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General News

Proposals for Revision of Code of Conduct

A proposed expansion of the Code of Conduct for the Import and Release of Exotic Biological Control Agents[1] was started by a workshop held at Imperial College London, UK in December 2002 under sponsorship of the Agrobiodiversity Theme of the Food and Agriculture Organization (FAO)/Netherlands Partnership Programme. The participants recommended fundamental changes to concepts underlying the Code of Conduct to reflect the range of biological control technologies now in use and the latest understanding of risk. Significant changes were recommended to the scope of the Code to include introductions of living organisms that do not self-replicate and others, such as soil additives, that are released for beneficial purposes rather than strictly for the purpose of pest control. There was also a shift from exotic* (meaning not native to a country) as the indication of greatest risk to a case specific analysis of risk according to the traits of the introduced organism. The participants noted, however, the value of the present approach to assigning responsibilities and requiring information in a dossier form, which has been adopted by numerous countries and should be maintained.

Background

The original Code of Conduct, developed through FAO, has been the general international protocol for countries implementing biological control to apply directly to introductions or to use as a model for national regulations since its endorsement by FAO member countries in 1995. Under the then new process of establishing International Standards for Phytosanitary Measures (ISPM) through the International Plant Protection Convention (IPPC), the Code of Conduct became ISPM No. 3 in 1996. The official revision of ISPM No. 3 will require country consultation with and subsequent endorsement by the 120 contracting parties to the IPPC, which has a Secretariat in FAO Rome. This revision process is likely to include consultation with representatives from the Convention on Biological Diversity (CBD) and other relevant programmes, international partners, and NGOs.

Classical biological control of arthropod pests and weeds by the introduction of exotic natural enemies has been implemented successfully for more than a century. However, as experience increased, practitioners became more aware of risks associated with the potentially irreversible introduction of organisms into new environments. Initial concern over possible impact on economically important plants (crops) and insects (notably honey bees) has widened in recent years as growing awareness of environmental issues drew attention to potential impacts on biodiversity and particularly rare or endangered species. With this growth in perception of risk came calls for guidance on decision making for countries using biological control as a management tool, either alone or as part of an IPM programme.

The ISPM No. 3 was a welcome guide to regulators regarding the institutional basis and information requirements necessary for informed decisions about import and release of biocontrol agents. Details include lists of responsibilities of government authorities and exporters and importers of a biocontrol agent. The information needed for decision making was laid out for reporting in dossiers for consideration by the importing government.

Initial results of a survey of the use of ISPM No. 3 were presented at the workshop in December. The report on this survey appears elsewhere in this issue[3].

Need for Revision

Although it was useful as a starting point, the ISPM No. 3 did not provide all the necessary guidance. The plan of FAO was for additional guidelines on decision making and implementation to be developed in support of the original Code. In fact, draft guidelines covering several topics were written but never finalized and distributed, and are now out of date.

In particular, ISPM No. 3 does not set out in detail how to assess whether a proposed introduction is safe – no actual risk analysis process is explained, although the requirement for collection of information in dossiers implied that risk analysis would be the basis of decisions. While other ISPMs detail the steps involved in Pest Risk Analysis to "determine whether pests should be regulated and the strength of phytosanitary measures against them"[2], this process is not entirely appropriate to the assessment of intentional introductions for the purpose of pest control.

Furthermore, ISPM No. 3 includes biopesticides in its scope, and even indicates that the Code may apply to genetically modified organisms, but there is little in the text to support such applications. The document is heavily oriented towards release of biocontrol agents that will persist in the environment. Although draft guidance for a new ISPM on transboundary shipment of sterile insects to be used in pest control programmes was presented to the IPPC annual meeting of members (the Interim Commission on Phytosanitary Measures) in 2002, many countries continue to feel that the sterile insect technique belongs under the umbrella of biological control. To accomplish this, it is suggested that the official definition used by the IPPC for biocontrol agents** be changed to encompass releases that are not self-replicating.

ISPM No. 3 was scheduled for revision in 2001 and a number of informal comments from IPPC member countries had been collated for that process. ISPM No. 3 also requires harmonization with the revised convention of the IPPC and other ISPMs that were developed since the Code was finalized in 1995. While the December workshop is not part of the official IPPC revision process, it was supported by FAO to consider issues raised and provide useful direction as the first step in a 2- or 3-year process.

Planning for Revision

Almost 7 years since the finalization of the first Code, the workshop to lay a plan for

*The official glossary of the IPPC[2] states that "As the Code is directed at introduction of biological control agents from one country to another, the term "exotic" is used for organisms not native to a country". The definition of exotic in the context of the Convention and other ISPMs, however, is "not native to a particular country, ecosystem or ecoarea (applied to organisms intentionally or accidentally introduced as a result of human activities)". This definition more closely relates to the potential for risk with the consideration of ecosystems, thereby taking into account other organisms present, varying climatic conditions, etc.

**The official definition for biological control agent is presently: "a natural enemy, antagonist or competitor, and other self-replicating biotic entity used for pest control"[2].

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the revision of ISPM No. 3 assembled a group comprising regulatory officials, pest management specialists, experienced participants with the IPPC system, and private- and public-sector end users from developed and developing countries. Regional standards that have generally gone far beyond ISPM No. 3 were discussed, along with various national approaches of the country experience represented in the consultation (Australia, Brazil, China, Kenya, New Zealand, Trinidad, UK and USA, and the European Union).

To review the scope for the revision, biological control was broken down into (1) classical, (2) augmentative macrobial and (3) microbial (biopesticides), as distinct features of these approaches had been obscured in the original Code. A significant change was the decision to include non-self replicating agents, namely (4) sterile insect technique, as an important form of biological control.

Through working groups, ISPM No.3 was systematically examined from the perspective of the four pest control approaches above, and found to be robust. With minor modification, the Code appeared to be an applicable process for evaluating every introduction to agro-production systems (other than the introduction of plants). From this process a strong recommendation emerged that existing (but not finalized) FAO guidelines also should be reviewed and new ones developed to cover this expanded scope. The need for new glossary definitions was also identified and suggestions were offered for adding or updating over 20 terms.

The inclusion of issues uniquely related to genetically modified organisms was judged to be premature, although this category may be reconsidered in 2 or 3 years. As the workