</td>
<td>23 September–9 October</td>
<td>CABI PF</td>
<td>advising on invasive weeds affecting indigenous biodiversity</td>
</tr>
<tr>
<td></td>
<td>Tanzania</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ms Jenkins</td>
<td>Azores</td>
<td>24 April–8 May</td>
<td>EU</td>
<td>mass production of fungal entomopathogens</td>
</tr>
<tr>
<td>Dr Lim</td>
<td>India</td>
<td>4–12 April</td>
<td>FAO</td>
<td>vegetable TOT</td>
</tr>
<tr>
<td>Mrs Lopez</td>
<td>Tobago</td>
<td>28 March</td>
<td>THA</td>
<td>represent CABI/IIBC at a Local Plant Clinic</td>
</tr>
<tr>
<td>Mrs Lopez</td>
<td>Tobago</td>
<td>26 January</td>
<td>THA</td>
<td>represent CABI/IIBC at a Local Plant Clinic</td>
</tr>
<tr>
<td>Mr Morais</td>
<td>Tobago</td>
<td>10 August</td>
<td>THA</td>
<td>represent CABI/IIBC at a Local Plant Clinic</td>
</tr>
<tr>
<td>Mr Mahmood</td>
<td>Nigeria</td>
<td>16 May–18 July</td>
<td>FAO</td>
<td>biological control of neem scale</td>
</tr>
<tr>
<td>Dr Murphy</td>
<td>Brazil</td>
<td>27 November–1 December</td>
<td>USDA FS</td>
<td>biological control of <em>Sirex noctilio</em></td>
</tr>
<tr>
<td>Dr Nyambo</td>
<td>Malawi</td>
<td>12–23 May</td>
<td>GTZ</td>
<td>brassica IPM planning workshop</td>
</tr>
<tr>
<td>Dr Nyambo</td>
<td>Ghana</td>
<td>8–12 September</td>
<td>CABI/IIBC</td>
<td>participatory IPM</td>
</tr>
<tr>
<td>Consultant</td>
<td>Country</td>
<td>Date</td>
<td>Sponsor</td>
<td>Purpose/Subject</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
<td>-------------------------------</td>
<td>----------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Dr Poswal</td>
<td>Pakistan</td>
<td>29 May–2 June</td>
<td>Himalayan Jungle Project</td>
<td>IPM</td>
</tr>
<tr>
<td>Dr Prior</td>
<td>Philippines</td>
<td>28 January–7 February</td>
<td>CABI PF</td>
<td>locusts</td>
</tr>
<tr>
<td>Dr Thomas</td>
<td>Azores</td>
<td>24 April–8 May</td>
<td>EU</td>
<td>Japanese beetle</td>
</tr>
<tr>
<td>Dr Waage</td>
<td>Indonesia</td>
<td>25 September–13 October</td>
<td>World Bank</td>
<td>Review team IPM implemenation project</td>
</tr>
</tbody>
</table>

**Training**

Two training courses were held in East Africa in 1995. The first concentrated on biological control of cypress aphids as a follow-up of field training carried out by KEFRI and IIBC whilst establishing permanent sample plots (PSPs) for cypress aphid monitoring and was held 6–10 March, at KEFRI, Muguga, Kenya, and co-organized by Ms Mercy Gichora, Head of KEFRI Entomology Sub-section. There were nine participants including foresters and assistant foresters from the Forest Department. The second was held in Zambia, 18–28 July, held at Forestry College, Kitwe, co-organized by Mr O. Shakacite, Head of Forest Protection. There were 11 participants including foresters, forest rangers and training officers. This course concentrated on forest pest monitoring, including recognition of symptoms of poor forest health caused by insects and disease. Resource persons included Mr F. Kirsten of PPRI South Africa and Dr T. Coutinho of University of Orange Free State, South Africa.

As part of IIBC’s growing involvement in IPM training and policy development, a training course on *Evaluation of Pesticide Effects on Natural Enemies and its Implications for Pesticide Registration* was organized jointly with IOBC and other collaborators. Sixteen participants from eleven Asian countries attended the two week practical course and workshop held in Malaysia in March, sponsored by GTZ and SDC. Recommendations from the workshop include a regional programme of pesticide testing on key natural enemies in rice and vegetable crops. An Asian Network on Natural Enemies and Pesticides was set up to support this regional initiative.

IIBC’s second annual UK-based training course on Biological Control of Arthropod Pests & Weeds took place in May, with participants from Colombia, India, Norway, Portugal and Grenada, in addition to 18 MSc students from Imperial College.

More than 30 people from Latin American NGOs and extension services took part in a two day introductory workshop on biological control, organized by IIBC in collaboration with the Venezuelan NGO, IPAT. The workshop was part of a Sustainable Agriculture conference held in July by the Latin American Agro-Ecological Movement.

An informal one day workshop on Evaluating Pesticide Effects on Natural Enemies was also run in September at Benguet State University, the Philippines.
Twenty-eight farmers' field schools with about 700 participants were held in the Philippines under the ADB CABI vegetable IPM project, and one training of trainers with 30 participants. Under the ADB CABI cotton IPM project, IPM training was given to 35 officers in China and to about 120 officers in India, and in Pakistan an IPM short course was given to 36 officers.

MSc and BSc classes from the University of Agriculture, Faisalabad; University and College of Agriculture, Rawalakot; and University of Arid Agriculture, Rawalpindi, visited PARC-IIBC.

### Training given by IIBC Staff

<table>
<thead>
<tr>
<th>Country of trainee</th>
<th>Trainee</th>
<th>Location</th>
<th>Training</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>R. Alves</td>
<td>UK</td>
<td>PhD</td>
<td>mycopesticide application</td>
</tr>
<tr>
<td>China</td>
<td>D. You</td>
<td>Europe</td>
<td>special techniques</td>
<td>biocontrol of forest insects</td>
</tr>
<tr>
<td>Colombia</td>
<td>A. Castaño</td>
<td>Colombia</td>
<td>IngAg</td>
<td>research project</td>
</tr>
<tr>
<td>Colombia</td>
<td>A. MacKay</td>
<td>Colombia</td>
<td>IngAg</td>
<td>research project</td>
</tr>
<tr>
<td>Colombia</td>
<td>J. Peralta</td>
<td>Colombia</td>
<td>IngAg</td>
<td>research project</td>
</tr>
<tr>
<td>Colombia</td>
<td>M. Portilla</td>
<td>UK &amp; Colombia</td>
<td>PhD</td>
<td>parasitoids of coffee berry borer</td>
</tr>
<tr>
<td>Colombia</td>
<td>F. Posada</td>
<td>UK &amp; Colombia</td>
<td>PhD</td>
<td>Beauveria bassiana on coffee berry borer</td>
</tr>
<tr>
<td>Colombia</td>
<td>R. Ruíz</td>
<td>Colombia</td>
<td>IngAg</td>
<td>research project</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>E. Hidalgo</td>
<td>UK</td>
<td>MSc</td>
<td>Beauveria bassiana formulations to control storage pests</td>
</tr>
<tr>
<td>Kenya</td>
<td>S. Kamunya</td>
<td>Kenya</td>
<td>MSc</td>
<td>conifer aphids</td>
</tr>
<tr>
<td>Kenya</td>
<td>B. Kanyi</td>
<td>Kenya</td>
<td>MSc</td>
<td>conifer aphids</td>
</tr>
<tr>
<td>Malawi</td>
<td>L. Chikaonda</td>
<td>Kenya</td>
<td>special techniques</td>
<td>conifer aphids</td>
</tr>
<tr>
<td>Malawi</td>
<td>C. Chilima</td>
<td>Kenya</td>
<td>special techniques</td>
<td>conifer aphids</td>
</tr>
<tr>
<td>Malaysia</td>
<td>S. Muid</td>
<td>UK</td>
<td>special techniques</td>
<td>entomopathogenic fungi</td>
</tr>
<tr>
<td>Malaysia</td>
<td>A. Sivapragasam</td>
<td>UK</td>
<td>special techniques</td>
<td>IPM and microbial control</td>
</tr>
<tr>
<td>Mauritius</td>
<td>N. Behary Paray</td>
<td>UK</td>
<td>MSc</td>
<td>Metarhizium flavoviride growth in relation to pH water hyacinth</td>
</tr>
<tr>
<td>Netherlands</td>
<td>J. van Rheenen</td>
<td>Kenya</td>
<td>MSc</td>
<td>diamondback moth pathogens</td>
</tr>
<tr>
<td>Nicaragua</td>
<td>L. Lacayo</td>
<td>UK &amp; Nicaragua</td>
<td>PhD</td>
<td>diamondback moth pathogens</td>
</tr>
<tr>
<td>Country of trainee</td>
<td>Trainee</td>
<td>Location</td>
<td>Training</td>
<td>Topic</td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------------</td>
<td>------------</td>
<td>------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Nigeria</td>
<td>F. Appiah</td>
<td>UK</td>
<td>special techniques</td>
<td>IPM of oil palm pests</td>
</tr>
<tr>
<td>Nigeria</td>
<td>P. Donli</td>
<td>Kenya</td>
<td>special techniques</td>
<td>insect-plant interactions</td>
</tr>
<tr>
<td>Nigeria</td>
<td>S.B. Sarah</td>
<td>Pakistan</td>
<td>biological control</td>
<td>biological control of insect pests especially scale insects</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>S. Laup</td>
<td>UK &amp; PNG</td>
<td>PhD</td>
<td><em>Beauveria bassiana</em> on cocoa mirids</td>
</tr>
<tr>
<td>Philippines</td>
<td>D. Santiago</td>
<td>UK</td>
<td>special techniques</td>
<td>mass production of metarhizium</td>
</tr>
<tr>
<td>Slovakia</td>
<td>J. Vavrac</td>
<td>Europe</td>
<td>special techniques</td>
<td>weed biological control</td>
</tr>
<tr>
<td>Tanzania</td>
<td>S. Kyaruzi</td>
<td>Kenya</td>
<td>special techniques</td>
<td>conifer aphids</td>
</tr>
<tr>
<td>Tanzania</td>
<td>S. Lekamoi</td>
<td>Kenya</td>
<td>special techniques</td>
<td>conifer aphids</td>
</tr>
<tr>
<td>Tanzania</td>
<td>I. Zilihona</td>
<td>Kenya</td>
<td>special techniques</td>
<td>conifer aphids</td>
</tr>
<tr>
<td>Thailand</td>
<td>C. Kittithamkul</td>
<td>Thailand</td>
<td>PhD</td>
<td>weed pathology</td>
</tr>
<tr>
<td>The Gambia</td>
<td>S. Sanyang</td>
<td>UK</td>
<td>PhD</td>
<td><em>mycopathogens and pesticides against grasshoppers and locusts</em></td>
</tr>
<tr>
<td>Trinidad &amp; Tobago</td>
<td>P. Smith</td>
<td>UK</td>
<td>PhD</td>
<td>whitefly pathogens</td>
</tr>
<tr>
<td>Uganda</td>
<td>R. Molo</td>
<td>Europe</td>
<td>special techniques</td>
<td>biological control of whiteflies</td>
</tr>
<tr>
<td>Uganda</td>
<td>C. Nankinga</td>
<td>UK</td>
<td>PhD</td>
<td><em>Beauveria bassiana</em> on banana weevils</td>
</tr>
<tr>
<td>UK</td>
<td>C. Causton</td>
<td>Venezuela</td>
<td>PhD</td>
<td>insects attacking <em>Passiflora mollisima</em></td>
</tr>
</tbody>
</table>
Conferences and Meetings

Third planning and evaluation meeting on IPM in cotton (5–8 September Kuala Lumpur, Malaysia)

Nineteen delegates from the participating countries (China, India and Pakistan), the donor and executing agencies, and from the Vietnamese national IPM programme attended the meeting. Achievements of the ADB-IIBC cotton IPM project and planning for the last phase of the project were discussed. Completed on-farm research activities in the three participating countries were reviewed and suggestions were made for improvements. Delegates agreed that, in addition to continuation of the on-farm IPM research, attention must be given to conducting farmers' field schools. An extension of the project until March 1997 was granted.

Regional workshop on biological control as a cornerstone of integrated pest management for sustainable agriculture in south-east Asia (11–15 September, Serdang, Malaysia)

This workshop, organized by IIBC, MARDI and ACIAR, was attended by about 40 delegates from Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Thailand and Vietnam. The main workshop objectives were to review current status and projects in classical biological control in south-east Asia, to identify opportunities and priorities for new classical biological control projects, to promote regional and international co-operation and to identify problems and constraints in classical biological control in the region. The workshop made a number of recommendations for new IPM and biocontrol initiatives, many requiring IIBC involvement and/or technical support.

African Forest Pest Management Network

A workshop entitled ‘Formation of an African Forest Pest Management Network’ was held at the Kenya Forest Research Institute in Nairobi, 24–28 April 1995, co-organized by IIBC, FAO and KEFRI. The aim of the workshop was to bring together Directors of Forestry Research and national Forestry Corporations and Policy Makers from East, Central and southern Africa to discuss the formation of a forestry pest management network for Africa. Six countries (Ethiopia, Kenya, Republic of South Africa, Sudan, Tanzania, Uganda), three International Organizations (CAB INTERNATIONAL, ICRAF, FAO), and Canadian Forest Service, were represented by 25 participants. The meeting agreed to the establishment of a regional forestry pest management network and for the further development of the network through a steering committee composed of representatives from Kenya, Tanzania and Uganda with technical support from IIBC.
Biocontrol-host plant resistance meeting

Dr Nyambo, Dr Thomas and Dr Hill attended a workshop organized jointly by CAB INTERNATIONAL, CTA and the Ethiopian Department of Agricultural Research in Addis Ababa, Ethiopia, 9–13 October, on the interaction between biological control and host-plant resistance. Dr Nyambo presented a paper giving an overview of biological control in East Africa. Dr Thomas gave a keynote address on the interaction between biological control and host plant resistance. This was based on a review of the topic carried out by Dr Thomas with support from CTA and CABI. The results of Dr Thomas’ studies will be published by CTA.

Integrated pest management of coffee pests

The CAB INTERNATIONAL Regional Office for Africa organized a regional workshop on coffee IPM in Masinga, Kenya, in February. This was attended by representatives from Burundi, Kenya and Uganda. Drs Moore and Nyambo attended on behalf of IIBC, and Drs Waller and Bridge, specialists respectively in coffee diseases and nematodes, attended from IIBC’s sister institutes of mycology and parasitology. As a follow up to that meeting, Dr Nyambo attended a regional coffee planning workshop in Uganda in October, following which Dr Nyambo on behalf of five countries in East Africa, prepared a regional coffee IPM proposal.

First Workshop of COST Action 816

The IIBC European Station organized the first workshop of COST Action 816 ‘Biological Control of Weeds in Crops’ on 5–6 October 1995 at Delémont, Switzerland. The workshop, ‘Genetic variations in weeds: implications for biological control of weeds’, was attended by 40 scientists from 12 European countries and Israel co-operating in this first European programme on biological weed control. The four Working Group Convenors reported on progress made during the first year, and plans for co-operative research in 1996 were discussed during parallel sessions of the Working Groups. The programme is being continued with enthusiasm and attracts increasing interest in countries not yet involved.
Information and Publications

The TIPS Unit was closely involved in the production of *Insects on Plants in the Maldives and their Management*, a book based on the surveys of crop pests and their natural enemies carried out in the Maldives by Dr Ooi and Dr Gillian Watson of IIE. The main part of the text consisted of data sheets on the pests and the potential for biological control, with many colour pictures of pests, their damage and some of the natural enemies found in the Maldives. The book was commissioned by FAO to be used as a training manual and field guide by staff of the Ministry of Fisheries and Agriculture of the Maldives.

Volume 16 of *Biocontrol News and Information* contained 3,063 abstracts selected from the world literature on biological control and integrated pest management, a further reflection on the continuing growth of interest in this area of pest control.

The review articles in volume 16 were:

- **Management of stem boring larvae (Chloropidae and Opomyzidae), especially Oscinella spp., in ryegrass in UK.** D. Moore.

- **A review of mycochemical and insect interactions.** M. Parry.


- **Biocontrol of pathogenic and spoilage microorganisms in food.** V.M. Dillon and P.E. Cook.

Promotion of IIBC’s activities continued in newsletters and journals from sustainable agriculture and development networks, along with items in IPMnetNews on the InterNet.

Issue 4 of the *African Water Hyacinth Newsletter* was produced during the year. It was edited by Dr Hill and processed by the TIPS Unit. Similarly, Number 3 of *Forestry Pest Management: A Newsletter for Eastern and Southern Africa*, edited at IIBC Kenya, was processed by the TIPS Unit. A 6-page pamphlet entitled *Mapping of the distribution of water hyacinth using satellite imagery: pilot study in Uganda* was produced by the southern and eastern African Regional Centre for Services in Surveying, Mapping and Remote Sensing in conjunction with IIBC, Cooperation Française and the Uganda Fisheries Research Institute. This was an outcome of the Rockefeller Foundation funded project to investigate the potential use of remote sensing for water hyacinth detection and monitoring.
Supply of Natural Enemy Cultures

During 1995 IIBC shipped natural enemies to a variety of countries and recipients as part of its current research projects and also in fulfilment of the continuing demand for natural enemies identified in previous projects. The latter are available when they are held in the laboratory or are easy to collect and costs can be covered. Details of all shipments are given in Project Summaries. The totals for the period covered by this report are 88 shipments of more than 80,000 individuals of 49 species to 16 countries, as well as 16 cultures of entomopathogenic fungi to 6 organizations in 5 countries.
Project Summaries

Caribbean and Latin America

Biological control of the leucaena psyllid, *Heteropsylla cubana*

*Heteropsylla cubana* is a major world-wide pest of *Leucaena leucocephala*, an important multi-purpose tree crop. Since 1988, IIBC has been involved in a classical biological control of the psyllid using two parasitic wasps, *Psyllaephagus yaseeni* and *Tamarixia leucaenae*, which attack the psyllid in the Caribbean and Central America. During 1995, cultures of both parasitoids were maintained and four shipments (three *T. leucaenae* and one *P. yaseeni*) sent to Tanzania and Kenya via UK, with more shipments scheduled during the early part of 1996.

(V.F. Lopez, S. Ali and C. Gannes. Funded by CIDA and FAO for eastern and southern Africa – IIBC Nos. 875 and 996, started 1991 and 1995; see also Kenya and UK projects.)

Socio-economic surveys of current farmers’ practices in key vegetable growing areas of Trinidad

Socio-economic surveys of current farmers’ practices in the Aranguez and Macoya areas of north Trinidad, and Dow Village and Mon Desir areas of south Trinidad, were concluded in January and March, respectively. Surveys for North Trinidad were carried out by IIBC staff while those in the south were done in collaboration with staff of Agricultural Extension Services (South), MALMR. Four vegetable crops (tomato, eggplant, sweet pepper and *Brassica* spp.) were targeted in the surveys because of the severity of insect pest problems in these crops: the whitefly *Bemisia argentifolii* (also known as *B. tabaci* strain B) on all four target crops; *Thrips palmi* on eggplant; and diamondback moth (*Plutella xylostella*) and budworm (*Hellula phidealis*) on the brassicas.

Based on interviews conducted with 52 farmers, the following conclusions were drawn from the north Trinidad surveys:

1. Vegetable farmers in Trinidad are quite well-educated and aware of their pest control problems.

2. Pest control is the single largest cost, accounting for 30–40% of total crop production costs and is perceived by farmers as a major constraint.

3. Pesticides are currently being being used inappropriately, potentially causing harm to the farmers and the environment and perhaps the consumer.

4. There is considerable scope for implementation of IPM based upon indigenous natural enemies; farmers are beginning to realize that chemical control is perhaps not the best control strategy and they are quite willing to try out other strategies provided it results in increased economic returns.
A report on the findings from the survey was prepared and widely distributed. A similar report for south Trinidad will be produced.


**Biological control of the hibiscus mealybug, *Maconellicoccus hirsutus***

The Old World mealybug *Maconellicoccus hirsutus* (known as hibiscus mealybug in Trinidad and Tobago and pink mealybug in Grenada) was recorded in Grenada in 1994 (a first record of the pest from the Caribbean and Latin America) and in 1995 spread to Trinidad and St Kitts. *Maconellicoccus hirsutus* is an extremely polyphagous pest and is known to attack more than 200 plant species; however it prefers members of Malvaceae, particularly *Hibiscus* spp., hence its common name in Trinidad and Tobago. Following its discovery in Trinidad, the MALMR has requested assistance from IIBC to support its initiatives in combating the pest, i.e. a two-pronged approach involving the introduction of *Anagyrus kamali* and coccinellid predators. On behalf of MALMR IIBC CLAS is handling the introduction of *A. kamali*, an encyrtid wasp that has been used by IIBC UK in its biocontrol programme for Grenada.

Mrs Lopez visited Grenada to learn practical details of culture techniques and subsequently established cultures of *M. hirsutus* at CLAS on pumpkins and other hosts. Starter colonies of *A. kamali* will be brought into Trinidad from IIBC UK early in 1996. The first releases of the wasp into the environment are expected to be made during the first quarter of 1996. Two technical staff from MALMR are to be seconded to CLAS from January 1996 to be trained in the culture methods for *M. hirsutus* and *A. kamali*.

(V.F. Lopez, M. Morais and C.V. Gannes. For MALMR, Trinidad and Tobago – IIBC No. 1034, started 1995. See also UK projects.)

**Biological control of the spiralling whitefly (*Aleurodicus dispersus*)**

As part of an FAO TCP for Togo, IIBC has started a project under Dr Carl’s leadership to study the host-specificity of *Nephaspis oculata*, a potential biological control agent for the spiralling whitefly, *Aleurodicus dispersus*. The host-specificity range of *N. oculata* will be tested against several insect groups, including whiteflies, mealybugs, psyllids, aphids and Lepidoptera. To this end, cultures of the spiralling whitefly, *Aleurodicus dispersus*, other whiteflies, and several available insect species are to be established. Protocols for host-specificity testing for *N. oculata* are to be developed.

The host-specificity studies will form the project for which Mrs Lopez is registering for an MPhil at UWI beginning January 1996. UWI has agreed to the appointment of Dr Carl as the Technical Supervisor for the project and has appointed Drs P. Bacon and A. Khan as joint UWI supervisors.

(K.P. Carl, V.F. Lopez and C.V. Gannes; UWI MPhil supervisors; P. Bacon and A. Khan. For Togo and FAO – IIBC No. 1033, started 1995.)
Activities at the CLAS Diagnostic Centre

Insect collection and library

Curation of the Lepidoptera proceeded with the families Arctiidae, Ctenuchidae, Noctuidae and Notodontidae being upgraded in curatorial levels.

Following discussions with library staff of MALMR, the IIBC library was extensively reorganized and the shelving system upgraded. New signs were placed to assist outside users and bring the system in line with those in use in other libraries in the country.

(M. Morais and M.J.W. Cock.)

Insect shipments

One shipment of leaf cutting ants *Atta cephalotes* was sent to the Parque de las Ciencias in Granada, Spain, for display purposes.

(M. Morais.)

Three shipments of *Tamarixia leucaena* and one of *Psyllaephagus yaseen* (totalling 3253 insects in four shipments) were sent to IIBC UK for forwarding to Tanzania and Kenya.

(V. Lopez, S. Ali, C.V. Gannes, A. Joseph, K. Williams and E. Holder.)
Europe

Agricultural Entomology Research Programme

Biological control of the apple ermine moth, *Yponomeuta malinellus*

Studies on the population dynamics of the apple ermine moth were continued and the sampling method developed previously was used to study host abundance and mortality factors in the field. Host abundance increased from 0.53 tents in 1994 to 1.28 tents per 30 leaf clusters at Biebesheim and reached 0.52 tents at Giessen which is similar to last year. A regression analysis showed that the number of egg batches laid per female increased significantly with higher temperature during the oviposition period in the field. The complex of primary parasitoids at both collection sites was the same as in 1993 and 1994. The rate of parasitism by *Ageniaspis fuscicollis* in the first larval stage increased from 6.3% in 1993, to 7.0% in 1994 and to 16.1% in 1995; rates of parasitism by the ichneumonid *Herpestomus brunnicornis* reached 9.5% at Giessen and 9.6% at Biebesheim. In addition, insect predators were abundant, particularly on egg masses. Life tables indicate that the impact of these predators reached 34.9% in 1993, 37.0% in terms of the total generational mortality 1994 and 51.0% in 1995. The impact of the parasitoids in relation to the total generational mortality of *Y. malinellus* was studied. Parasitoids killed 6.4% of *Yponomeuta malinellus* in the generation in 1993, 4.4% in 1994 and 6.0% in 1995. This is equivalent to 21.3% in 1993, 16.0% in 1994 and 15.4% in 1995 of the total generational mortality.

Laboratory experiments were conducted on oviposition behaviour of *A. fuscicollis* females within host egg batches. The encyrtids were found to oviposit indiscriminately into host eggs of *Y. malinellus* in a random order. The number of ovipositions per single female exceeded the number of available hosts per egg batch, thus self-superparasitism occurred frequently. Parasitoid eggs were found to have a small chance of survival, due to degeneration of those eggs that were not inserted into the *Y. malinellus* embryo. This provides an adequate explanation of low parasitism rates. Field data on *Agria mamillata* (Sarcophagidae) and the relationship between the number of prey eaten per predator and number of prey available per predator indicated that predation rate decreases as the number of prey available per predator increases.

(U. Kuhlmann, S. Erb and D. Babendreier. For Canada – IIBC No. 709, started 1987.)

Biological control of the blueberry leaffier, *Croesa curvalana*, in Canada

Thanks to close co-operation with Dr Dixon at the Newfoundland Research Station, an adequate supply of the Canadian host insect, *Acleris curvalana*, was available at the right stage and at the right time for extensive experiments to confirm its suitability as a host of the braconid *Earinus gloriotarius*. It was found that the North American species is equally susceptible to attack by the European parasitoid as its normal host, *Acleris variegana*, on which *E. gloriotarius* is the dominant parasitoid. Considering that *E. gloriotarius* is oligophagous, as is suggested by literature records, and therefore
unlikely to pose a risk to non-target insects, its introduction into Canada is strongly recommended. Unfortunately, field collections were unsuccessful because host populations had disappeared from known infestation sites, apparently owing to unusual winter conditions with heavy late snowfall disrupting the synchronization of host plant phenology with that of the insect, and the failure to find new infestations. It will be necessary to locate new sites in 1996, carry out collections and parasitoid rearings, and introduce the parasitoid for release in Canada in 1997.

(K. Carl and S. Erb. For Canada – IIBC No. 817, started 1989.)

**Biological control of the apple sawfly, *Hoplocampa testudinea***

Emergence of the apple sawfly, *Hoplocampa testudinea*, from hibernated cocoons kept under near out-door conditions at Delémont was monitored. Synchronization with the flight period monitored by sticky traps in one orchard in north-eastern Switzerland was good though not as perfect as last year. In an experiment on longevity and fecundity in a large field cage covering a whole tree the apple sawfly lived longer (11.5 days±2.9 SD) and laid more eggs (about 25) than the year before but still did not use its full reproductive potential. A new collection site was found in central Switzerland. Collections made in IPM-orchards in eastern Switzerland produced only low parasitism by *Lathroleses ensator*, the target biological control agent. Parasitism in the collection sites in Switzerland was generally higher than last year but lower than in 1993, with rates ranging from 6 to 24.2%. Experiments carried out in large field cages and field observations have shown that *L. ensator* females parasitize preferably second instar larvae. Findings from the field revealed that development of apple sawfly larvae is very concentrated, therefore the time for egg laying by this parasitoid is short, about one week. Parasitism by the cocoon parasitoid *Aptesis nigrocincta* in 1994 increased because some individuals stayed in prolonged diapause and emerged in 1995. Parasitism rate in 1995 was 21% in the first generation. *A. nigrocincta* develops at least two generations per year, thereby increasing its effectiveness as a mortality factor on its univoltine host.

(D. Babendreier and K. Carl. For Canada – IIBC No. 918, started 1992.)

**Bertha armyworm, *Mamestra configurata***

This project was carried out in close co-operation with Dr P. Mason while he was posted at USDA-ARS Montpellier and visited Delémont several times. Selected fields in a vegetable market garden area south of Lake Biel (Seeland) were sampled at weekly intervals to follow population development of the cabbage moth *Mamestra brassicae* and its egg and larval parasitoids. As farmers were unwilling to provide unsprayed experimental plots in their fields, census work was hampered by the disruptive effects of chemical control measures which affected both host and parasitoid populations. The more motile hosts re-invaded sprayed fields more rapidly than their parasitoids. Nevertheless, rates of parasitism by the larval parasitoid *Microplitis mediator* under favourable conditions rose to 70% in third larval host stages, and by the egg parasitoids *Telenomus* sp. and
Trichogramma buesi together to over 60%. The former was the dominant egg parasitoid and generally appeared earlier in the season than T. buesi. The application of pesticides appeared to be a major factor limiting control by these natural enemies.

Biological studies on egg parasitoids and their interactions as well as hibernation studies on M. mediator were initiated, and parasitoids were sent to Canada for parallel investigations with Mamestra configurata as host.


Biological control of woolly whitefly, Aleurothrixus floccosus, in eastern Africa

The woolly whitefly, native in Central and South America, appeared in Africa south of the Sahara in the 1980s. Presently citrus plantations in several countries in western and eastern Africa are seriously affected. Biological control was successful in California, Hawaii and southern Europe. Various parasitoids have been credited as successful biocontrol agents: the aphelinid Cales noacki in Europe, this and the platygasterid Anitus spiniferus in California, and these and yet another aphelinid, Eretmocerus sp., in Hawaii. The relative importance of the three species is not well-known. Each species appears to have a restricted climatic tolerance and none seems to be adapted to the dry heat in the interior of California.

A small stock culture of A. spiniferus has so far been obtained from Hawaii from which a culture was set up at Delémont. Rearing techniques need to be perfected before material can be shipped to Uganda which has been selected as the first East African country for release.

(K. Carl and R. Dolch. For GTZ – IIBC No. 1009, started 1995.)

Temperate Forestry Research Programme

Biological control of gypsy moth, Lymantria dispar

The gypsy moth was introduced from Europe into the USA in the 19th century. Since then, it has become the most serious pest of broadleaved trees in eastern North America. Work in Europe is presently focused on the collection of two tachinid parasitoids, Ceranthia samarensis and Parasetigena sylvestris, for shipment to Canada. C. samarensis is a low density parasitoid which is best collected using the host exposure technique. Releases started in 1994 in Canada and there are already indications that it has successfully parasitized the gypsy moth in the field. P. sylvestris is the most important mortality factor of gypsy moths in western and central Europe, where it commonly reaches 70–95% parasitism. It is already present in North America where parasitism is much lower. The European strain was shipped to Canada for comparative studies with the North American strain.

As in previous years, gypsy moth larvae were exposed in France and Switzerland to obtain puparia of the tachinid Ceranthia samarensis, but parasitism was very low,
probably because a late frost had killed the freshly emerged females. In contrast, more *C. samarensis* were collected from a natural population in France. In this population, the main parasitoid was the other tachinid, *Parasetigena sylvestris*. The collection of both parasitoids was limited by the occurrence of a virus which caused heavy mortality in the gypsy moth population. A total of 84 *C. samarensis* and 214 *P. sylvestris* was shipped to Canada in August.

(M. Kenis, D. You, N. Otten and A. Van averbeke. For Canada – IIIB No. 50, started 1975.)

**Biological control of the pine false webworm, *Acantholyda erythrocephala***

The pine false webworm is a European species accidentally introduced into North America where it has become a serious pest of pine plantations. Surveys for natural enemies were made by IIIB in the 1980s, but these had been discontinued because of the low population densities in Europe. This year, new efforts were made to locate populations and collect natural enemies.

Eggs and larvae were collected in spring in an outbreak population in southern Poland. Eggs were not parasitized while 17% of the larvae contained young ichneumonid eggs and larvae, but most of these were encapsulated.

Eggs of *A. erythrocephala* were exposed in the field in Italy. These were attacked by a gregarious parasitoid which stayed in diapause in the host eggs. A low density population of *A. erythrocephala* was found in north-eastern Italy. Digging the soil for eonymphs in spring showed that these were heavily parasitized by an ichneumonid, *Olesicampe monticola*.

(M. Kenis, N. Otten, D. You and A. Vanaverbeke. For Canada – IIIB No. 536, started 1981.)

**Collection of a cold tolerant *Trichogramma* sp.**

In previous years, a study of the parasitoid complex of the spruce seed moth, *Cydia strobilella*, had shown that, at high altitudes in the Alps, eggs were attacked by a *Trichogramma* sp. that was active at low temperatures. The Canadian Forest Service asked IIIB to collect this cold tolerant species to be used in inundative programmes against several lepidopterous forest pests in Canada.

This year, the spruce cone crop was particularly high in Europe. As a result, very few eggs of *C. strobilella* were found per cone, and parasitism was too low to allow collection of a sizeable number of *Trichogramma*. As an alternative, eggs of *Ephestia kuehniella* were exposed at the two sites where the cold tolerant *Trichogramma* sp. had been collected in the last two years. Females of *Trichogramma* sp. emerged from the exposed eggs and were reared on *E. kuehniella* eggs in the laboratory. Rearing under different conditions showed that females oviposited at temperatures as low as 10°C. Parasitized eggs were shipped to Canada, where a colony was established.
Biological control of the white pine weevil, *Pissodes strobi*

The white pine weevil, or spruce weevil, is a native pest of pine and spruce plantations in North America. Investigations on the natural enemies of related *Pissodes* spp. in Europe suggested that a diapausing biotype of the egg-prepupal parasitoid *Eubazus semirugosus* (Braconidae) occurring in the mountains is the best candidate for introduction against *P. strobi* because it is more likely to synchronize its phenology to that of the target host.

Collections of *Pissodes pini* parasitized by the diapausing biotype of *E. semirugosus* were made in the Swiss Alps in spring and 190 females were sent to Canada for compatibility tests with *P. strobi*. These tests showed that *E. semirugosus* attacks and develops successfully on the target host. More specimens should be collected next year for field releases in British Columbia.

From cross-mating experiments with diapausing and non-diapausing biotypes of *E. semirugosus* it is now clear that the diapause is genetically based, as it can be transmitted from father to offspring. An obligatory diapause was also found in mountain populations of a sister species, *E. robustus*, parasitoid of the pine cone weevil, *P. validirostris*. *E. robustus* could be considered for introduction if *E. semirugosus* fails to become established in Canada.

A population of *P. harcyniae*, a species living in spruce trunks, was found in Poland. Investigations on spruce *Pissodes* spp. are important, because most of the damage in Canada is found on spruce, and it is not yet certain that *E. semirugosus* collected from pine *Pissodes* spp. will naturally locate *P. strobi* in spruce leaders. The main parasitoid of *P. harcyniae* in Poland is a *Eubazus* sp., probably *E. semirugosus*, but investigations on diapause are needed before considering this *Eubazus* for introduction.

(M. Kenis, A. Van averbeke, N. Otten and D. You. For Canada – IIBC No. 672, started 1983.)

Minor biological control projects against Canadian forest pests

Birch leaf mining sawflies, *Fenusa pusilla* and *Profenusia thomsoni*

As in previous years, mature larvae of *Fenusa pusilla* were collected in eastern Austria. The first generation, collected in June, provided over 1400 cocoons of the two parasitoids, *Lathrolestes nigricornis* and *Grypocentrus albipes*, for shipment to Canada. Collections of the second generation in August and September provided an additional 1900 *L. nigricornis* cocoons. Specimens of both parasitoid species collected in 1994 and 1995 were released in Alberta, Canada. *L. nigricornis* has already been recorded from the field, which is a good sign of establishment.
For the first time since the beginning of this project, a sizeable population of the rare species, _Profenusa thomsoni_, was located in the Swiss Jura. Although the population density was low, parasitism by an unknown gregarious chalcid was as high as 40%. Emphasis next year will be on the study of this promising parasitoid.

**Spruce budmoth, Zeiraphera canadensis**

In previous years, investigations of the natural enemy complex of European _Zeiraphera_ spp. suggested that the pupal parasitoid _Tycherus osculator_ (Ichneumonidae) was the best candidate for the biological control of _Z. canadensis_. This summer, over 3000 pupae of the larch budmoth, _Zeiraphera diniana_, were collected in France, from which about 140 were parasitized by _T. osculator_, and 700 by an undetermined gregarious chalcid. Females of _T. osculator_ are kept for overwintering in Delémont and will be sent next year to Newfoundland, Canada, for compatibility tests with the spruce budmoth.

**Spruce budworm, Choristoneura fumiferana**

Populations of the closely related European fir budworm, _C. murinana_, are still low in Europe. A low density population was investigated in the Vosges mountains in France. Although two larval and four pupal parasitoids were found, total parasitism was very low.

**Spruce cone maggots, Strobilomyia spp.**

Work in Europe is presently focused on parasitoids attacking _S. anthracina_ puparia in the soil, using the host exposure technique. Puparia exposed last year in the Swiss Alps were parasitized by a gregarious parasitoid, _Tritneptis_ sp. nr _lophyrorum_ (Pteromalidae). New exposures were made this year at the same sites, but none was attacked by this parasitoid. In contrast, several puparia were parasitized by solitary parasitoids which are presently in diapause.

**Hemlock looper, Lambdina fiscellaria**

Two braconids of the genus _Aleoides_, and two ichneumonids of the genus _Dusona_, reared last year from European hosts, were sent in January to Newfoundland for compatibility tests against the hemlock looper. As none of the parasitoids was able to develop on the new host, it has been decided to stop the project. Work this year was limited to the completion of studies on the biology of these parasitoids for future publications.

(M. Kenis, K. Carl, A. Van averbeke, N. Otten, D. You and E. Altenhofer. For Canada – IIBC No. 888, started 1986.)
Temperate Weeds Research Programme

Investigations on potential control agents of scentless chamomile, *Tripleurospermum perforatum*

Scentless chamomile is a plant of European origin, introduced into North America by the end of the 19th century. Since then it has become a widespread noxious weed, especially in the Canadian prairie provinces where it is associated with agriculture, causing yield reductions in several crops. As chemical and cultural control often prove uneconomic or unsuccessful, it was concluded that a self-sustaining biological control programme could provide long term reductions of scentless chamomile populations in marginal habitats, from where seeds are spread onto cultivated fields.

Work in Europe started with investigations on the biology and host specificity of the stem-mining weevil *Microplitus (Ceutorhynchus) edentulus* in 1991. After submission of the final report in January 1993, additional host specificity tests with critical test plant species were requested and carried out in 1994 and 1995. An expanded final report is in preparation and will be submitted in spring 1996.

Host range screening with the stem miner *Microplitus (Ceutorhynchus) rugulosus* and the root-feeding weevil *Apion confluens* was carried out as combined oviposition and larval development tests on potted plants. Unfortunately, hardly any *A. confluens* emerged, probably due to poor condition of control plants, caused by heavy attack by *Napomyza lateralis* (Agromyzidae). Multiple-choice tests under semi-natural conditions

![Image of a moth](image)

Female of the gall midge *Rhopalomyia hypogaea* on scentless chamomile
were terminated for *A. confluens* from the Rhine Valley, as well as with critical test plant species for the *A. confluens* population from Austria.

Considerable progress has been made on the rearing of *Rhopalomyia hypogaea*. As this gall midge has only been found in low numbers at one site in eastern Austria so far, it was essential to establish a breeding colony. Two generations have been reared through at the institute, and preliminary screening tests have been started. Although wild *Chrysanthemum* species are regarded as the usual host of this gall midge according to the literature, no galls were induced in no-choice tests on *Leucanthemum vulgare* and *L. maximum*. Studies on the life history and host range of this species will be continued in 1996.

(H. Hinz and A. Geisen. Jointly funded by Alberta Environmental Centre and Alberta Agriculture – IIBC Nos 823, 826, started 1990.)

**Investigation on potential control agents of mouse-ear hawkweed, *Hieracium pilosella***

Of the ten hawkweed species introduced into New Zealand, it is especially *Hieracium pilosella* which has become a widespread weed on sheep pastures in hill and high country areas. In Idaho, USA, another two invasive Eurasian species, *H. caespitosum* and *H. aurantiacum*, attained weed status. These stolon forming perennial herbs form dense mats excluding other forage species and thereby reducing pasture production.

During field surveys in Europe in 1993 and 1994 eight oligophagous phytophagous insect species were found, seven of which are considered of potential interest for biological control of hawkweed.

Investigations in 1995 concentrated on the gall wasp *Aulacidea subterraneus*, the pterophorid moth *Oxyptilus pilosellae*, the syrphid fly *Cheilosia praecox*, and the gall midge *Macrolabis pilosellae*. The biology and life history of these species was studied in greater detail and host range screening commenced.

In multiple-choice oviposition tests with *A. subterraneus* including seven *Hieracium* species, galls were formed exclusively on *H. pilosella* and *H. aurantiacum*. Preliminary oviposition and no-choice feeding tests with *O. pilosellae* strongly indicate that its host range is restricted to species in subgenus *Pilosellae* to which all target species belong. The same was found in tests with *C. praecox*. These results are encouraging and justify continuation of host range screening in 1996.


**Investigations on potential control agents of hound’s-tongue, *Cynoglossum officinale***

The search for potential biological control agents has been requested by British Columbia to prevent the spread of *C. officinale* into rangeland following the successful biological control of other rangeland weeds. Additional host specificity screening tests
with the weevil *Mogulones cruciger* and the flea beetle *Longitarsus quadriguttatus* using critical European and native North American plant species were terminated during 1995. The final screening report for *M. cruciger* will be available in spring 1996, but submission of the petition for field release is already under way. For *L. quadriguttatus* data can only be summarized after adult emergence in spring 1996. Thus, the final screening report will be available in summer 1996.

Good progress has been made with host range screening of the syrphid fly *Cheilosia pasquorum*. Despite political constraints, seeds and root stocks of all plant species that still need to be tested could be transferred to Serbia during the 1995 season. Thus, it is hoped to terminate host range investigations for the fly by the end of 1996.

Some 320 adults of the seed-feeding weevil *Mogulones borraginis* emerged from the laboratory breeding colony during spring. Thus, host range investigations could be continued. Results confirmed the narrow host range of *M. borraginis* to a few species in the genus *Cynoglossum*.

(M. Schwarzlaender, I. Tosevski, J. Freise and A. Kroupa. For Ministry of Forests and Lands, British Columbia and Department of Agriculture, Montana through Montana State University – IIBC No. 746, started 1988.)

**Screening of additional control agents for leafy spurge, *Euphorbia esula***

Leafy spurge (*E. esula*), an aggressive, poisonous perennial rangeland weed of Eurasian origin, is declining at an increasing number of release sites in North America after the establishment of five root feeding flea beetles in the genus *Aphthona* (Chrysomelidae) in open areas with well-drained soils. Control is still not adequate in mesic- and wet-spring, shaded and cool-summer sites; in Eurasia, these are primarily habitats of spurge other than *E. esula*, so the problem is to find insects with a host range broad enough to accept the target weed, but narrow enough not to threaten North American native spurge. Nearly half of the 1995 programme was spent on collecting, rearing and shipping insects to North America. A special effort was made to collect and rear *Chamaesphecia crassicornis* (Sesiidae), the best adapted European species in this family of root-boring moths.

The permit for importation and field release of *A. venustula*, the final report of which was presented in April 1995, is expected be obtained soon. The host range screening of *A. ovata*, a species from open and half shaded mesic areas was completed in 1995. In no-choice laboratory adult feeding tests, *A. ovata* was found to be restricted to species in the genus *Euphorbia*, while the larval feeding range, with a few exceptions, is restricted to species in subgenus *Esula*. The final screening report will be provided in spring 1996. Investigations of *A. violacea* have started. It is a species from open and half shaded wet habitats. Adult and larval starvation tests were made with 20 plant species. The experimental host range of *A. violacea* appears to be similar to those of *A. venustula* and *A. ovata*, with a slightly higher larval survival rate on some species outside subgenus *Esula*. In contrast to *A. venustula* and *A. ovata*, the adults of *A. violacea* have no summer reproductive diapause.
Investigations have continued with *Obera moravica* (Cerambycidae) from open and half shaded habitat in Europe, and *O. donceeli* from cool-summer areas in Inner Mongolia, China. The observation of mating couples appears to be the safest method for separating males and females of *Obera* spp. Males and females which had copulated were marked with a small colour dot on the elytra. Two mated females each were put into multiple-choice oviposition cages. After ten days all females were exposed to males in mating containers. Most females mated a second time, and were returned into oviposition cages. Even so, low rates of oviposition were observed in cages. Some larval development was observed outside subgenus *Esula*.

(A. Gassmann, I. Tosevski and T. Reisenbüchler. Jointly funded by Agriculture Canada; Department of National Defense, Canada; Saskatchewan Agriculture Development Fund; Department of Agriculture, Province of Alberta; United States Department of Agriculture, APHIS; Montana State University; USDA-ARS Rangeland Weeds Laboratory, Bozeman, Montana; Richland County Weed Board, Sidney Montana; North Dakota Department of Agriculture; Crook County Weed and Pest Control District, Sundance, Wyoming; College of Agriculture University of Wyoming; USDA Bureau of Indian Affairs; Fremont and Crook Counties; Converse and Campbell Counties – IIBC Nos 019, 788, 434, 826, 778, 951 and 953, started in 1987.)

**Investigations on potential control agents of sulfur cinquefoil, *Potentilla recta***

*Potentilla recta*, a perennial herb native to the Black Sea region, recently has begun to spread and to invade open habitats such as pastureland. Considering its ecology, there is concern that *P. recta* may invade areas where knapweed (*Centaurea* spp.) has been controlled successfully. Moreover, because of its close taxonomic relation to strawberry and blackberry it could become an alternative host for pests of these two economically important crops.

The paramount demand that potential biocontrol agents must not attack rosaceous crops or any native North American *Potentilla* species limits the number of phytophagous insects worth closer investigation. So far only two species, the clearwing moth *Tinthia myrmosaeformis*, and the flower-bud attacking weevil *Anthonomus rubripes* ab. *femoratus*, seem to fulfil the stringent host specificity requirements.

During 1995, the life history of both species has been studied in detail, and the first series of host range screening tests was carried out with encouraging results. Moreover, field observations in Bulgaria (*A. rubripes*) and Turkey (*T. myrmosaeformis*) strongly indicate that both species are monophagous on *P. recta*.

Investigations in 1996 will focus on host recognition by *Tinthia* females and the experimental investigation of the impact of *Tinthia* on field populations of *P. recta* in Turkey. At the same time host range screening will be continued with both species.

Investigations on potential control agents of old man’s beard, *Clematis vitalba*

In New Zealand the invasive European vine *Clematis vitalba* endangers the remains of native forests, mainly in steep river valleys, by overgrowing the forest canopy and killing even large trees by shading and smothering. Biological control is considered the only ecologically suitable solution of the problem, but is hampered by the large number of native *Clematis* species.

During the past four years research in Europe concentrated on the scolytid *Xylocleptes bispinus*, the agromyzid leaf-miner *Phytomyza vitalbae*, and the leaf-feeding sawfly *Monophadnus spinolae*. No-choice, single-choice and simultaneous multiple-choice tests were carried out with *X. bispinus*, screening adult feeding, oviposition and larval development on critical native New Zealand *Clematis* species. The tests will be evaluated in early 1996. A final series of screening tests was carried out with *P. vitalbae*, and no-choice oogenesis tests were made with freshly emerged females. It is hoped to obtain permission for introduction into quarantine to complete host range screening with a few native *Clematis* species. Screening of *M. spinolae* indicated that it develops exclusively on *C. vitalba*. The final screening report will be written in 1996.

(R. Wittenberg and O. Urena. Funded by Landcare Research Ltd, New Zealand – IIBC No. 847, started 1990.)

Investigations on potential control agents of Dalmatian and yellow toadflax, *Linaria dalmatica* and *L. vulgaris*

These perennial weeds of European origin are causing concern in southern Canada and the adjacent north-western USA. Yellow toadflax, formerly a weed of uncultivated land, is now spreading into cropland where minimum tillage is adapted. Dalmatian toadflax is spreading in the dry interior of British Columbia and similar climatic areas in the USA, especially Montana. It is expected to increase rapidly as biological control of knapweed (*Centaurea* spp.) is achieved.

After one year’s interruption, during which the permission for field release has been obtained for the last agent screened by IIBC, i.e. the root-galling weevil *Gymnetron linariae*, the study and screening of another two *Gymnetron* spp., *G. hispidum* and *G. thapsicola*, commenced in 1995.

Beetles were obtained from Russia, and investigations on their life history started during the 1995 field season to design meaningful host range screening tests to be carried out from 1996 onwards. Since F1 adults do not oviposit prior to hibernation, only preliminary adult feeding tests could be carried out. During these tests it has been demonstrated that both species accept plants of the two target weed populations for normal pre-hibernation feeding.

A test plant list has been established for critical review by the Technical Advisory Groups on Biological Control in Canada and the USA.

(C. Paetel and J. Nash. Jointly funded by Department of Agriculture, Alberta, Alberta Environmental Centre, Ministry of Agriculture British Columbia, B.C. Cattlemen
Biological control of pigweeds, *Amaranthus retroflexus*, *A. powellii* and *A. bouchonii*

The project is part of a cooperative European research programme entitled "Biological Control of Weeds in Crops". The programme was initiated by Switzerland, and after a Memorandum of Understanding had been signed by Denmark, Germany, Hungary, Switzerland, the Netherlands and the UK, it was endorsed in February 1994 as COST Action 816.

The investigations on plant population dynamics started in 1994 were continued. During the summer the growth pattern of plants was monitored in experimental plots at two locations. During September the *Amaranthus* plants and all other weeds were harvested and brought to the laboratory for analysis. Biomass and seed production of the plants grown in different densities, as well as the influence of the pressure of other weeds on these parameters are being investigated. Germination of seeds was followed at weekly intervals with soil samples taken in spring 1995 at three different places in one of the fields investigated.

During summer 1995, four extended surveys were made. Ten locations in Switzerland and neighbouring countries were visited at monthly intervals. At each locality 200 sweepings were made. In addition 50 plants were randomly selected and dissected for insect attack in the laboratory (some 2700 plants in total). No insects were found within the stems or in the roots. Sweeping plants produced a certain number of lepidopterous larvae and nymphs of bugs. Immature stages were reared to adult and forwarded for determination to specialists. The diseased leaves collected were sent to Mr J. Lawrie, our COST collaborator in England.

It is well known from literature that several *Amaranthus* species are cultivated for human nutrition and as forage crops. The three most important species are *A. hypochondriacus*, *A. caudatus* and *A. cruentus*. Discussions showed that in Central Europe crop amaranths are of only of marginal interest and will be so in the future. Although climate would permit their cultivation, the potential market is considered very small. In southern and eastern Europe (mainly in Russia), *Amaranthus* is cultivated as a forage crop (some 100,000 hectares). More information on crop amaranths needs to be collected and potential conflicts of interests discussed prior to the selection of potential biocontrol agents for closer investigation.

At a meeting of the Biological Control of Weeds Group of the European Weed Research Society, at Montpellier in February 1995 two interesting contacts were established for collaboration within the COST project. Mr Lawrie, IACR Long Ashton Research Station at Bristol, UK, came to Delémont. He started research on pathogens of *Amaranthus* in UK in 1994 and provided advice for the collection and preparation of fungal pathogens. Pathogens field collected in Switzerland will be forwarded to Mr Lawrie for primary screening. Mr Lawrie's visit coincided with the visit of Dr L. Cagan, University of Agriculture, Nitra, Slovakia. Dr Cagan is an entomologist. He
surveyed for phytophagous insects and pathogens at selected sites in Slovakia, Czech Republic and Poland during the 1995 field season. Agreement was reached on sampling methods to apply to assure comparative analysis of sampling data. (H.-M. Bürki and M. Hunt. COST project No. 816 – IIBC No. 982, started 1994.)

Services

Supply of natural enemies of weeds to Agriculture Canada Research Station, Lethbridge, Alberta

a) Leafy spurge, *Euphorbia esula* s.l.

Four shipments of control agents were sent. They contained *Chamaesphecia crassicornis* (1320 eggs) and *C. hungarica* (980 eggs).

b) Diffuse and spotted knapweed, *Centaurea diffusa* and *C. maculosa*.

A collection of mature larvae of *Pelochrista medullana* was made in eastern Austria, and a breeding colony established at Delémont.

One shipment was sent containing *Chaetorellia acroleophi* (600 puparia).

c) Dalmatian and yellow toadflax, *Linaria dalmatica* and *L. vulgaris*.

Six shipments of control agents were sent. They contained *Etebalea serratella* (8262 eggs).

Supply of natural enemies of weeds to USA

a) Leafy spurge, *Euphorbia esula* s.l.

One shipment containing *Chamaesphecia hungarica* (80 larvae/pupae) to the USDA-APHIS Biological Control Laboratory, Mission, Texas, to strengthen the breeding colony.

b) Diffuse and spotted knapweed, *Centaurea diffusa* and *C. maculosa*.

Four shipments of control agents were sent to the USDA-APHIS Biological Control Laboratory, Mission, Texas. They contained *Pterolonche inspersa* (670 mature larvae), *Larinus obtusus* (4600 adults), *Terellia virens* (7000 pre-pupae), and *Chaetorellia acroleophi* (600 puparia).

Two shipments of control agents were sent to the USDA-ARS Rangeland Weeds Laboratory, Bozeman, Montana. They contained *Larinus obtusus* (1400 adults) and *Terellia virens* (2000 pre-pupae).

c) Purple loosestrife, *Lythrum salicaria*

A shipment of *Nanophyes marmoratus* (298 adults) was sent to the USDA-APHIS Biological Control Laboratory, Mission, Texas.
Two shipments of control agents were sent to the South Dakota Department of Agriculture via Quarantine at Bozeman, Montana. They contained *Galerucella calma-riensis* (234 adults) and *G. pusilla* (4446 adults).
Kenya

Tropical Forestry Research Programme

Biological control of conifer aphids on Cupressus and Pinus in eastern and southern Africa and associated pests of forestry

Three exotic conifer aphids, two on pines (Eulachnus rileyi and Pineus sp.) and one especially damaging to cypress (Cinara cupressi) have recently spread through much of eastern and southern Africa, causing massive losses to forestry. The African part of the programme has two elements, regional co-ordination and training of national programmes and studies on the ecology and biological control of forest pests, concentrating on aphids. In 1995, the project expanded from working solely with aphids, to assisting Zambia with the control of eucalyptus borers using a parasitoid supplied from the Republic of South Africa.

Regional co-ordination

The project co-ordinator, Ms Allard made repeat visits to Malawi, Republic of South Africa, Tanzania, Uganda and Zambia for project evaluation. Mr Mutitu accompanied Ms Allard on two visits to Tanzania for project evaluation and to assist with a survey for pine woolly aphid Pineus sp., and natural enemies in Sao Hill. Dr Day visited Malawi for natural enemy impact assessments and Uganda for release of Pausia juniperorum.

Project staff co-organized a workshop with FAO and KEFRI on Formation of an African Forest Pest Management Network. The workshop was held at KEFRI Nairobi, 24–28 April, bringing together Directors of Forestry Research and national Forestry Corporations and Policy Makers from eastern, Central and southern Africa to discuss the formation of a forestry pest management network for Africa. Twenty-five participants attended, representing six countries (Ethiopia, Kenya, Republic of South Africa, Sudan, Tanzania and Uganda) and three International Organizations (CAB INTERNATIONAL, ICRAF, FAO) as well as the University of the Orange Free State, South Africa, and Canadian Forest Service.

Since 1992 an informal network of forestry pest management personnel has been established under the auspices of the IIBC Regional Biological Control Programme for Conifer Aphids, sponsored by CIDA, ODA and FAO. Through this network links have already been established throughout eastern and southern Africa involving information and scientific exchange. Thus this workshop represented the culmination of several years experience and discussion. Proceedings have been edited and are being published by FAO.

Assistance was provided to KEFRI and to the Forest Department, Zambia, to carry out in-country training courses (see training courses section). Exchange visits were organized for several technical staff from the region and for Dr P. Donli from the University of Maiduguri in Nigeria (see training courses section).
The Project Monitor, Dr B. Moody from Canadian Forest Service, attended the network workshop and afterwards visited the National Programme in Zambia accompanied by the co-ordinator. A CIDA Review Team visited East Africa, 11–25 November, to evaluate the project which is due for completion in March 1996. The team, Dr V. Nordin and Mr W.M. Ciesla, visited Kenya and Uganda and had discussions with representatives from Malawi, Rwanda and Zambia.

The project continued to provide assistance for greenhouse construction in Uganda and Zambia and this is now completed, except that interior furnishing is still needed. The project also provided limited funds for operational costs incurred in population sampling for conifer aphids and surveys for pine woolly aphid and natural enemies in Kenya and Tanzania.

Conifer aphid ecology and biological control activities on conifer aphids and eucalyptus borers

Natural enemies for tree pest biocontrol have been released in several countries this year. The first release of a biological control agent for control of the eucalyptus borers Phoracantha semipunctata and P. recurva was made in Zambia. An egg parasitoid, Avetianella longoi, which originated from Australia was exported from South Africa by PPRI to Zambia in January 1995 and released in one selected field site in Chipata, Eastern Province. The parasitoid rapidly established in the field and within ten months had dispersed approximately 70 km from the original release site. Plans are under way to transfer this parasitoid within the country to the Copperbelt Province where population monitoring of this important pest is being carried out following a training course held in July 1995.

Further releases of Puaesia juniperorum have been made in Malawi and Kenya. In Malawi releases in 1994 failed to establish, but following releases this year large numbers of mummies are being observed several months after the releases, increasing the probability of the parasitoid population surviving the rainy season when aphid populations are normally very low. Releases in Kenya have not been so successful, no recoveries being made beyond the first generation. The first releases of P. juniperorum have also been made in Uganda.

Leucopsis tapiae, the predator of pine woolly aphid that has been discovered in southern Africa despite never having been introduced there, has been imported into quarantine at Muguga ready for shipping to Uganda once import permits have been secured.

Much work this year has focused on assessing natural enemy impact, of both introduced and local natural enemies. In Malawi the results of the 1994 releases of P. juniperorum were reviewed, and it was concluded further releases were merited. Also in Malawi a preliminary assessment of impact of L. tapiae was made using data sets from pine woolly aphid monitoring. Although conclusive evidence of a major effect of the predator was not found, the relative densities of predator and prey suggest that at certain times and locations the predator must be exerting a substantial effect. The predator, which was released in Tanzania and Kenya in the 1970s, has not been found during surveys in these countries, so the origin of the Malawi population is not clear.
In both Tanzania and Kenya, however, the predatory bug *Tetrathelps raoi*, also introduced in the 1970s, is found to be widespread. Detailed monitoring in Kenya shows at some times of the year populations are very high, while at others they are very low. An exclusion/inclusion experiment is in progress in Kenya to quantify the impact of the predator complex in general and *T. raoi* in particular, on the pine woolly aphid.

An exclusion experiment was also conducted to assess the effect of predators on cypress aphid. Vandalism damaged some of the experiment, but the remainder confirmed earlier data indicating generalist predators are not having a major effect.

(G.B. Allard, R.K. Day and E.K. Mutitu. For CIDA – IIBC No. 875, started 1991. See also UK projects.)

**Leucaena psyllid**

The leucaena psyllid *Heteropsylla cubana*, causes extensive dieback, loss of foliage and death of *Leucaena leucocephala* plants. *L. leucocephala* is an important multi-purpose tree species which has been badly affected by the psyllid since its arrival in Africa in 1992. The psyllid was first detected on the Indian Ocean coasts of Kenya and Tanzania and quickly spread south to Malawi and Mozambique, east to Zaire and north to Ethiopia. It may be expected to colonize all appropriate habitats in Africa within the next few years. IIBC has been involved with leucaena psyllid biological control in Asia and the Pacific and was asked by FAO to carry out a consultancy to implement biological control in Kenya and Tanzania. While several generalist coccinellid predators have been identified elsewhere attacking the psyllid, IIBC believes that two specific parasitoids, *Tamarixia leucaenae* (Eulophidae) and *Psyllaephagus yaseeni* (Encyrtidae), identified in the original range of the pest in meso-America, should be the main agents for classical biological control.

Plots for monitoring the psyllid, natural enemies and leucaena growth and damage have been set up in two areas in Tanzania, and suitable sites identified in Kenya, in collaboration with TAFORI and KEFRI respectively. Permits were obtained for the import and release of *Tamarixia leucaenae* and *Psyllaephagus yaseeni* for Tanzania (immediate release after third country quarantine in the UK) and Kenya (following one generation in quarantine). *T. leucaenae* was released in Morogoro and Tanga in Tanzania in July and August. Post-release breeding populations have been observed at both release sites. In Tanga four months after releases the parasitoid was found to be relatively common and to have dispersed 10 km from the release site. If *T. leucaenae* is confirmed to be established, this will be the first successful introduction of this parasitoid anywhere in the exotic range of the psyllid. Both species have been imported to IIBC Kenya and the first preliminary releases of both species were made at the ICRAF Machakos field station at the end of December. Evaluation of both parasitoids in Kenya and Tanzania will continue in 1996 and further parasitoid releases will be made.

Tropical Weeds and Entomology Research Programme

Biological control of the larger grain borer *Prostephanus truncatus*

This project is the first to attempt classical biological control of a stored products pest. The larger grain borer is a native of Central America, and as an exotic in Africa causes severe losses to stored maize. It is currently found infesting stored maize in eastern Africa in Burundi, Kenya, Malawi, Rwanda and Tanzania. Following extensive studies in the area of origin of *P. truncatus*, a predatory histerid beetle, *Teretriosoma nigrescens*, has been selected as a suitable candidate agent for biological control.

The predator was released in May 1992. Population dynamics of the pest and predator are monitored using pheromone traps baited with the *P. truncatus* aggregation pheromone which attracts both species. We have five years' continuous trapping data dating back to 1990. For the first three years, the population dynamics of *P. truncatus* showed strong seasonal peaks of abundance between November and January in association with the short rains in East Province of Kenya. Following the establishment and spread of the predator into the trapping area at the KARI Kiboko Range Station in 1994, the annual peaks of pest abundance have not been observed in the pheromone traps and year-round incidence of the pest in the traps has been very low.

While there are no data to verify this directly, there is strong circumstantial evidence to link the decline in pest catches with the appearance of the introduced predator *T. nigrescens*. By contrast, pheromone traps placed in Tsavo National Park (to which *T. nigrescens* has yet to spread) continue to show high numbers of *P. truncatus* during the short rains. Monitoring is continuing, as are other studies aimed at trying to evaluate the biological control agent. This is being carried out through a Rockefeller PhD study award to Mr Nang’ayo.

In addition to the above work, a small study to investigate the establishment and impact of *T. nigrescens* in the Taita Hills in Coast Province of Kenya was set up. Approximately 60,000 adult predators were released at 60 sites covering a range of five agro-ecological zones in and around the Taita Hills. Pheromone traps were placed within the zones for ten months prior to the releases to get background information on pest population levels. Repeat surveys will be carried out in the coming years to determine the establishment success and impact of the predator in the different agro-ecological zones which range in altitude from 600 to 1600 metres. The results of the study will provide information on the likely impact of the predator in other parts of Kenya where it has not yet been released.

(M.G. Hill and F.L. Nang’ayo. For ODA/KARI – IIBC No. 995 and Rockefeller Foundation No. 980, started 1990.)

Survey of natural enemies of *Coccus viridis*

The green scale, *Coccus viridis*, is a cosmopolitan polyphagous pest which is believed to originate in East Africa. In Australia it is a pest of citrus and the Queensland
Department of Primary Industries wishes to develop better biological control for the pest as a part of its citrus IPM programme. A survey of green scale on citrus was made on the Kenya coast from Malindi in the north to Kwale in the south. More than 100 parasitoids from at least seven species were collected. About half of these have been identified by taxonomists at the International Institute of Entomology. At least one new species of primary parasitoid in the genus Metaphycus (Encyrtidae) has been identified, together with a new species in the genus Aprostocetus (Eulophidae) which may be a primary or secondary parasitoid.

(A.M. Varela, E.A. Chandi, P. Karanja and M.G. Hill. For the Queensland Department of Primary Industries – IIBC No. 998, started 1995.)

**IPM in horticulture**

East Africa has a large and growing horticulture industry for both local consumption and export. IIBC carried out a season-long IPM consultancy for Sulmac Ltd, a Kenyan flower grower, providing information on the identification, abundance and impact of natural enemies of horticultural pests, mainly spider mites, thrips and Helicoverpa armigera in experimental flower production areas.

At the request of the Kenya Standing Technical Committee on Imports and Exports (KSTCIE), IIBC Kenya, in collaboration with colleagues from KARI, developed draft guidelines for the importation and release of augmentative biological control agents into Kenya. These guidelines are still under discussion but will pave the way for the legal importation into Kenya of augmentative biological control agents produced by commercial companies in Europe and other parts of Africa.


**IPM implementation in vegetables and coffee in Kenya**

Pesticide use in high value crops is increasing in Kenya. Several studies have indicated that many pesticides which enter the farming system for use on export crops are subsequently used to control pests and diseases on other crops growing nearby, notably vegetables for local consumption. A small study to initiate the development of curricula for farmer participatory approaches to IPM on smallholder coffee and vegetable farms, with an emphasis on careful use of pesticides and natural enemy conservation, has begun as a joint venture between IIBC, the Coffee Research Foundation of Kenya (CRF) and the Kenya Institute of Organic Farming (KIOF). The project started in November 1995 with a survey to identify suitable areas for the work and will continue in 1996 with the development of pilot training of trainers and development of curricula for farmer field schools. This project is one of several pilot projects being funded through the IPM Facility.

(B.T. Nyambo, M.G. Hill, M. Kimani (KIOF) and D. Masaba (CRF) For FAO/IPM Facility – IIBC No. 1032, started 1995.)
Control of water hyacinth in the Shire River, Malawi

Water hyacinth has been slowly advancing up the lower Shire River in Malawi, threatening a hydro-electric scheme, irrigation schemes, fish farms and ultimately the Lake Malawi and Lake Malombe fisheries. A project to control the weed was initiated in August in collaboration with the Malawi Fisheries Department. A preliminary survey at the start of the project revealed that the weed had spread to the Upper Shire and was present in large quantities in the Lilongwe River which flows into Lake Malawi.

The project began by initiating emergency spraying of the weed with glyphosate in the Lilongwe River followed by the immediate release of *Neochetina eichhorniae* and *N. bruchi* into the infestations in the Lilongwe River and Upper Shire. The immediate release of the agents was carried out in an attempt to ensure that when the rains start at the end of the year, the weed from these new infestations travels downstream to uninfested parts of the rivers with biocontrol agents attached.

The project, which will run for three years, aims to control the weed using several biological control agents. It will also investigate the impact of the weed on aquatic biodiversity and socio-economics of riparian communities affected by the weed.

(G.N.S. Phiri and M.G. Hill. For ODA – IIBC No. 1021, started 1995.)

Services

Coffee berry borer parasitoid studies

Shipments of coffee cherries infested with the coffee berry borer, *Hypothenemus hampei*, were collected from commercial coffee plantations in western Kenya and shipped on a monthly basis to IIBC UK to establish a rearing method and culture of *Phymastichus coffea* in quarantine.

(B.T. Nyambo and E.A. Chandi. For ODA – IIBC No. 958A, started 1995. See also UK and Colombia projects.)

Supply of biological control agent for prickly acacia

Following extensive surveys and feeding studies carried out by the Queensland Department of Lands, permission was obtained for the release in Australia of the chrysomelid beetle *Weiseana barkeri*, a specific defoliator of prickly acacia (*Acacia nilotica*). Prickly acacia, a major pest of pastures in Australia, is native to Africa and Asia. The subspecies introduced into Australia is found in eastern Africa. Collections of adult *W. barkeri* were made at several sites in the Rift Valley in Kenya and two shipments were sent to Australia, from which a successful breeding population was obtained for field releases.

(B.T. Nyambo and E.A. Chandi. For Queensland Department of Lands – IIBC No. 997, started 1995.)
Malaysia

ADB-IIBC Regional project on IPM in cotton

The general objective of the technical assistance project on cotton IPM is to test and implement IPM methods in cotton-based cropping systems in China, India and Pakistan. Since the initiation of the project, emphasis was mainly given to benchmark surveys, on-farm research and demonstrations, and exchange of information. Results of the cotton on-farm IPM research in China, India and Pakistan during 1993 and 1994 have indicated that IPM plots yielded higher than farmers’ practice plots, that high levels of insecticide applications induced high populations of whitefly, and sometimes also cotton boll worm. Releases of *Trichogramma* and predators in non-sprayed plots in Pakistan gave encouraging results. During the third planning and evaluation meeting in September 1995, it was decided that season-long (60 days) cotton IPM training of trainers (TOT) as well as farmers field schools be carried out. As a follow-up of the meeting, India successfully conducted two 60 days or season-long cotton IPM training of trainers courses in Guntur and Nagpur.

(S. Ramaswamy (FAO), G.S. Lim and J. Vos. For ADB – IIBC No. 933, started 1993.)

Farmer-centered Agricultural Resource Management Programme (FARM) – IPM Sub-Programme

The IPM Sub-Programme of FARM became operational in February 1995. During the first half year of the project, work concentrated on the compilation and design of training exercises for cruciferous and solanaceous crops. Special attention was given to crop management exercises, such as nursery techniques, mulching, choice of cultivars, and fertilization. Development of training curricula in the three project countries India, Indonesia and Vietnam was facilitated by providing relevant information, exchange of training material, and through participation in workshops. During the second half year, greater attention was given to participation in season-long TOT courses. Assistance was given to these IPM training courses by way of participation as facilitator/resource person during visits of 1–2 weeks duration. Both in India (Faridabad) and Vietnam (Hanoi), support was provided to combined cabbage and tomato IPM TOTs. The visits to Indonesia (Medan) concerned a hot pepper IPM TOT. In addition, assistance was also rendered to a cabbage IPM study in Chiang Mai, Thailand. In Malaysia, evaluation of some training exercises was initiated at the IIBC station, while on-farm studies were initiated in the Cameron Highlands.

(J. Vos and M.H. Yahaya. For FAO – IIBC No. 0014, started 1995.)
POP M ALAM

= 2,9 %

= 0,4 %

KETERANGAN

JUMLAH DAUN : 2493
CABANG : 29,3
BUNGA : 2,5
BUNGA : 3,2
TANAMAN : 47,2

CABANG : MENGEMANG
VARITAS : K. BEJAR
ULAT : 46 HST
LAMIN : RAIS

BIPEL (DIPEL) ↓
ULAT

VARITAS KERING BESAR.

JUMLAH DAUN : 530
VARITAS : K. BEJAR
ULAT : 46 HST
LAMIN : RAIS
Pakistan

IPM of fruit and vegetable pests and transfer of technology to the farmers in Malakand Division

This project is funded by Swiss Intercooperation, under Pakistan/Swiss Malakand Fruit and Vegetable Development Project (MFVDP) since June 1990. It completed its second 3-year phase in June 1995. At the expiry of this phase a 1 year continuation project was agreed up to June 1996. The objective of the IIBC project is to develop biological control based integrated pest management for fruit and vegetable pests in the Malakand area, and provide need-based biological control inputs in, and transfer of technology to the farmers. Major inputs have been provided in control of pests described below.

San José scale

Population density of San José scale on apple remained at sub-economic level because of successful releases and recovery of a parasitoid, Encarsia perniciosi, in 1993–94, and a predator, Chillocorus internalis, in 1990–91 in Upper Swat. This year, mean percentage parasitism of E. perniciosi was 69% at Shangwati in August, and 70 adults of C. internalis were counted on five hundred 5 cm² branches.

Codling moth

Preliminary work was initiated to develop a predictive model on heat-unit summations for codling moth, Cydia pomonella, at Shangwati. This year the first moth was collected from the pheromone traps in the last week of March.

Over the year codling moth infestation has been expanding from its initial base in Mingora into new areas previously considered free from this pest. On the basis of pheromone trap catches at 15 different localities around Mingora it appears to have spread 1 km further in upper Swat.

Woolly aphid

The parasitoid Aphelinus mali kept woolly aphid, Eriosoma lanigerum, under excellent control throughout the infested area. Mean parasitism was 76% during the year and farmers are no longer using any insecticides against this pest.

Mites

The total life span of the mite predator Stethorus gilvifrons in the laboratory is 21 days. Efforts are also under way to develop a mass rearing technique for this predator.

Flatheaded peach bark borer

The work on distribution of flatheaded peach bark borer Sphenoptera dadkhani was continued at different altitudes. So far infestations have not been found above 1500 m.
Cabbage butterfly

Use of the parasitoid *Pteromalus puparum* for control of cabbage butterfly *Pieris brassicae* was investigated. The parasitoid was reared by releasing its adults on fresh pupae of *P. brassicae* and *Artogeia rapae*. At a mean temperature of 20.9°C many thousand adult *P. puparum* emerged after three weeks. On average 102.5 (range 95–110) adults of *P. puparum* emerged per pupa.

Extension work

In December a seminar on integrated pest management (IPM) was delivered to the extension staff of Dutch funded PATA Integrated Agricultural Development Project.

In June a training in Map Reading was attended in coordination with Farming Systems mapping unit of MFVDP, Swat.

In July and November work on IPM implementation studies in Chitral was started in coordination with staff of Agha Khan Rural Support Programme and Fruit and Vegetable Development Board.

In October a three-week IPM training was organized for a trainee from the FAO funded Fruit Development Project, Quetta.

(M.A. Qureshi and M.A. Poswal. For Malakand Fruit and Vegetable Development Project – IIBC Nos 855 and 1023, started July 1993.)

**Biological control of *Aonidiella orientalis* in Nigeria**

Neem tree, *Azadirachta indica*, was introduced into Africa a century ago. Because of its adaptability to arid climates it has been widely planted in the northern states of Nigeria. *Aonidiella orientalis*, which is a native of Indo-Pakistan subcontinent and adjacent regions was first recorded in 1970 in Africa and in 1987 in Nigeria. It has now assumed serious pest status and causes severe defoliation leading to ultimate death of neem trees in Nigeria.

In a two month survey of neem trees in Nigeria in the summer of 1995, *A. orientalis* was found to be most abundant in Borno State, followed by Adamawa, Bauchi, Yobe, Jigawa, and Kano. It was also recorded in outbreak proportions from Abuja (Federal territory) on several plants. Other scale insects recorded from neem in order of abundance were *Parlatoria crypta*, *Lepidosaphes tapleyi*, *Pseudoaonidia trilobitiformis*, *Coccus hesperidum* and *Saissetia* sp.

Parasitoids recorded from *Aonidiella orientalis* were endoparasitoids *Habrolepis aspidiota* and *Comperiella* sp. from Kano, Gashua, and Borno, *Aprostocetus* sp. from Adamawa and Bauchi, and two unidentified ecto-parasitoids from Adamawa and Bauchi.

A predator, *Cybocephalus* sp., was recorded breeding on *Aonidiella orientalis* on *Thevetia nerifolia*, *Dodonea viscosa* and *Rosa indica* at Maiduguri (Borno state) and on *Parlatoria*
crypta on Nerium indicum at Kano (Kano state). Empty pupae of Chilocorus sp. were recorded in groups on neem and it is probably an incidental predator of scale insects on neem.

An action plan for integrated pest management of Aonidiella orientalis in Nigeria was prepared for the Government of Nigeria. The promising biocontrol agents for introduction into Nigeria against A. orientalis from the area of its origin were also proposed.

(R. Mahmood. For Nigeria, IIBC No. NCC-1003 16 May–18 July, 1995. See also UK projects.)

Survey of oriental yellow scale, Aonidiella orientalis, and its natural enemies

A survey for Aonidiella orientalis and its natural enemies which started in October 1994 continued during 1995 to select biological control agents for introduction into Nigeria to control this scale on neem trees (Azadirachta indica). The scale is very widely distributed throughout Pakistan and has a wide host range. During this survey it was recorded from 29 different trees and shrubs of more than 15 families. Of these Ficus bengalensis seems to be the preferred host with a six month average of 45.99 scales per leaf, followed by A. indica with 2.59 scales/leaf, while Ficus religiosa, Erythrina cumini, Dalbergia sissoo and Mangifera indica all averaged more than 1.0 scales/leaf. On most plant hosts the scale infestations peaked in September, but on F. bengalensis in Rahim Yar Khan and A. indica at Multan, two peaks were observed, one in April and the other in September.

Natural enemies of Aonidiella orientalis recorded during this survey include the parasitoids Aphytis sp. (lingnanensis group), Aphytis sp. (melinus group) [for names of these species see UK projects], Encarsia spp., Comperiella sp., C. aspidiotiphaga, Aprostocetus purpureus; and predators Pharoscymnus flexibilis, Chilocorus nigris and Cybocephalus semiflavus. The Aphytis spp. were recovered from Aonidiella orientalis on Azadirachta indica in March from Karachi area, and in April from Rahim Yar Khan and Multan areas, but at a very low level. Average percentage parasitism by a complex of Aprostocetus purpureus, Encarsia spp., Comperiella sp. and C. aspidiotiphaga was 5.3% and 14.33% in April and September, respectively. Maximum parasitism (31.98%) by this complex of parasitoids was recorded in September from Aonidiella orientalis on Erythrina cumini at Rahim Yar Khan. Pharoscymnus flexibilis was the dominant predator species feeding on scales on F. bengalensis, M. indica, D. sissoo, Alstonia sp. and Cassia fistula in September/October. Cybocephalus semiflavus was recorded from Karachi on Azadirachta indica, Ricinus communis, F. bengalensis and M. indica in March; from Lahore on D. sissoo in October and from Rahim Yar Khan and Multan on A. indica in April.

Three shipments of Aphytis spp. collected from various host scales and plants were sent to UK.

(J.A. Qureshi, M.A. Poswal and H. Raza – IIBC No. 985, started 1994. See also UK projects.)
Natural Enemies of *Cinara* spp.

As part of the Africa programme on biological control of cypress aphids, explorations for natural enemies of *Cinara cupressi* were made in the northern foothills and plains of Pakistan. *Cupressus* spp. are exotic to Pakistan although cultivated plantations of this genus can be located at old gardens and graveyards in the plains and lower hills. As anticipated, *Cinara* spp. were not found at any location on *Cupressus* plants. However, *Cinara tujaflina* was recorded during the studies as a serious pest of *Thuja orientalis*, an ornamental plant mainly used for hedges in parks and house gardens. At Rawalpindi-Islamabad, *C. tujaflina* appeared around November onwards, and its populations remained available till the end of April after which the aphid populations crashed. However, *C. tujaflina* was available in abundance in March-April on *T. orientalis* in the lower parts of the country (Hyderabad, Sargodha, Faisalabad, and Okara). No parasitoid has yet been recovered from *C. tujaflina*. However, several predator species including the coccinellids *Scymnus coccivora*, *Menochilus sexmaculatus* and *Leis dimidiata*, and the syrphids *Syrphus balteatus*, *Metasyrphus* spp. and *Xanthogramma scutellare* were recorded feeding on this aphid species.

(J.A. Qureshi and M.A. Poswal. IIBC – No. 875, started, 1994. See also UK and Kenya projects.)

Biological control of the brown peach aphid, *Pterochloroides persicae* for Yemen

A survey for natural enemies of the brown peach aphid, *Pterochloroides persicae*, a very serious introduced pest of peach trees in Yemen, was initiated in May 1995 in northern and western Pakistan. So far, the aphid has been recorded from the northern foothills (Rawalpindi), wet hills (Abbotabad), Taxila, Haripur, Swat Valley and dry hills (Balocharstn) from peach, plum, almond, apricot and apple. During this extensive survey, one very effective primary parasitoid, *Pauesia antennata*, and two hyperparasitoids *Pachyneuron nazeeri* and *Dendrocerus carpenteri* have been recovered from field populations of brown peach aphid in Balocharstn. *Chrysoperla* sp. from Swat Valley and four predatory coccinellid species from Balocharstn, *Chilocorus bipustulatus*, *Adonia variegata*, *Adalia quadrispilota* var. *bispilota*, and *Coccinella septempunctata*, were also recorded on brown peach aphid.

Hyperparasitoids seem to suppress *Pauesia antennata* populations; of the 1000 field collected mummies 23.5% contained *Pachyneuron nazeeri*, 0.2% *D. carpenteri* and only 9.6% *Pauesia antennata*. In laboratory conditions (22±2°C 12:12 L:D regimes) and in the presence of host aphids and liquid honey solution, female *P. antennata* live for 2.2 days, and males 2.5 days on average. In preliminary tests, pieces of peach var. Florida King branches, 25–30 cm long and 2.5–4 cm diameter, with one end submerged in tap water in jam jars, proved a more suitable medium for establishing laboratory culture of the brown peach aphid than plum, cultivated apricot, *Pyrus*, or wild apricot. Studies on host range, population dynamics, phenology, varietal susceptibility, and dispersal behaviour of brown peach aphid are also being investigated in collaboration with the Deciduous Fruit Development Centre Quetta.
(M.A. Poswal, J.A. Qureshi, M. Karim and A.N. Khan. For FAO and Yemen – IIBC No. 1008, started 1995. See also UK projects.)
UK

Insect Pathology Research Programme

LUBILOSA – the collaborative research programme on the biological control of locusts and grasshoppers

The LUBILOSA project (LUtte Biologique contre les LOcustes et SAuteriaux) is a collaborative research programme between IIBC, the Plant Health Management Division of IITA and AGRHYMET (formerly DFPV), a division of CILSS. The project is based at IIBC UK, IITA Cotonou, Benin, and AGRHYMET-CILSS, Niamey, Niger, and aims to develop a biopesticide based on the fungus *Metarhizium flavoviride* for integration into ecologically sound management programmes for acridoid pests.

In the final year of its second phase, LUBILOSA concentrated on two major objectives: the achievement of a successful field trial on a scale of 100 ha and a report on the economic viability of mycopesicides for acridoid control.

For the second year running the LUBILOSA project collaborated with the Plant Protection Research Institute of South Africa to carry out trials against the brown locust (*Locustana pardalina*) in the Karoo. A large microlight aircraft fitted with Micronair AU7000 atomizers was used to apply the standard *Metarhizium flavoviride* isolate to ten hopper bands in the Richmond District of the Karoo in South Africa. All treated bands showed significantly greater mortality than the controls, with up to 98% mortality in field maintained samples after 3 weeks. Mortality in caged samples was often faster than with hoppers maintained in field enclosures. The relative efficacy of the various methods of aerial application will need confirmation in further trials; a volume rate of 2.5 l/ha appeared to give more consistent results than 1 l/ha applications. Mortality was probably related to droplet impaction, affected primarily by the wind speed at the time of spraying.

Large scale field trials in Niger

Rates of $5 \times 10^{12}$ conidia/ha in 2 l/ha were applied to replicated 50 ha plots by Ulvamast vehicle-mounted sprayer. The plots were open grassland, infested by a mixture of acridid species at 20–80 second and third stage nymphs/m² in which *Oedaleus senegalensis* and *Acrotylus blondeli* were dominant. Population differences were detectable by day 6 and reached 75% reduction in the treated plots by day 21. Residual infectivity was much higher than expected and persisted at least until day 12, which merits further investigation.

150 ha of savannah woodland, near Maïne Soroa (Niger) infested with high populations of *Oedaleus senegalensis* and other grasshopper species, were successfully treated with the *Metarhizium* formulation by a Mk. II 'Ulvamast'. The trial consisted of three 50 ha treated plots and three similarly sized controls. The trial was a success with population reductions of >70% 3 weeks after application.
Field trials in Benin against *Zonocerus variegatus*

A replicated trial was carried out on 1 ha plots at Mono, southern Benin to test the efficacy of lower rates of strain I91–609. Even the lowest rate of $5 \times 10^{11}$ conidia/ha in 2 litres/ha gave >90% control. The principal effect of increasing the dose was not increased kill, but increased time over which the residual deposit remained infective.

Collaborative field trials in Mali (with the Mali Service de Protection des Végétaux and IER)

Significant population reductions occurred following treatment of mixed grasshopper populations in 5 ha replicated plots. Counts fell to 1.8/m² on day 8 and 1.3/m² by day 15 in the treated plots but remained at 4–6/m² in the control plots.

Field trials in Mauritania

Two trials were carried out in 1995 against hopper bands of *Schistocerca gregaria* in cooperation with the Mauritanian SPV and the GTZ team. Cage samples gave up to 90% mortality after 11 days. Attempts to track treated bands met with mixed success because bands frequently dispersed and intermingled with other bands. Because of natural mortality the size of untreated bands diminished as the insects matured, but the treated bands diminished to a significantly greater extent. Development of more sophisticated methods to monitor post-treatment effects will be a Phase 3 objective.

Production

Construction of the new production wing at Cotonou was begun in 1995 and is now nearing completion. It will have the capacity to produce all the *Metarhizium* material needed for Phase 3 activities. The vacuum particle sizer for spore collection was finished and installed in Cotonou.

Formulation and application

The survival of conidia formulated and sprayed through the Mk. II exhaust nozzle sprayer (ENS) was evaluated by Mr J. Griffiths, a student at Imperial College of Science, Medicine and Technology, London. Germination of the conidia collected from the spray was reduced by 30% as compared to unsprayed conidia. However in bioassays there was no detectable difference in virulence with conidia collected from the spray samples and unsprayed formulation. This indicated that despite a reduction in viability the virulence of the conidia was not affected by the stresses of the exhaust nozzle sprayer. This evaluation has demonstrated a useful degree of stability with an oil-based formulation of *M. flavoviride* in the ENS and suggests that field trials using this sprayer could now be attempted. The droplet size spectra produced by the sprayer were investigated using the Malvern series 2600 cc particle size analyser.
Other laboratory research has centred around the development of a stable, reliable product (tentatively named 'Green Muscle'). This has involved the development of a device for separating individual dry spores to a high specification, with help from Ms S. Mermelstein, a student at South Bank University, London. Work has also been initiated on the development of more user friendly oil miscible flowable concentrates to facilitate large scale field applications.

Ecology and modelling

Ecological studies continued in collaboration with the Leverhulme Unit. The major focus of these was to develop methods to examine the fate of the pathogen after spraying to help interpret results of field trials more fully. The studies were conducted as part of field trials against Z. variegatus in southern Benin in the spring and as part of the 150 ha trial conducted against sahelian grasshoppers in Niger in August. A common finding in these experiments was that spores of M. flavoviride formulated in oil appear to survive for several days after spraying and contribute significantly to total mortality from the spray treatment. This additional mortality is especially important where direct impact of the spray droplets is limited by dense vegetation or where there is significant movement of grasshoppers into and out of the sprayed areas.

The ecological studies also revealed that the mortality rate of grasshoppers that remain in the field after spraying is often lower than in grasshoppers collected from the field and then incubated in the laboratory. This observation is consistent with a number of other studies, particularly in North America, where it has been suggested that high ambient temperatures and the possibility that nymphs raise their body temperatures above ambient by thermoregulation, may be important factors limiting the field efficacy of pathogens. This said, there is no evidence in the case of Metarhizium that this slowing in disease development, whether active or passive, actually prevents mortality; population reductions in several studies have exceeded 80–90%. However, these results do illustrate that evaluation of field trial results is complicated by a number of factors which are not apparent in trials with conventional chemicals. Our studies are now demonstrating how ecological and modelling approaches can provide a link between laboratory and field data and can aid the interpretation of field trial results when factors such as dispersal, low mortality and variable routes of infection, make quantification through direct methods difficult.

Economic report

A survey of potential producers of Metarhizium in Africa and Europe was conducted by Dr D. Swanson, economics consultant. He concluded that the development of myco-pesticides on a small scale was suitable for some niche markets but that large-scale production using more sophisticated and expensive technology would be more competitive for large markets such as desert locust plagues. The report recommends that LUBILOSA concentrates on product improvement, registration, developing a marketing strategy compatible with sociological goals and motivating industrial partnerships.
Registration

In 1995, LUBILOSA complied with Canadian government guidelines for biopesticide field tests that allowed it to carry out two specific trials on areas up to 1000 ha. In future trials >10 ha, compliance will also be sought to conform with these guidelines and further data will be obtained to proceed towards registration compliance with Canadian requirements.

Australian trials

In 1995, CSIRO, the Australian Plague Locust Commission (APLC) and New South Wales Department of Agriculture carried out trials against the wingless grasshopper (*Phaulacridium bivittatum*) and the Australian plague locust (*Chortoicetes terminifera*). Excellent results were obtained in the wingless grasshopper trials, including a trial on a 50 ha plot sprayed from the air by APLC. Trials on Australian plague locust were less successful, owing to unexpectedly cold conditions during incubation of the samples, which slowed mortality.

Recognising that LUBILOSA had completed its Phase 2 objectives successfully, the project’s sponsors CIDA, SDC, DGIS and ODA attended the 12th programme management committee meeting in Ottawa and agreed to consider a proposal for a third phase 1996–1998. In this phase, the major objectives will be the improvement and commercialization of the mycopesticide product, further field trials under operational conditions by national programmes and the development of a national capability to use the mycopesticide in management schemes for acridoid pests in four selected West African countries (Benin, Ghana, Niger and Senegal). During Phase 3 the LUBILOSA structure has been expanded to include GTZ as a full partner. CILSS has replaced DFPV as a result of internal reorganization. SDC has arranged for bridging funding arrangements to secure continuity of the programme into 1996.


Temperate Weeds and Tropical Entomology Research Programmes

Biological control and IPM for St Helena

As part of an ODA consultancy mission to the island, an IPM proposal and plan were developed. A crucial part of this will be the classical biological control of a range of key alien pests on the island that currently cause immense damage to agricultural crops. For example, citrus trees seldom produce useful fruit any more due to infestations of the citrus woolly whitefly (*Aleurothrixus floccosus*), the citrus psyllid (*Trioza erytreae*), a citrus aphid (*Toxoptera citricidus*) and tetranychid mites. Several of these
pests have been successfully controlled biologically in other parts of the world, so the prospects for their control on St Helena are very good. Collections of pest species were made on the island including new records of scale, whitefly and dipteran species. This emphasizes the importance of improved quarantine, particularly of incoming plant material, and this also would be a key part of any future IPM programme.

Monitoring of the action of the coccinellid beetle *Hyperaspis pantherina*, released for the control of the scale *Orthezia insignis* on the endemic gumwood trees (*Commidendrum robustum*, Compositae) in 1993, has continued. The levels of infestation by the scale have dropped so impressively that the Department of Agriculture & Forestry staff involved in culturing the coccinellid are having problems finding enough prey to keep the culture going. The two remaining stands of gumwoods are clearly recovering, with many trees producing new, uninfested leaves in contrast to the almost complete blackening of the older foliage by sooty moulds. Dr Q. Cronk, the expert on the endemic flora of St Helena, was on the island at the time of Dr Fowler’s visit, and credits IIBC with ‘saving the gumwoods’.

Finally, the gorse mite (*Tetranychus lintearius*) and the gorse thrips (*Sericothrips staphylinus*) were taken to the island for release against gorse, which invades pasture and indigenous vegetation on the island. Releases of the mite were made during the visit, and numbers of the thrips are being built up in a laboratory culture for later release. Monitoring of these releases will take place in subsequent years. The releases of the gorse thrips will provide the first field test of the optimum release size predicted from studies in New Zealand undertaken by IIBC/Leverhulme and Landcare Research scientists.

(S.V. Fowler and R.H. Shaw. For ODA/St Helena – IIBC No. 928, started 1995. See also Leverhulme Unit projects.)

**Biological control of gorse, *Ulex europaeus***

Field collections were made in Portugal for the Pempelid moth, *Pempelia genistella*, which were sent to Hawaii and New Zealand for release against gorse (*Ulex europaeus*).

(S.V. Fowler and R.H. Shaw. For Landcare Research, New Zealand, and Hawaii – IIBC No. 450, started 1979 and IIBC No 1014, started 1995.)

**Biological control of Scotch broom, *Cytisus scoparius***

Scotch broom (*Cytisus scoparius*) is a weed in New Zealand and Australia, where it invades pasture, commercial forests and areas of conservation importance such as braided river valleys and native forests. The biological control programme against Scotch broom for New Zealand was initiated in 1981. A concurrent programme for Australia was started by CSIRO/NSW Agriculture which includes substantial ecological work on the weed in both the UK and France.

At IIBC UK host range testing of agents continued with particular attention to pioneering developmental tests on the weevil *Sitona regensteinensis* and rearing of the moth
Chesias legatella. Shipments of the chrysomelid Gonioctena olivacea and the seed-beetles Exapion fuscrostre and Bruchidius villosus were sent to Australia, the latter of which is to be released shortly.

Dr Paynter operated the broom biological control programme in France, based at the CSIRO European laboratory in Montpellier. Monitoring of the ecological studies continued and a new experiment to test the effects of inter- and intra-specific competition on the establishment and growth of broom seedlings was set up.

Host specificity testing of the geometrid moth Pseudoterpna pruinata, the gall forming eriophydid mite, Aceria genistae (which produced very encouraging results), and the aphid Ctenocallis setosa were carried out. Populations of several promising new agents were identified this year, including an unusual gall-forming agromyzid fly, Hexomyza sarothamni, the gall midge Asphondylia sarothamni and a stem-mining moth, Phyllonorycter scopariella. Furthermore, a promising pathogen Uromyces genistae-tinctoriae f.sp scoparii, which is reported to be specific to broom was discovered during a survey of the Pyrenees. Shipments of the aforementioned seed-beetles were also sent to Australia.

The collaborative studies on the population dynamics of broom between IIBC/Leverhulme Unit, Landcare Research and CSIRO/NSW Agriculture were continued and expanded including the addition of a four country comparison of seed predation. Dr Fowler went to New Zealand to work with Dr Memmott on the gorse thrips release experiment and Mr Shaw visited Australia and New Zealand as part of the on-going British Council funded links scheme and was involved in the population dynamics recording and setting up the seed predation studies.

Final host range testing was carried out on the heather beetle, Lochmaea suturalis, and excellent results, coupled with a favourable environmental impact assessment should lead to this promising agent being shipped and released next year against heather (Calluna vulgaris) in New Zealand.

(S.V. Fowler, Q. Paynter, R.H. Shaw and J. Memmott. For Landcare Research, New Zealand – IIBC No. 740, started 1981; and CSIRO/NSW Agriculture, Australia – IIBC No 879, started 1991. See also Leverhulme Unit projects.)

**Tropical Forestry Research Programme**

**Biological control of conifer aphids on Cupressus and Pinus in eastern and southern Africa**

This project on biological control of conifer aphids has been in operation since 1991 and has two main objectives: first, the permanent biological control of three aphid pests, Cinara cupressi, Pineus boerneri and Eulachmus rileyi, in eastern and southern Africa; second, the strengthening of the capacity within national forestry research departments for the development and implementation of biological control and integrated pest management. Project activities are organized from IIBC UK and IIBC Kenya.
During 1995, work in the UK was focused on the field collection, laboratory production, quarantine screening and shipment of selected agents to Africa. Some further work was also carried out on the laboratory assessment of potential agents. The majority of natural enemies processed were for control of Cinara cupressi but some work on parasitoids of Heteropsylla cubana the leucaena psyllid was also carried out. Work on American chamaemyiid predators of Pineus boerneri was suspended pending the outcome of field evaluation on the impact of the European species, Leucopis tapiae, in Malawi.

Several trips to collect Pausidia juniperorum to boost cultures were made to sites in England and France. In total, 15 shipments of Pausidia juniperorum were sent to three countries in Africa; five to Kenya, eight to Malawi, and two to Uganda. Field releases of the parasitoid were made in all three countries. Although results from Malawi have continued to be encouraging, releases in Kenya have not been as successful. In Malawi, there are indications that the parasitoid is dispersing from the original release trees.

Further laboratory studies to assess the potential of P. juniperorum showed that foraging success is not limited when the parasitoid searches for hosts on Cupressus macrocarpa or Cupressus lusitanica. Thus, it is likely that the parasitoid is well adapted to exploit hosts on other Cupressus spp. grown in Africa. Studies were also carried out, using Coccinella 7-punctata as an example, to determine if generalist predators are likely to limit foraging success of P. juniperorum. The results of these studies did not reveal any adverse effects, thus it is unlikely that generalist predators that have adapted to exploit Cinara cupressi in Africa would limit the action of P. juniperorum.

During the year two shipments of the leucaena psyllid parasitoid Tamarixia leucaena were also processed in the quarantine facility and shipped to Tanzania for field release.

(S.T. Murphy, Y.J. Abraham, A.E.Cross, M.T.K. Kairo, E. White and S.L. Wheeler. For eastern and southern Africa – IIBC Nos 875 and 878, started 1991. See also Kenya projects.)

Emergency assistance to control oriental scale, Aonidiella orientalis, on neem trees in Nigeria

The exotic armoured scale insect Aonidiella orientalis has become a serious pest of neem, Azadirachta indica, in Nigeria. In 1994 an FAO funded project was initiated with the objective of finding, identifying and selecting potential biological control agents of Aonidiella orientalis for introduction into Nigeria. Included in the project was the training in biological techniques of two personnel from collaborating Nigerian institutions.

A culture of Aonidiella orientalis has been established under quarantine at IIBC UK and maintained on a variety of vegetable squashes (Cucurbitaceae). Surveys for natural enemies carried out by IIBC Pakistan (see Pakistan projects) identified several promising parasitoids with species of Aphytis being the most dominant. Shipments of scales parasitized by Aphytis spp. were sent from Pakistan to the UK, where with the help of taxonomists from IIE two species of Aphytis were identified, A. melinus and A. lingnanensis. The two species were separated for rearing and various methods of culturing Aphytis have been investigated.
Two six week study tours, one to Kenya and one to Pakistan, were undertaken by Nigerian personnel; they received training in the procedures of field surveys, screening, mass rearing, release and assessment of natural enemies.


**Biological control of brown peach aphid, *Pterochloroides persicae*, in Yemen**

In 1993 *Pterochloroides persicae*, a lachnine aphid pest of mainly *Prunus* spp., was reported for the first time in Yemen. The aphid rapidly spread to all parts of the country causing widespread damage to peach (*Prunus persicae*), almond (*Prunus amygdalus*) and other related fruits. The centre of diversity of *Pterochloroides persicae* is probably somewhere in western China or Central Asia. It is likely that from this general area the aphid was spread westwards as a result of human activities along the old trade routes. Records of the aphid seem to indicate that it is gradually extending its range westwards and southwards.

This new project, funded by FAO, is aimed at implementing classical biological control against the pest in Yemen. Exploratory surveys for natural enemies have been initiated from IIBC Pakistan and one potential agent, *Pauiesia antennata* (Braconidae), has been selected for further work. Research to develop culturing techniques for the aphid and *P. antennata* have also been initiated in both Pakistan and UK. Selected potential agents will be quarantined in the UK prior to shipment to Yemen.

(M.T.K. Kairo and J. Hodgson. For Yemen – IIBC No. 1008, started May 1995. See also Pakistan projects.)

**Weed Pathology Research Programme**

**Fungal pathogens for biological control of weeds**

**Bathurst burr, *Xanthium spinosum***

Bathurst burr is one of the most widespread weeds in Australia, and is a particular problem in the south-eastern states, where, as well as being a noxious competitive weed of many arable crops and rangeland, its main economic impact is as a contaminant of wool, significantly increasing the processing costs. Dr B. Auld (NSW Agriculture) has been investigating the mycoherbicide potential of a number of indigenous pathogens, in particular, the anthracnose fungus *Colletotrichum orbiculare*. Reports from an entomological survey in Argentina (Dr A.J. Wapshere), indicated that an anthracnose disease was severe in certain regions, and this prompted a search for coevolved strains of *Colletotrichum* in the centre of origin of *X. spinosum*. The 7000 km survey in March 1995, assisted in part by Dr Auld, revealed a number of damaging pathogens in the different ecological zones, including *C. orbiculare*, *Erysiphe cichoracearum* and *Cercospora xanthiicola*. Various isolates of *Colletotrichum orbiculare* have been obtained in culture and are being
screened for pathogenicity and specificity. Preliminary results are extremely encouraging, the Argentinian strains are killing *X. spinosum* significantly faster than Australian isolates and with a high level of specificity. A follow-up survey in November 1995 was undertaken in order to monitor the effect of anthracnose on young plants at the beginning of the growing season (spring). Unfortunately, the visit coincided with a widespread drought and the original objectives were modified accordingly.


Serrated tussock, *Nassella trichotoma*

*Nassella trichotoma* is a perennial tussock-forming grass belonging to a South American genus with a predominantly Andean distribution. It is now a major weed of both natural and agricultural ecosystems in the Old World (Australia, New Zealand, South Africa). The visit to Argentina to survey *X. spinosum* was extended to search for pathogens on *N. trichotoma*, especially in the natural habitats comprising upland, rocky scree. A tussock decline, associated with an as yet unidentified basidiomycete (Corticaceae) considered to represent a new genus, was encountered consistently during the survey. Pathogenicity tests have proved to be inconclusive and a chronic rather than an acute disease syndrome may be involved. In addition, species of *Ascochyta*, *Stagonospora* and *Puccinia* were collected, which are new pathogen records for this host.

(H.C. Evans and C.A. Ellison. For CSIRO – IIBC No. 1002, started March 1995.)

Saffron thistle, *Carthamus lanatus*

Saffron thistle is a widespread annual weed of arable crops and rangelands in Australia. It is especially common in the eastern wheat belts, where it ranks as one of the most important weeds. A survey for pathogens was undertaken, in conjunction with Dr J.P. Aeschlimann, in a purported centre of origin in southern Greece, in early spring (April 1995), to coincide with the early rosette stage. A microcyclic rust, *Puccinia sommeriana*, previously known only from the type locality in Malta, was particularly common and damaging. A combined attack with a leaf spot fungus, *Septoria centrophylli*, was associated with plant death.

(H.C. Evans. For CSIRO – IIBC No. 010, started April 1995.)

Eurasian water milfoil, *Myriophyllum spicatum*

*Myriophyllum spicatum* (Haloragidaceae) is a submerged aquatic plant that grows in a wide range of environmental conditions, and constitutes part of the natural aquatic flora throughout the UK and mainland Europe but rarely reaches weed status. *M. spicatum* was introduced into the USA at the turn of the century and is now a serious ecological and economical weed in larger bodies of water in North America.
Surveys for *M. spicatum* have been carried out during 1995 in the UK and parts of mainland Europe (Austria, Italy, Slovenia, Spain, Portugal). Over 400 isolates comprising 54 identified species from 38 genera, have now been obtained from material collected. Of the isolates tested for pathogenicity, eleven have caused severe damage and were reisolated successfully from the plant tissue: Indeterminate sp. (Hyphomycete) (x2), Indeterminate sp. (Coelomycete), *Fusarium solani, Fusarium sporotrichoides, Acremonium sp., Cylindrocarpon destructans, Gliocladium roseum* (x2), *Embellisia telluster, Glomerella cingulata, Geotrichum candidum, Phoma sp.* and *Pythium periplocum*. Work is continuing to evaluate their biological control potential.

(J.L. Harvey, H.C. Evans and D.R. Varley. For US Army Corp of Engineers – IIBC No. 956, started 1994.)

Itch grass, *Rottboellia cochinchinensis*

*Rottboellia cochinchinensis* is an aggressive, annual grass and a serious weed in many areas of the tropics. It has an Old World centre of origin, but was introduced into the New World, probably at the beginning of the century, where it is rapidly increasing its range. Although both a mycoherbicidal and a classical approach have been investigated during the course of this project, this year has focused on two agents that have the potential for classical biological control: a head smut, *Sporisorium ophiuri*, and a rust, *Puccinia rottboelliae*. This particular phase of the project began at the end of 1993 and is due to finish in March 1996.

Itch grass occurs as a number of biotypes, and isolates of the smut and rust have been found to be biotype specific. Intensive searches have identified smut isolates pathogenic towards New World biotypes of the weed, and surveys for new rust isolates are under way. The smut forms a systemic infection, eliminating seed set from infected plants. The fact that itch grass is an annual weed, with a relatively short lived seed bank (up to 3 years), and seed as the only means of propagation indicates that such a sterility-inducing fungus could have potential as a biological control agent. Population dynamic studies were continued in Thailand to predict whether the smut would significantly affect populations of the weed in the long term, should it be released in the New World. The data from these studies are being used to improve a model of the weed-pathogen system, being developed by NRI personnel in collaboration with the Leverhulme Unit. Funding is currently being sought for ODA-NRI to continue the work through to the field release stage in Central America.

(C.A. Ellison, R.H. Reeder and P.J. Reeves. For ODA-NRI – IIBC No. 961 started 1993; for USDA – IIBC No. 916, started 1992.)

*Lantana, Lantana camara*

Lantana is a spreading, woody shrub of the Verbenaceae native to the Americas, and is now a major Palaeotropic weed, particularly in conservation areas. The weed has been targeted for biological control with insects since the early 1990s, but with little
success, hence the recent evaluation of fungal agents. A rust, *Prosopodium tuberculatum*, appears to be one of the most promising pathogens, although all isolates so far screened (from Brazil) appear to be specific to one of the varieties of the weed, the common pink from Australia. Under this project Dr R.W. Barreto of Vicsosa University (Minas Gerais) is carrying out surveys in Brazil to identify further strains pathogenic to all the major weedy varieties, as well as other potential pathogens.

(C.A. Ellison and S. Williams; R.W. Barreto (Vicsosa University). For USDA – IIBC No. 916, started 1992.)

Giant sensitive plant, *Mimosa pigra*

*Mimosa pigra* var. *pigra* is a spiny leguminous shrub native to the Neotropics which has recently become a noxious weed in the Northern Territory of Australia, where it poses a serious threat to conservation areas such as the prestigious Kakadu National Park. Several host specific insects from tropical America have already been released and two fungal pathogens from Mexico have been evaluated as potential biocontrol agents at IIBC UK as part of the control programme.

The coelomycete *Phloeospora mimosae-pigrae* for which host specificity had been confirmed in three years of rigorous host range testing in Mexico and the UK, was first released in Australia in March 1994. Mass releases have continued in the Northern Territory during the wet season of 1995 and the fungus has shown good infection in the field. Recent surveys carried out by CSIRO staff in areas infested with *Mimosa pigra* around Darwin have indicated that the pathogen has survived the dry season in the field showing fresh sporulation at the beginning of the current wet season.

The host range testing of the second promising pathogen, the rust *Diabole cubensis*, was completed during the first half of 1995 and proved that the pathogen is host specific to the *Mimosa pigra* complex. The proposal of importation was approved by the Australian quarantine authorities in November and import permission into Australia was granted. Deep frozen rust teliospores packed in dry ice were sent as the first shipment in December and there are indications that the pathogen is established in the quarantine greenhouse at CSIRO / Brisbane. *Diabole cubensis* will be propagated in the greenhouse at CSIRO over a few months in order to provide sufficient inoculum for field release. It is envisaged that the first releases will take place at the beginning of the dry season in the Northern Territory in April/May 1996.

Being complementary to each other in seasonal occurrence, the two fungal pathogens should prove to be a useful addition throughout the year to the insect control agents for *Mimosa pigra* already released.

This project was successfully finished at IIBC UK by the end of June 1995 with the submission of the import proposal. The pathogens are being maintained in the greenhouse as well as in liquid nitrogen at IMI in order to supply fungal material for further shipments.

Parthenium weed (*Parthenium hysterophorus*)

*Parthenium hysterophorus*, native to Central America, is a problem weed of Australian rangeland, particularly in Queensland, where it has colonized huge areas of native pasture and cultivation. In addition, the plant is reported to cause allergic reactions in the form of dermatitis and asthma in susceptible humans and to be harmful to livestock.

Previous research carried out at IIBC UK has already led to the release of the host specific rust *Puccinia abrupta* var. *partheniocola* in Australia in 1991. However, this pathogen originates from semi-arid, upland areas in Mexico and is adapted to cooler night temperatures. Since the infestation with *Parthenium* weed is currently spreading into humid lowland areas of Queensland with a subtropical to tropical climate, the need has arisen to broaden the search for fungal pathogens which are more suitably adapted to these conditions.

The project, therefore, was renewed in July 1995, as a collaboration between Queensland Department of Lands and CSIRO in Australia, the Instituto de Ecologia (IE) (Ms A. Romero and Ms G. Carrión)/Xalapa in Mexico and IIBC UK in order to compile an inventory of the fungal pathogens of *Parthenium hysterophorus* throughout its native range. The phenology, epidemiology and biology of selected agents are being studied in the field and in the greenhouse. In addition, host-range testing with promising candidates for biological control of the weed is being undertaken.

The first survey was carried out in Mexico in collaboration with staff from IE in September 1995 and several pathogens have been collected and identified. Of these, a downy mildew and a rust, *Puccinia melampodii*, have been selected for further field and greenhouse evaluations both in Mexico and in the UK.


**Potential for biological control of Philippines locusts**

Ash falls from the Mount Pinatubo eruption in central Luzon have provided new breeding sites for the migratory locust (*Locusta migratoria*) and swarms have been damaging sugarcane crops. Philippines locust control scientists are keen to develop control methods using mycoinsecticides, based on the successes of the LUBILOSA programme. In cooperation with CSIRO, IIBC scientists visited the Philippines to discuss the development of a programme to implement a mycopsisde for locust control, and Partnership Facility funds have also been used to bring a Philippines scientist to IIBC UK and IITA Cotonou to exchange information on assay and production techniques.

(C. Prior. For CABI Partnership Facility.)

**IPM in taro (*Colocasia esculenta*) in the South Pacific**

With assistance from the CABI Partnership Facility, IIBC and IMI are cooperating on the development of a project proposal from South Pacific Commission (SPC) nations
for funding for research on IPM solutions to the major taro problems of blight, virus infection (and the key insect vectors) and major insect pests. IIBC and IMI will prepare a proposal for presentation at the SPC liaison officers’ meeting in Fiji in February.

(C. Prior and M. Holderness (IMI). For CABI Partnership Facility, started 1995.)

**Leverhulme Unit for Population Biology and Biological Control**

**How best to release a biological control agent?**

Fewer than 50% of biocontrol agents released against alien pests, and fewer than 65% of agents released against alien weeds, become established successfully in the field. A collaborative programme between the UK and New Zealand has been asking whether better release strategies could improve on these statistics. Field experiments have been used to investigate the relationship between the probability of establishment and the number of individual agents released, the first time that this relationship has been unequivocally tested in the field for biological control agents. The data from the experiments are being used to design optimal release strategies for biological release agents.

One of the experiments involves gorse, *Ulex europaeus*, a leguminous shrub which has been deliberately introduced into many countries and like many alien plants, has become a serious weed of pasture, forest and native habitats. One of the most badly affected countries, New Zealand, has conducted a classical biological control programme against gorse since 1979. The programme aims to introduce a range of gorse feeding insects from Europe to reduce the vigour and invasiveness of the plant in New Zealand. Ideally, biological control agents would be released in huge numbers, but difficulties in the collection, rearing, shipment or quarantine of potential agents invariably result in limited numbers being available for release. Therefore biological control workers face a dilemma: should they make a limited number of large releases or a large number of small releases? Similar questions are likely to be faced by all projects which make releases into the natural environment, whether for biological control or for other purposes such as re-establishment of locally extinct species.

While there are large bodies of work on the theory of establishment and many retrospective analyses of the literature, there is a decided paucity of field tests. The following experiment describes one of the very few field tests investigating the effect of release size on the probability of establishment.

In the New Zealand field experiments, replicated releases of varying size for the gorse thrips were made onto isolated small gorse bushes in a large field site in Canterbury, New Zealand. One year later the bushes were sampled. The thrips is polymorphic but predominantly wingless: sampling of adjacent bushes verified that dispersal from the release bushes was insignificant over the course of the experiment. We define establishment as the presence of second generation adult thrips the following year. There was a positive relationship between the size of release and the probability of recovery.

The relationship between release size and probability of establishment enables us to predict that the optimum release strategy for future releases of the thrips is to make
multiple releases of between 30 and 90 thrips. The probability of successful establishment drops to zero when fewer than 30 thrips are released, suggesting a threshold below which establishment will not occur. We do not know the exact value of this threshold, it may be close to a value of 30 and, as it may be sensitive to environmental conditions, choosing a release size of 90 would be a more risk averse strategy. Practical considerations would also favour a release of 90 versus 30, because it is easier to release and monitor nine batches of 90 thrips than 27 batches of 30 thrips.

With gorse thrips, the release strategy designed to optimize establishment leads to the choice of relatively small initial inocula in contrast to the original strategy in New Zealand which used inoculates of 1000 thrips. The new strategy would lead to a more than ten-fold increase in the total number of release sites, leading to a radical improvement in geographical coverage and hence in the efficiency of the gorse thrips control programme both in New Zealand and in other countries where release of the gorse thrips is imminent.

(J. Memmott, S.V. Fowler and R.L. Hill. See also UK projects.)

The importance of biomass allocation patterns and herbivory for the invasion of exotic plants

Attempts to identify general attributes of invading plants have been largely unsuccessful. Only a small proportion of species that have been introduced actually become established populations, and even fewer become serious weed problems. A potentially important, but poorly investigated observation is that some weed species appear to be more vigorous and productive in their alien environments, compared with their native habitats.

Herbivory frequently induces changes in plant traits such as morphology, internal resource allocation and root:shoot ratios. The ‘optimal defence hypothesis’ predicts that plants show a trade off in biomass between growth, maintenance, storage, reproduction and defence. In an environment free of specialist herbivores, such as often occurs when an alien plant species becomes established, it is likely that the selective pressure of herbivory will be altered. Under such circumstances, it is important to know whether changes in selection pressures contribute to plants becoming aggressive invaders.

This project focuses on the observation of increased vigour in alien weeds. In so doing, the research aims to determine experimentally whether observed differences in plant performance reflect environmental differences between the alien and native habitats, or genetic changes in populations of the invading species. The optimal defence hypothesis may help explain the putative differences between alien and indigenous genotypes of weeds, and could account for the increased vigour of weeds in their introduced range.

Purple loosestrife (*Lythrum salicaria*) is a perennial species of wetlands, native to Britain and Europe and which has become an invasive weed of conservation areas in
parts of North America. The subject of an on-going biological control programme, this species was used as a model system to investigate the observation of increased vigour in weeds. During the spring/summer of 1995 plants germinated from seeds representing alien and indigenous genotypes of purple loosestrife were grown in a 'common garden' experiment at Silwood Park. At the conclusion of the experiment, in autumn of the same year, plants were harvested and several indices of plant growth were determined including height, mass, and several measures of reproductive effort. The data are still being analysed, but already show clear differences between genotypes, with evidence that indigenous genotypes are generally smaller and less vigorous than alien genotypes. Complementary work in a reciprocal experiment conducted in the USA confirms these early trends. Experiments testing the optimal defence hypothesis and which aim to investigate the performance of biocontrol herbivores on alien and indigenous genotypes of the weed are planned for 1996.

(A.J. Willis.)
Projects at Other Locations

Management of the African rice gall midge (*Orseolia oryzivora*) in West Africa

This is a three-year collaborative WARDA/IIBC project funded by ODA. Project staff carried out on-farm trials and sampling in south east Nigeria, on-station experiments at IITA (the project's base) and surveys in the far west of WARDA's mandate area. As in 1994, project staff collaborated closely with Dr E.S. Heinrichs and Dr B.N. Singh of WARDA and Dr M. Ukwungwu of NCRI, Nigeria. IITA continued to provide essential office, laboratory and field facilities at Ibadan.

In September and October surveys of African rice gall midge were undertaken in Guinea and Guinea-Bissau, in collaboration with IRAG and INPA respectively. These combined detailed sampling of lowland rice fields at intervals along the survey routes, less detailed observations on neighbouring fields, and interviews with national research and extension staff. Data on a set of agro-ecological characteristics were recorded to help identify those associated with African rice gall midge infestation. For a subsample of sites, galls were dissected to obtain African rice gall midge parasites for identification by IIE and to determine parasitism levels. To maximize the usefulness of the surveys, data were also recorded on other rice pests and weeds.

African rice gall midge was found throughout Guinea-Bissau but not in southern Guinea away from the coastal plain. Tiller infestation levels were generally low: the maximum level for a sampled field was 13.4%. However, the interviews indicated that both countries had experienced higher infestations in some recent years (as usual, associated with above-average rainfall) and there was some evidence of an increasing trend of midge infestation, particularly in coastal areas of Guinea. Nevertheless, at present African rice gall midge is clearly a less important pest in these countries than in Nigeria, Burkina Faso or Mali. This could be partially due to agro-ecological conditions which might soon change: for example many farmers in both countries currently grow traditional lowland rice varieties (which may be less susceptible than some improved ones) and use little or no inorganic fertilizer (high levels of which have been shown to increase rice gall midge infestation). In both countries *Platygaster diplosiae* and *Aprostocetus procerae* were the only African rice gall midge parasitoids abundant enough to play an important role as natural biocontrol agents. The same is true of all other countries for which data on African rice gall midge parasitoids is available.

On-farm research in Nigeria was concentrated around Abakaliki, Enugu State, one of three localities sampled through 1994. Project staff continued population monitoring in the area and ran on-farm trials in collaboration with Dr Ukwungwu, Dr Singh and Enugu State ADP. The largest of four researcher-managed varietal trials tested 80 rice lines for resistance to African rice gall midge under heavy natural infestation. The lines tested included many nominated by Dr Ukwungwu as a result of his screen-house testing at NCRI. The trial confirmed strong resistance in 20 lines of the indigenous African cultivated rice *Oryza glaberrima*. It also identified 16 traditional Asian and African lines of *O. sativa* which, though not strongly resistant, showed infestation levels significantly below those on 'Cisadane', a partially resistant check
variety. This level of resistance, acting in combination with natural biological control, might be enough to prevent serious outbreaks.

Also around Abakaliki, 53 farmers participated in farmer-managed trials to test 'Cisadane' against their usual varieties and investigate the effect of transplanting date. At each test site African rice gall midge infestation levels and other agro-ecological conditions were monitored and yield cuts were taken. After harvest, participants were interviewed for their evaluations of 'Cisadane'. Preliminary examination of the results shows that on very heavily attacked plots where agronomic conditions were not good, yields of both 'Cisadane' and the farmer's check variety were near zero. However, under less extreme conditions 'Cisadane' seems to give a worthwhile yield benefit. It also has several agronomic characteristics which made it popular with the farmers. In 1995 African rice gall midge built up earlier and faster than in 1994, probably as a result of earlier and more abundant rains. Near Abakaliki higher gall densities were detectable in May (before rice crops were planted) on wild *O. longistaminata* and volunteer *O. sativa*. This suggests that simple, location-specific risk prediction systems based on early wet season scouting could be developed.

At IITA a third yield loss trial was carried out to examine the effect of duration of African rice gall midge attack, and an experiment was started to determine levels and causes of African rice gall midge egg mortality and to investigate seasonal changes. The eggs are laid exposed on the plant surface, so they and the newly hatched larvae are more susceptible to predators and unfavourable weather conditions than the subsequent immature life-stages, which are well protected within galls. Two more host range tests were also conducted. Results continue to support the conclusion from the 1994 field sampling that African rice gall midge is restricted to *Oryza* species, a much narrower host range than has been assumed. More identifications were received from IIE for African rice gall midge parasitoids collected during 1994. These included two new species from Nigeria: a *Neanastatus* sp. and a *Eupelmus* sp.

As last year, the project funded research by national scientists on African rice gall midge ecology and control through the WARDA IPM Task Force. This work included surveys in southern Mali and northern Cameroon, more screening for varietal resistance in Nigeria, Burkina Faso and Sierra Leone and studies on parasitoids and effects of cropping sequence in Nigeria.

During 1995 a proposal for a short extension to the project (July 1996 to March 1997) was accepted by ODA.

(C.T. Williams, K.M. Harris and O. Okhidievbie. For ODA/WARDA – IIBC No. 948, started 1993.)

**Integrated pest management for coffee in Colombia**

The coffee berry borer, *Hypothenemus hampei*, is Colombia’s most serious pest. Ongoing studies to develop an IMP approach (funded by ODA and the Colombian Growers Federation) has focused on 1) studying farmers adoption rates of current
control methods, 2) development of farm budgets to study costs and benefits of control measures, 3) field mortality factors, including emergence and dispersal of the borer, 4) the field effectiveness of the wasp Cephalonomia stephanoderis and the fungus Beauveria bassiana, 5) the efficiency of cultural control techniques, 6) mass rearing of C. stephanoderis, 7) introduction of Phymastichus coffea, an adult parasitoid from Africa.

Results suggest that farmers are using cultural control (mostly hand-picking of infested berries) and insecticides as the main ways to control the borer, though hand-picking is inefficient and ways should be studied to improve it. Most farmers use insecticides but have not adopted research recommendations for the way in which they are used; many also do not measure pest levels before spraying. Surveys are producing many interesting and unexpected results which call for a reassessment of the current IPM strategy.

Field work on established biocontrol agents reveals that much more research is needed for them to reach the effectiveness of the methods most currently used. For Colombia, with very high wage costs, mass release of parasitoids is an attractive though still distant goal. Four shipments of the eulophid Phymastichus coffea, a parasitoid of the adult borer, have been sent to Colombia after quarantine at IIIB UK and individuals have reached the F3 generation though growth of the culture is slow.


Integrated pest management for highland vegetables in the Philippines

This project is managed from IIIB Malaysia, as an Asian Development Bank’s Technical Assistance to the Department of Agriculture, Philippines (ADB 2019-PH).

The TA is effectively contributing to a successful IPM programme in the Cordillera highlands. Diamondback moth (Plutella xylostella) populations have been kept low (reduced from 100% infestations to only 3.33%) by the parasitoid Diadegma semiclaustrum. Highland cabbage farmers have greatly reduced their use of insecticides from Pesos 60 million in 1991 to less than P15 million in 1995 and at the same time maintaining, and even increasing, yields from 25 to 35 T/ha.

The project has trained IPM specialists from local government units which now facilitate farmers field schools (FFS) in the municipalities. A training manual on FFS, a farmers pocket field guide to vegetable pests and natural enemies and a storybook presentation of FFS are being prepared. Insect pests and natural enemies are being collected and preserved to build up an identification reference collection. Diadegma semiclaustrum rearing facilities have been upgraded. Farmers’ consultative workshops were conducted to obtain suggestions on how to further upgrade and improve the FFS and to get information necessary to formulate the Cordillera Administrative Region IPM strategy.

Benchmarks and monitoring information systems have been developed and are being used; computers for storing and analysing data have been purchased and e-mail
software installed to access local and international IPM results. Case and impact studies are in progress.

Appendix 1

Staff List

Headquarters and UK Centre at Silwood Park

Silwood Park, Buckhurst Road, Ascot, Berkshire, SL5 7TA, UK
Tel. 01344-872999
Telex 9312102255 (BC G)
Telecom Gold/Dialcom 84:CAU015
CG/NET 157:CGI 163
Fax (01344) 875007
E-mail CABI-IIBC-HQ@CABI.org
or for individuals: <first initial>.<last name>@CABI.org

Headquarters

Director J.K. Waage, PhD
Assistant Director Operations M.J.W. Cock, PhD
Assistant Director Programme Development R. Wang, PhD
Consultants D.J. Greathead, DSc; K.M. Harris, PhD; M. Sabelis, PhD

HQ Administrative Support
Administrative Manager M.A. Affonso, BA
Accountant L.K. Dix; I. Stewart (August–September)
Computer Officer P.M. Higgins, PgD (to August)
Clerical Staff P.J. Briggs; S.L. Huddison; M. Scott (March–October); B. Ball (part time from October); A. Ranjal (part time March–September)
Secretarial Staff P.M. Oldfield; L. Fulham (from April)

Training, Information and Policy Support
Leader D.J. Girling, MSc
Training and Information Officer S. Williamson, MSc
Information Officer A.H. Greathead, BSc

Leverhulme Unit for Population Biology and Biological Control
Research Fellows J. Memmott, PhD; M.B. Thomas, PhD; A.J. Willis, PhD
UK Centre

Insect Pathology Research Programme
Leader C. Prior, PhD
LUBILOSA Project Manager W.M. Steele, PhD
Scientists R.P. Bateman, PhD; N.E. Jenkins, BSc; D. Moore, PhD
Research Assistant S.E. Barnes, BSc (until June)
Technical Assistants D.G. Batt; M.L. Carey
Temporary Assistant M. Kabiru-Usman (from September)
PhD Students R. Alves (from July); L. Lacayo (returned from Nicaragua July); S. Laup, MSc; M. Portilla (May–August); F. Posada (January–May); P.A. Smith, MSc

Temperate Weeds and Tropical Entomology Research Programmes
Leader S.V. Fowler, DPhil
Scientists Q. Paynter, PhD (at CSIRO, Montpellier); R. Shaw, BSc
Temporary Assistants R. Mitchell, MSc; E. Green, MSc

Tropical Forestry Research Programme
Leader S.T. Murphy, PhD
Scientists Y.J. Abraham, BSc; A.E. Cross, MSc; M.T.K. Kairo, MSc
Technical Assistants S.L. Wheeler; E. White
Temporary Assistants A. Rivero, PhD; A. Rott, DiplBiol; J. Hodgson, MSc
(June–December)

Weed Pathology Research Programme
Leader H.C. Evans, PhD
Scientists C.A. Ellison, PhD; J.L. Harvey, PhD; R.H. Reeder, MSc; M.K. Seier, DiplBiol
Research Assistant S.E. Barnes, BSc (from July); N. Bird, BSc (from September)
Technical Assistants P.J. Reeves; D.R. Varley; S. Williams, RHS Hort
PhD Student C. Kittithamkul, BSc (in Thailand)
External collaborator R.W. Barreto, PhD (Vicosa University, Brazil)
IIBC Stations

Caribbean & Latin America

Gordon Street, Curepe, Trinidad & Tobago
Tel. (809) 662–4173
Fax (809) 663–2859
E-mail CABI-IIBC-CLAS@CABI.org
Scientist-in-Charge (acting) R.A. Hammond, PhD
Administrator A. DeGazon
Project Scientist and Technical Manager V.F. Lopez, BSc
Librarian/Curator M. Morais, BSc
Field Laboratory Technician C.V. Gannes, DipTec (from September)
Laboratory Assistant S. Ali (part-time, until September)
Auxilliary Staff A. Joseph; K. Williams; E. Holder

Collaborators from CES, Ministry of Agriculture, Land and Marine Resources, Centeno, Trinidad
Entomologists M. Jones, BSc
Technician K. Charles (until August)

NIHERST Pathology Group (until June)
Leader R.A. Hall, PhD
PhD Students B. Ali, BSc; D. Peterkin, BSc; K. Uddenberg, BSc

Europe

1 Chemin des Grillons, CH–2800 Delémont, Switzerland
Tel. 066–22 12 57
Fax 066–20 05 15
E-mail CABI-IIBC-europe@CABI.org
Scientist-in-Charge K.P. Carl, DnatSc
Secretary M. Gyseler

Agricultural Entomology Research Programme
Leader K.P. Carl, DnatSc
PhD Student U. Kuhlmann, DiplBiol
Temporary Assistants D. Babendreier (May-June); H. Desmeules (June–September); R. Dolch (August–September); S. Erb (May–August); J. Nash (October–December)
Temperate Forestry Research Programme
Leader K.P. Carl, DnatSc
Scientist M. Kenis, DiplIngAgr
Temporary Assistants N. Otten (May–August); A. Van averbeke (April–September); D. You (July–September)
Collaborators (part-time) E. Altenhofer, PhD (in Austria)

Temperate Weeds Research Programme
Leader D. Schroeder, DnatSc
Scientists A. Gassmann, PhD; U. Schaffner, PhD
PhD Students H.-M. Bürki, DiplBiol; H. Hinz, DiplBiol; M. Schwarzlaender, DiplBiol; R. Wittenberg, DiplBiol
Diploma Students G. Grosskopf
Temporary Assistants J. Freise (May–August); A. Geisen (May–September); M. Hunt (May–September); A. Krupa (April–September); R. Mitchell (April–September); U. Onanchi (May–September); C. Paetel (March–September); T. Reisenbüchler (April–September); D. Stubbe (May–September)
External collaborators I. Tosevski, PhD (in Serbia)
Collectors (part-time) P. Esposito (Italy); G. Nikolova (Bulgaria); T. Perju (Romania); G. Petersen (Germany); E. Rusu (Romania); G. Scheibelreiter (Austria)
Technical Support Staff S. Gygax, DiplGard; E. Leschenne

Kenya
IIBC Kenya Station, PO Box 76520, Nairobi, Kenya
Tel. Karuri (0154) 32394
Fax Karuri (0154) 32090
Telex 22040 ILRAD (KE) (for IIBC Muguga)
E-mail CABI-IIBC-kenya@CABI.org
Scientist-in-Charge M.G. Hill, PhD

Administrative Support
Accountant/Office Manager M. Odhiambo
Secretary V. Wanjiku
Clerical Officer S N. Gichuhi (KARI)
Driver J. Milulu

Tropical Forestry Research Programme
Regional Coordinator G.B. Allard, MSc
Scientists R.K. Day, PhD; E.K Mutitu, BSc (KEFRI); G.S.N. Phiri, PhD (from August)
Project Administrator (conifer aphids) P.I. Kilewe (KARI)
Technicians B.M. Mutulili; P.C. Nganga, OD (until November); D. Chacha,
DipRangeMgt; M.T. Lusele, OD; S.O. Odhiambo; J.O. Agano

Tropical Weeds and Entomology Research Programme
Scientists M.G. Hill, PhD; B.T. Nyambo, PhD; G.S.N. Phiri, PhD (from August);
J-C. Nsengimiana, MSc (from October); S.A. Simons, PhD (part-time)
Technicians E.A. Chandi; D.N. Njenga; P. Karanja (KARI – September/October
only)
External collaborator A.M. Varela, PhD (August/September)

Malaysia
IIBC Regional Station, Malaysia, PO Box 210, 43409 UPM Serdang, Selangor,
Malaysia
Tel. 60-3-9426489
Fax 60-3-9426490
E-Mail CABI-IIBC-malaysia@CABI.org
Scientist-in-Charge G.S. Lim, PhD
IPM Coordinator S. Ramaswamy, PhD (FAO)
Scientists H. van den Berg, PhD (to March); J.G.M. Vos, PhD (from February)
Research Assistant K. bt M. Hashim (to March); M.H. Yahaya (from June)
Administrative/Clerical Officer W.L. Koh
Clerical Assistant V. d/o Nainoo (from October)

Pakistan
PARC-IIBC Station, PO Box 8, Rawalpindi, Pakistan
Tel. (051) 423210
Fax (051) 451147
E-mail IIBC@sdnpk.undp.org
Telex 55948/5949 PCORP PK BIOCONTROL
Scientist-in-Charge M.A. Poswal, PhD

Administrative Support
Administrative Officer/Accountant M. Rafiq, BCom
Office Secretary A. Bakhsh, D.Com
Drivers G. Mohammad; Abdul Qayyum
Gardener Rehmatullah
Chowkidar A. Khan
Senior Entomologist R. Mahmood, MSc
Junior Entomologists T. Hasnain, MSc; M. Azhar Qureshi, MSc; J. Alam Qureshi,
MSc
Scientific Officer M. Murtaza, BSc
Research Assistant Melad-ul-Karim, BSc
MSc Student A.N. Khan
Technical Assistants B. Ahmad, FA; S. Mohammad
Laboratory Assistant S.A. Shah; A. Iqbal; Tahir Javed; I. Hussain
Field Staff M. Khan; M. Afzal

IIBC staff at other locations

Colombia
Coffee IPM Project, Cenicafé, Apartado Aereo 2427, Manizales, Chinchina, Caldas, Colombia
Fax (968)594723; (968)506630; (968)507561

Coffee IPM Project
Project Leader P.S. Baker, PhD
Socioeconomist H. Duque
Technologists J.A. Ríos; O. Ríos
Technical Assistants R. Garcia; C.M. Giraldo; A. Valencis; S.P. Velarde
PhD Students M. Portilla; F. Posada
First Degree Students A. Castaño; A. MacKay; J. Peralta; R. Ruíz

France

c/o CSIRO Unit of Biological Control, Campus International de Baillarguet,
34982 Montferrier sur Lez, France
E-mail paynter@montpellier.inra.fr
Scientist Q. Paynter, PhD
Temporary Assistant R. Thum

Nigeria
WARDA-CABI Rice Gall Midge Project
c/o Plant Health Management Division, IITA, Oyo Road, PMB 5320, Ibadan,
Nigeria
International mailing address c/o IITA Ibadan, Nigeria, c/o L.W. Lambourne &
Co Ltd, Carolyn House, 26 Dingwall Road, Croydon, Surrey, CR9 3EE, UK
E-mail IITA@CGNET.COM (mark attn Charles Williams, WARDA-CABI Rice
Gall Midge Project)

WARDA-CABI Rice Gall Midge Project
Project Leader C.T. Williams, PhD
Scientist O. Okhidievbie, MSc (from April)
Driver S. Moore
Field worker A.A. Kehinde
Main Collaborators E.A. Heinrichs (WARDA); B.N. Singh (WARDA); M. Ukwungwu (NCRI, Nigeria)
Consultant K.M. Harris, PhD

Philippines
IIBC/IPM for Highland Vegetable Project
BPI Complex, Guisad, Baguio City, Philippines
Tel./Fax 63–074–422–2686
Cellphone 09–737–62299, 09–737–63621
E-mail CABI-IIBC-phl@CABI.org

IIBC/IPM for Highland Vegetables Project
Team Leader F.M. Laigo, PhD
Master Trainers I. Bernard; R. Carpio; E. Dula; H. Fagyan; F. Langpaoen; L. Palengleng; A. Pedro; G. Sala-id
Management Systems and Logistics Specialist W.R. Rola (from October)
Clerical Officer D. Wenceslao
Drivers M. Comila; R. Laban; R. Ramiscal (to August); P. Shontogan; A. Vincent; H. Walang
# Appendix 2

## Conferences and Meetings

<table>
<thead>
<tr>
<th>Date</th>
<th>Meeting</th>
<th>Venue</th>
<th>Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 January</td>
<td>Ciba, biopesticides</td>
<td>Basle, Switzerland</td>
<td>Dr Prior</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Waage</td>
</tr>
<tr>
<td>6–7 February</td>
<td>Joint Meeting of IIBC European Station-CSIRO-USDA</td>
<td>Montpellier, France</td>
<td>Mr Bürki*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Gassmann*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ms Hinz*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Schaffner*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Schroeder*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mr Schwarzlaender*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mr Wittenberg*</td>
</tr>
<tr>
<td>8–10 February</td>
<td>European Weed Research (EWRS) Workshop on Biological Control of Weeds</td>
<td>Montpellier, France</td>
<td>Mr Bürki*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Gassmann</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Harvey*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ms Hinz*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Schaffner</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Schroeder</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mr Schwarzlaender</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mr Varley</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mr Wittenberg</td>
</tr>
<tr>
<td>13–17 February</td>
<td>East African Regional Coffee Workshop</td>
<td>Embu, Kenya</td>
<td>Dr Nyambo*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Hill</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Moore</td>
</tr>
<tr>
<td>23–26 February</td>
<td>Spruce Aphid Research</td>
<td>Fagerfjell, Norway</td>
<td>Mr Kuhlmann*</td>
</tr>
<tr>
<td>2–3 March</td>
<td>Joint FAO/IIBC IPM Global IPM Facility meeting</td>
<td>Nairobi, Kenya</td>
<td>Dr Waage</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Nyambo</td>
</tr>
<tr>
<td>13–26 March</td>
<td>Training Course and Workshop on Evaluation of Pesticide Effects on Natural Enemies and its Implications on Pesticide Registration</td>
<td>MARDI, Malaysia</td>
<td>J.A. Qureshi</td>
</tr>
<tr>
<td>15–17 March</td>
<td>WARDA IPM Task Force Meeting</td>
<td>Mbe Bouake, Côte d'Ivoire</td>
<td>Dr Williams*</td>
</tr>
<tr>
<td>16 March</td>
<td>HORTEC '95</td>
<td>Nairobi, Kenya</td>
<td>Dr Hill*</td>
</tr>
<tr>
<td>Date</td>
<td>Event</td>
<td>Location</td>
<td>Organizer(s)</td>
</tr>
<tr>
<td>--------------</td>
<td>------------------------------------------------------------------------</td>
<td>------------------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>20-24 March</td>
<td>Institute of Agro-environmental Studies and other Japanese institutes</td>
<td>Tsukubu, Japan</td>
<td>Dr Waage</td>
</tr>
<tr>
<td>27-31 March</td>
<td>Entomological Conference of the DGaaE</td>
<td>Göttingen, Germany</td>
<td>Ms Hinz, Mr Kuhlmann*, Dr Schaffner*, Dr Schroeder*, Mr Schwarzlaender</td>
</tr>
<tr>
<td>30-31 March</td>
<td>11th Project Management Committee—LUBILOSA</td>
<td>Cotonou, Benin</td>
<td>Dr Waage, Dr Prior</td>
</tr>
<tr>
<td>3-8 April</td>
<td>GTZ/CILSS International conference on locust control</td>
<td>Bamako, Mali</td>
<td>Dr Prior*</td>
</tr>
<tr>
<td>24-28 April</td>
<td>Workshop on the formation of an African Forest Pest Management Network</td>
<td>KEFRI, Muguga, Kenya</td>
<td>Ms Allard*, Dr Day*, Dr Murphy*, Dr Hill</td>
</tr>
<tr>
<td>4 May</td>
<td>National Plant Protection Technical Committee meeting</td>
<td>Islamabad, Pakistan</td>
<td>Dr Poswal</td>
</tr>
<tr>
<td>9 May</td>
<td>47th International Symposium on Crop Protection</td>
<td>Gent, Belgium</td>
<td>Dr Schroeder*</td>
</tr>
<tr>
<td>9-11 May</td>
<td>IFPRI Vision 2020</td>
<td>Washington DC, USA</td>
<td>Dr Waage</td>
</tr>
<tr>
<td>12-18 May</td>
<td>GTZ-IPM Horticulture Planning Workshop</td>
<td>Lilongwe, Malawi</td>
<td>Dr Nyambo</td>
</tr>
<tr>
<td>20-24 May</td>
<td>International Environmental Management Conference</td>
<td>Port of Spain, Trinidad</td>
<td>Mr Morais, Mrs Lopez</td>
</tr>
<tr>
<td>26-28 May</td>
<td>Workshop on Population Biology of Plants</td>
<td>Kiel, Germany</td>
<td>Mr Bürki, Ms Hinz*, Mr Schwarzlaender</td>
</tr>
<tr>
<td>28 May</td>
<td>IPM Working Group meeting</td>
<td>Nairobi, Kenya</td>
<td>Dr Nyambo</td>
</tr>
<tr>
<td>7 June</td>
<td>Kenya National Horticulture Seminar</td>
<td>Nairobi, Kenya</td>
<td>Dr Nyambo</td>
</tr>
<tr>
<td>2-7 July</td>
<td>8th International Plant Protection Congress</td>
<td>The Hague, Netherlands</td>
<td>Dr Nyambo*, Dr Prior*, Dr Waage</td>
</tr>
<tr>
<td>3-7 July</td>
<td>10th Congress Entomology Society of Southern Africa</td>
<td>Grahamstown, South Africa</td>
<td>Ms Allard</td>
</tr>
<tr>
<td>3-7 July</td>
<td>IPPC Forum</td>
<td>The Hague, Netherlands</td>
<td>Dr Waage</td>
</tr>
<tr>
<td>Date</td>
<td>Event</td>
<td>Location</td>
<td>Organizer(s)</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------------------------------</td>
<td>---------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>10–12 July</td>
<td>9th EWRS Symposium of Weed Science</td>
<td>Budapest, Hungary</td>
<td>Dr Gassmann</td>
</tr>
<tr>
<td>12–14 July</td>
<td>US Congressional OTA Panel on Biocontrol</td>
<td>Washington, USA</td>
<td>Dr Waage</td>
</tr>
<tr>
<td>16–21 July</td>
<td>Society for Invertebrate Pathology Annual Meeting</td>
<td>New York, USA</td>
<td>Dr Thomas*</td>
</tr>
<tr>
<td>19–22 July</td>
<td>Food, culture, trade and the environment</td>
<td>Seoul, Korea</td>
<td>Dr Lim</td>
</tr>
<tr>
<td>23–30 July</td>
<td>Congress of Entomological Society of Colombia (SOCOLEN)</td>
<td>Caldas, Colombia</td>
<td>Dr Waage* Dr Baker</td>
</tr>
<tr>
<td>6–12 August</td>
<td>IUFRO 20th World Congress</td>
<td>Tampere, Finland</td>
<td>Dr Kenis* Mr Kairo</td>
</tr>
<tr>
<td>20–26 August</td>
<td>BioNet International Global Workshop (BIGW)</td>
<td>Cardiff, Wales</td>
<td>Dr Hammond</td>
</tr>
<tr>
<td>24–25 August</td>
<td>National Agricultural Research Foundation, IPM</td>
<td>Athens, Greece</td>
<td>Dr Prior</td>
</tr>
<tr>
<td>28–29 August</td>
<td>FAO EMPRES meeting</td>
<td>Cairo, Egypt</td>
<td>Dr Prior</td>
</tr>
<tr>
<td>28 August–2 September</td>
<td>International Conference on Integrated Fruit Production</td>
<td>Cedzyna, Poland</td>
<td>Dr Bateman Dr Carl* Mr Kuhlmann*</td>
</tr>
<tr>
<td>4–6 September</td>
<td>Regional Coffee Research and Development Conference</td>
<td>Kampala, Uganda</td>
<td>Dr Nyambo</td>
</tr>
<tr>
<td>5–8 September</td>
<td>Third planning and evaluation meeting on IPM in cotton</td>
<td>Kuala Lumpur, Malaysia</td>
<td>Dr Waage Dr Lim Dr Vos</td>
</tr>
<tr>
<td>11–15 September</td>
<td>MARDI/ACIAR/CABI Workshop on biological control for sustainable agriculture in Southeast Asia</td>
<td>Serdang, Malaysia</td>
<td>Dr Wang Dr Poswal Dr Lim Dr Vos</td>
</tr>
<tr>
<td>13–15 September</td>
<td>18th Symposium of the Royal Entomological Society Forests and Insects</td>
<td>London, UK</td>
<td>Ms Abraham Ms Allard Mr Kairo</td>
</tr>
<tr>
<td>13–21 September</td>
<td>FAO Farmer participatory extension workshop</td>
<td>Ghana</td>
<td>Dr Nyambo</td>
</tr>
<tr>
<td>25–27 September</td>
<td>IFAD locust meeting</td>
<td>Rome, Italy</td>
<td>Dr Prior</td>
</tr>
<tr>
<td>Dates</td>
<td>Event Description</td>
<td>Location</td>
<td>Attendees</td>
</tr>
<tr>
<td>---------------</td>
<td>-----------------------------------------------------------------------------------</td>
<td>-------------------------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>5–6 October</td>
<td>COST Meeting</td>
<td>Delémont, Switzerland</td>
<td>Mr Bürki</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Gassmann</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ms Hinz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Schaffner</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Schroeder</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mr Schwarzlaender</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mr Wittenberg</td>
</tr>
<tr>
<td>9–14 October</td>
<td>CTA/IAR/IIBC African Workshop on biological control and host plant resistance in IPM</td>
<td>Addis Ababa, Ethiopia</td>
<td>Dr Nyambo*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Hill</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Thomas*</td>
</tr>
<tr>
<td>11 October</td>
<td>Workshop on Japanese knotweed -- a strategy for effective control</td>
<td>Loughborough University, UK</td>
<td>Mr Shaw</td>
</tr>
<tr>
<td>13 October</td>
<td>AAFC Biocontrol Working Group Meeting</td>
<td>Victoria, Canada</td>
<td>Mr Kuhlmann*</td>
</tr>
<tr>
<td>14 October</td>
<td>Canadian Forum for Biological Control Meeting</td>
<td>Victoria, Canada</td>
<td>Mr Kenis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mr Kuhlmann</td>
</tr>
<tr>
<td>15–18 October</td>
<td>Entomological Society of Canada Annual Meeting</td>
<td>Victoria, Canada</td>
<td>Mr Kenis*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mr Kuhlmann</td>
</tr>
<tr>
<td>18–19 October</td>
<td>CFS Biocontrol Working Group Meeting</td>
<td>Victoria, Canada</td>
<td>Mr Kenis</td>
</tr>
<tr>
<td>26–27 October</td>
<td>12th Project Management Committee–LUBILOSA</td>
<td>Ottawa, Canada</td>
<td>Dr Waage</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Prior</td>
</tr>
<tr>
<td>26–27 October</td>
<td>Technical Advisory Group – pink mealybug management</td>
<td>St George’s, Canada</td>
<td>Dr Hammond</td>
</tr>
<tr>
<td>30 October–3</td>
<td>Workshop on methyl bromide alternatives</td>
<td>Bangkok, Thailand</td>
<td>Dr Vos</td>
</tr>
<tr>
<td>November</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 October–3</td>
<td>Experts meeting on identifying and monitoring biodiversity and its utilisation in</td>
<td>Valletta, Malta</td>
<td>Dr Fowler*</td>
</tr>
<tr>
<td>November</td>
<td>Commonwealth small island developing states</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 November</td>
<td>British Mycological Society Meeting</td>
<td>Kew, UK</td>
<td>Dr Prior</td>
</tr>
<tr>
<td>20 November</td>
<td>The changing world of weeds (pre-symposium meeting, Brighton Crop Protection</td>
<td>Brighton, UK</td>
<td>Dr Fowler</td>
</tr>
<tr>
<td></td>
<td>Conference)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28 November–1</td>
<td>UNEP Seminar on Facilitating Access to Environmental Information in the Caribbean</td>
<td>Kingston, Jamaica</td>
<td>Dr Hammond</td>
</tr>
<tr>
<td>December</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8–9 December</td>
<td>National IPM workshop</td>
<td>Cameron Highlands, Malaysia</td>
<td>Dr Lim</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Laigo</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dr Vos</td>
</tr>
</tbody>
</table>
17–23 December  Culture and agriculture  Bangkok, Thailand  Dr Lim
             Dr Laigo
             Dr Vos

18 December  IPM Coordination Network  Islamabad, Pakistan  Dr Poswal
Appendix 3

Publications and Reports

Publications


**Posters & presentations**


GASSMANN, A. Biological control of weeds. Half day seminar to high-school teachers at University of Geneva, 20 January 1995.

GASSMANN, A. Biological control of weeds. Invited seminar by Natural History Society of Porrentruy, Switzerland, 22 October 1995.

GASSMANN, A. Biological control of *Euphorbia esula* in North America; prospects for the biological control of *Cirsium arvense*. Invited seminar at the Zoological Institute, University Bern, 30 October 1995.

GASSMANN, A. Biological control of weeds. Invited seminar at the Institut des Hautes Etudes de Belgique, University of Brussels, 8 November 1995.


GASSMANN, A. Biological control of weeds. Invited seminar by Société d’écologie et de protection des oiseaux de Delémont, Switzerland, 14 December 1995.


HINZ, H. Biological control of scentless chamomile – a weed associated with agriculture in western Canada. Paper presented at Meeting of EWRS Biological Control of Weeds Group, Montpellier, France, 8–10 February 1995.


KENIS, M.; HULME, M.A. Biological control of the white pine weevil using exotic parasitoids from Europe. Poster presented at the IUFRO 20th World Congress, Tampere, Finland, 6–12 August 1995.


SHAW, R. Saving the gumwoods. Using the coccinellid, *Hyperaspis pantherina* as a biocontrol agent against the jacaranda bug in St Helena. Talk given to Landcare Research and Lincoln University, New Zealand, 27 April, 1995.

SHAW, R. Saving the gumwoods. Using the coccinellid, *Hyperaspis pantherina* as a biocontrol agent against the jacaranda bug in St Helena. Talk given to CSIRO, Montpellier, 14 December, 1995.

SEIER, M.K. Biological control of *Mimosa pigra* L. using fungal pathogens. Talk presented at the University of Braunschweig/Germany, 4 December 1995.


Reports


# Glossary of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAFC</td>
<td>Agriculture and Agri-Food Canada</td>
</tr>
<tr>
<td>ACIAR</td>
<td>Australian Centre for International Agricultural Research</td>
</tr>
<tr>
<td>ADB</td>
<td>Asian Development Bank</td>
</tr>
<tr>
<td>AGRHYMET</td>
<td>Agronomie Hydrologie Météorologie (CILSS)</td>
</tr>
<tr>
<td>CAR</td>
<td>Cordillera Administrative Region</td>
</tr>
<tr>
<td>CES</td>
<td>Central Experimental Station, MALMR, Trinidad &amp; Tobago</td>
</tr>
<tr>
<td>CIDA</td>
<td>Canadian International Development Agency</td>
</tr>
<tr>
<td>CILSS</td>
<td>Comité Interétats de Lutte contre la Sècheresse dans le Sahel</td>
</tr>
<tr>
<td>CIRAD</td>
<td>Centre de Cooperation Internationale en Recherche Agronomique pour le Développement (France)</td>
</tr>
<tr>
<td>CLAS</td>
<td>Caribbea and Latin American Station (IIBC)</td>
</tr>
<tr>
<td>COST</td>
<td>Co-operation in Science and Technology (European Union)</td>
</tr>
<tr>
<td>CRF</td>
<td>Coffee Research Foundation of Kenya</td>
</tr>
<tr>
<td>CSIRO</td>
<td>Commonwealth Scientific and Industrial Research Organization (Australia)</td>
</tr>
<tr>
<td>CTA</td>
<td>Technical Centre for Agricultural and Rural Cooperation (The Netherlands)</td>
</tr>
<tr>
<td>DFPV</td>
<td>Département pour la Formation en Protection des Végétaux (Niger)</td>
</tr>
<tr>
<td>DGIS</td>
<td>Netherlands Directorate General for International Cooperation</td>
</tr>
<tr>
<td>DPIF</td>
<td>Department of Primary Industry and Fisheries (Australia)</td>
</tr>
<tr>
<td>ENS</td>
<td>exhaust nozzle sprayer</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization (United Nations)</td>
</tr>
<tr>
<td>FARM</td>
<td>Farmer-centered Agricultural Resource Management Programme</td>
</tr>
<tr>
<td>FFS</td>
<td>farmers field schools</td>
</tr>
<tr>
<td>FVDP</td>
<td>Fruit and Vegetable Development Board (Swat, Pakistan)</td>
</tr>
<tr>
<td>GTZ</td>
<td>Gesellschaft für Technische Zusammenarbeit (Germany)</td>
</tr>
<tr>
<td>IAR</td>
<td>Institute of Agricultural Research (Ethiopia)</td>
</tr>
<tr>
<td>ICIPE</td>
<td>International Centre for Insect Physiology and Ecology (Kenya)</td>
</tr>
<tr>
<td>ICRAF</td>
<td>International Council for Research on Agroforestry</td>
</tr>
<tr>
<td>IDRC</td>
<td>International Development Research Centre (Canada)</td>
</tr>
<tr>
<td>IFAD</td>
<td>International Fund for Agricultural Development</td>
</tr>
<tr>
<td>IE</td>
<td>Instituto de Ecologia, Mexico</td>
</tr>
<tr>
<td>IER</td>
<td>Institut d’Economie Rurale (Mali)</td>
</tr>
<tr>
<td>IIE</td>
<td>International Institute of Entomology (CABI)</td>
</tr>
<tr>
<td>IITA</td>
<td>International Institute for Tropical Agriculture</td>
</tr>
<tr>
<td>INPA</td>
<td>Instituto Nacional de Pesquisa Agraria (Guinea-Bissau)</td>
</tr>
<tr>
<td>IPIAT</td>
<td>Instituto de Producción e Investigación de la Agricultura Tropical</td>
</tr>
<tr>
<td>IOBC</td>
<td>International Organization for Biological Control</td>
</tr>
<tr>
<td>IPM</td>
<td>integrated pest management</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
</tr>
<tr>
<td>IRA</td>
<td>l'Institut de Recherche Agronomique de Guinee (Guinea)</td>
</tr>
<tr>
<td>ISAR</td>
<td>Institut des Sciences Agronomiques du Rwanda</td>
</tr>
<tr>
<td>IWS</td>
<td>International Wool Secretariat</td>
</tr>
<tr>
<td>KARI</td>
<td>Kenya Agricultural Research Institute</td>
</tr>
<tr>
<td>KEFRI</td>
<td>Kenya Forest Research Institute</td>
</tr>
<tr>
<td>KIOF</td>
<td>Kenya Institute of Organic Farming</td>
</tr>
<tr>
<td>KSTCIE</td>
<td>Kenya Standing Technical Committee on Imports and Exports</td>
</tr>
<tr>
<td>LUBILOSA</td>
<td>Lutte Biologique contre les Locustes et Sauteriaux</td>
</tr>
<tr>
<td>MALMR</td>
<td>Ministry of Agriculture, Land and Marine Resources, Trinidad &amp; Tobago</td>
</tr>
<tr>
<td>MARDI</td>
<td>Malaysian Agricultural Research and Development Institute</td>
</tr>
<tr>
<td>MFVDP</td>
<td>Pakistan/Swiss Malakand Fruit and Vegetable Development Project</td>
</tr>
<tr>
<td>NCRI</td>
<td>National Cereals Research Institute (Nigeria)</td>
</tr>
<tr>
<td>NGO</td>
<td>non-government organization</td>
</tr>
<tr>
<td>NIHERST</td>
<td>National Institute of Higher Education, Research, Science and Technology, Trinidad</td>
</tr>
<tr>
<td>NRI</td>
<td>Natural Resources Institute (ODA)</td>
</tr>
<tr>
<td>ODA</td>
<td>Overseas Development Administration (UK)</td>
</tr>
<tr>
<td>PF</td>
<td>Partnership Facility (CABI)</td>
</tr>
<tr>
<td>PPRI</td>
<td>Plant Protection Research Institute (South Africa)</td>
</tr>
<tr>
<td>PSP</td>
<td>permanent sampling plot</td>
</tr>
<tr>
<td>ROAF</td>
<td>Regional Officer for Africa (CABI)</td>
</tr>
<tr>
<td>SDC</td>
<td>Swiss Development Corporation</td>
</tr>
<tr>
<td>SOCOLEN</td>
<td>Society for Colombian Entomology</td>
</tr>
<tr>
<td>SPC</td>
<td>South Pacific Commission</td>
</tr>
<tr>
<td>SPV</td>
<td>Service de la Protection des Végétaux (Mauritania)</td>
</tr>
<tr>
<td>TAFORI</td>
<td>Tanzania Forestry Institute</td>
</tr>
<tr>
<td>TCP</td>
<td>Technical Cooperation Programme</td>
</tr>
<tr>
<td>THA</td>
<td>Tobago House of Assembly</td>
</tr>
<tr>
<td>TOT</td>
<td>training of trainers</td>
</tr>
<tr>
<td>UNEP</td>
<td>United Nations Environmental Programme</td>
</tr>
<tr>
<td>USDA FS</td>
<td>United States Department of Agriculture Forest Service</td>
</tr>
<tr>
<td>USDA-APHIS</td>
<td>United States Department of Agriculture American Plant Health Inspection Service</td>
</tr>
<tr>
<td>USDA-ARS</td>
<td>United States Department of Agriculture Agricultural Research Service</td>
</tr>
<tr>
<td>USDA-ARS</td>
<td>United States Department of Agriculture Agricultural Research Service</td>
</tr>
<tr>
<td>USDI</td>
<td>United States Department of the Interior</td>
</tr>
<tr>
<td>UWI</td>
<td>The University of the West Indies</td>
</tr>
<tr>
<td>WARDA</td>
<td>West Africa Rice Development Association</td>
</tr>
<tr>
<td>XAU</td>
<td>Xinjiang Agricultural University</td>
</tr>
</tbody>
</table>
Species Index

Acacia nilotica, 46
Acantholyda erythrocephala, 30
Aceria genistae, 61
Acleris curvata, 27
Acleris variegata, 27
Acremonium sp., 65
Acrotlyus blodellii, 54
Adalia quadridispilota var bispilota, 52
Adonia variegata, 52
Ageniaspis fuscoflavus, 27
Agria mamilata, 27
Alcoides, 32
Aleurodicus dispersus, 25
Aleurothrixus floccosus, 29, 58
Alstonia sp., 51
Amaranthus bouchonii, 38
Amaranthus caudatus, 38
Amaranthus cruentus, 38
Amaranthus hypochondriacus, 38
Amaranthus powellii, 38
Amaranthus retroflexus, 38
Amaranthus spp., 38
Amistus spiniferus, 29
Anagyrus kamlai, 10, 25
Anthocoris rubripes, 36
Anthonomus rubripes ab. femoratus, 36
Aonidiella orientalis, 50, 51, 62
Aphelinus mali, 49
Aphthona, 35
Aphthona cyparissiae, 7
Aphthona lacertosa, 7
Aphthona nigricutis, 7
Aphthona ovata, 35
Aphthona venustula, 35
Aphthona violacea, 35
Aphthona spp., 7
Aphytis lingnanensis, 62
Aphytis melinus, 62
Aphytis sp. (lingnanensis group), 51
Aphytis sp. (melinus group), 51
Aphytis spp., 51, 62
Apion confusens, 33
Aprostocetus, 45
Aprostocetus procerae, 71
Aprostocetus purpureus, 51
Aprostocetus sp., 50
Aptesis nigricincta, 28
Artegaria rapae, 50
Ascochya sp., 64
Asphondylia sarothamni, 61
Atta cephalotes, 26
Aulacidea subterranea, 34
Avetianella longoi, 10, 42
Azadirachta indica, 50, 51, 62
Beauveria bassiana, 18, 19, 73
Bemisia argentifolii, 24
Bemisia tabaci strain B, 24
Brassica spp., 24
Bruchidius villosus, 61
Cales noacki, 29
Calluna vulgaris, 61
Capsicum spp., 5
Carthamus lanatus, 64
Cassia fistula, 51
Centaurea diffusa, 39
Centaurea maculosa, 39
Centaurea spp., 36, 37
Cephalonomia stephanoderis, 73
Ceranthia samarensis, 29, 30
Cercospora xanthicola, 63
Chaetocnema acrolophi, 39
Chamaesp fica crassicornis, 35, 39
Chamaesp fica hungarica, 39
Cheilosia pasquorum, 35
Cheilosia praecox, 34
Chesias legatella, 61
Chilocorus bipustulatus, 52
Chilocorus infernalis, 49
Chilocorus nigritis, 51
Chilocorus sp., 51
Choristoneura fumiferana, 32
Choristoneura mairina, 32
Chortoicetes terminifera, 58
Chromolaena odorata, 15
Chrysanthemum spp., 34
Chrysoperla sp., 52
Cinara cupressi, 41, 52, 61, 62
Cinara tujaflina, 52
Cinara spp., 52
Clematis vitalba, 37
Clematis spp., 37
Coccinella septempunctata, 52, 62
Coccus hesperidum, 50
Coccus viridis, 44
Colletotrichum orbiculare, 63
Colletotrichum strains, 63
Colocasia esculenta, 67
Commidendrum robustum, 14, 59
Comperiella aspidiotaphaga, 51
Comperiella sp., 50, 51
Crosia curvula, 27
Cryptostegia grandiflora, 9
Ctenocallis setosa, 61
Cupressus lusitanica, 62
Cupressus macrocarpa, 62
Cupressus spp., 41, 52, 61, 62
Cybecephalus semiflavus, 51
Cybecephalus sp., 50
Cydia pomonella, 49
Cydia strobiella, 30
Cylindrocopron destructans, 65
Cynoglossum, 35
Cynoglossum officinale, 34
Cytisus scoparius, 59

Dalbergia sissoo, 51
Dendrocerus carpenteri, 52
Diabole cubensis, 9, 66
Diadegma semiclausum, 73
Dodonaea viscosa, 50
Dusona, 32

Earias gloriorius, 27
Embellisia tellustre, 65
Encarsia perniciosi, 49
Encarsia spp., 51
Ephesia kuehniella, 30
Eretmocerus sp., 30
Eriosoma lanigerum, 49
Erythrina cumini, 51
Esula (subgenus), 35, 36
Eteobatesa serratala, 39
Eubius robustus, 31
Eubius semirugosus, 31
Eubius sp., 31
Eulachnus rileyi, 41, 61
Eupelmus sp., 72
Euphorbia esula, 35
Euphorbia esula s.l., 7, 39
Exapion fuscrostre, 61

Fenusa pusilla, 31
Ficus bengalensis, 51
Ficus religiosa, 51
Fusarium solani, 65
Fusarium sporotrichoides, 65

Galerucella calamiensis, 14, 40
Galerucella pusilla, 14, 40
Geotrichum candidum, 65
Gliocladium roseum, 65
Glomerella cingulata, 65
Goniocema olivacea, 61
'Green Muscle', 12, 57
Grypocentrus albipes, 31
Gymnetron hispidum, 37
Gymnetron linariae, 37
Gymnetron thapsicola, 37
Gymnetron spp., 37

Habrolepis aspidiota, 50
Helicoverpa armigera, 5, 45
Hellula phidealis, 24
Herpestomus brunnicornis, 27
Heteropsylla cubana, 24, 43, 62
Hexomyza sarothamni, 61
Hibiscus spp., 25
Hieractum aurantiacum, 34
Hieractum caespitosum, 34
Hieractum pilosella, 34
Hieractum spp., 34
Hoplocampa testudina, 28
Hylobius transversovittatus, 14
Hyperaspis pantherina, 12, 59
Hypothemenus hampei, 46, 72

Indeterminate sp., 65

Lambdia fiscellaria, 32
Lantana camara, 65
Larinus obtusus, 39
Lathrolestes ensator, 28
Lathrolestes nigricollis, 31
Leis dimidiata, 52
Lepidophanes inpleyi, 50
Leucaena leucocephala, 24, 43
Leucanthemum maximum, 34
Leucanthemum vulgare, 34
Leucopis tapiae, 42, 62
Linaria dalmatica, 37, 39
Linaria vulgaris, 37, 39
Lochmaea suturalis, 61
Locusta migratoria, 67
Locustana pardalina, 54
Longitarsus quadrigundatus, 35
Lymnantria dispar, 29
Lythrum salicaria, 14, 39, 69

Macconellicoccus hirsutus, 10, 25
Macrolobis pilosellae, 34
Mamestra brassicae, 28
Mamestra configurata, 28, 29
Mangifera indica, 51
Maravalia cryptostegiae, 9
Menochilus sexmaculatus, 52
Metaphycus, 45
M. flavoviride, 6, 19, 54, 56, 57
Metarhizium spp., 5
Metasyrphus spp., 52
Microplitis mediator, 28, 29
Microplitis (Ceutorhynchus) edentulus, 33
Microplitis (Ceutorhynchus) rugulosus, 33
Mimosa pigra, 8, 9, 66
Mimosa pigra complex, 66
Mimosa pigra var. pigra, 66
Mogulones borraginis, 35
Mogulones cruciger, 35
Monophadnus spinolae, 37
Myriophyllum spicatum, 64

Nanophyes marmoratus, 14, 39
Napomyza lateralis, 33
Nassella trichotoma, 64
Neanastatus sp., 72
Neochetina bruchi, 46
Neochetina eichhorniae, 46
Nepetaspis oculata, 25
Nerium indicum, 51

Oberea donceeli, 36
Oberea moravica, 36
Oberea spp., 36
Oedaleus senegalensis, 12, 54
Olesica munticola, 30
Orseolia oryzivora, 71
Orthexia insignis, 12, 13, 59
Oryza glaberrima, 71
Oryza longistaminata, 72
Oryza sativa, 71
Oryza spp., 72
Oscinella spp., 22
Oxyt节us pilosellae, 34

Pachyneuron nazeeri, 52
Parasitigena sylvestris, 29, 30
Parlatioria crypta, 50, 51
Parthenium hysterophorus, 67
Passiflora mollissima, 19
Pauesia antennata, 52, 63
Pauesia juniperorum, 41, 42, 62
Pelochrista medullana, 7, 39
Pemelia genistella, 59
Pharascymnus flexibilis, 51
Phaulacridium biwallatum, 58
Phloeospora mimosa-pigrae, 8, 9, 66
Phoma sp., 65
Phoracantha recurva, 10, 42
Phoracantha semipunctata, 10, 42

Phylophryctera scopariella, 61
Phymastichus coffea, 46, 73
Phytomyza vitalbae, 37
Pieris brassicae, 50
Pilosellae (subgenus), 34
Pineus boerneri, 61, 62
Pineus sp., 41
Pinus spp., 41, 61
Pissodes harcyi, 31
Pissodes pini, 31
Pissodes strobi, 31
Pissodes validirostris, 31
Pissodes spp., 31
Platypaster dipsosae, 71
Plutella xylolista, 24, 73
Potentilla recta, 36
Potentilla spp., 36
Protenusa thomsoni, 31, 32
Prospodium tuberculatum, 66
Prostephanus truncatus, 44
Prunus amygdalus, 63
Prunus persicae, 63
Prunus spp., 63
Pseudaulidium trilobiformis, 50
Pseudoterpena pruinata, 61
Psyllaphagus yaseeni, 24, 26, 43
Pterochlorodes persicae, 22, 52, 63
Pterolochne inspersa, 39
Pteromalus puparum, 50
Puccinia abrupta var. partheniicola, 67
Puccinia melampodi, 67
Puccinia rothboschiae, 65
Puccinia sommeriana, 64
Puccinia sp., 64
Pyrus, 52
Pythium periplocum, 65

Rhopalomyia hypogaea, 33, 34
Ricinus communis, 51
Rosa indica, 50
Rottboellia cochinchinensis, 65

Saissia sp., 50
Schistocerca gregaria, 56
Scymnus coccivora, 52
Septoria centrophylli, 64
Sericothrips staphylinus, 7, 59
Sirex noctilio, 15
Sitona regensteinensis, 59
Sphenopiera dadkhani, 49
Sporisorium ochruri, 65
Suganocephala sp., 64
Stethorus gilvivrons, 49
Strobilomyia anthracina, 32
Strobilomyia spp., 32  
Syrphus balleatus, 52  

Tamarixia leucaena, 9, 24, 26, 43, 62  
Telenomus sp., 28  
Terellia virens, 39  
Teretriosoma nigrescens, 10, 44  
Tetranychus lintearius, 59  
Tetranychus raoi, 43  
Thevetia nerifolia, 50  
Thrips palmi, 24  
Thuja orientalis, 52  
Tinithia myrmoseformis, 36  
Toxoptera citricidus, 58  
Trichogramma buesi, 29  
Trichogramma sp., 30, 47  
Trisetia erytreae, 58  
Tripleurospermum perforatum, 33  

Tritneptis sp. nr lophyrorum, 32  
Tycherus osculator, 32  

Ulex europaeus, 59, 68  
Uromyces genistae-lintoriae f.sp scoparii, 61  

Weiseana barkeri, 46  

Xanthium spinosum, 63, 64  
Xanthogramma scutellare, 52  
Xylocleptes bispinus, 37  

Yponomeuta malinellus, 6, 27  

Zeiraphera canadensis, 32  
Zeiraphera diniana, 32  
Zeiraphera spp., 32  
Zonocerus variegatus, 56, 57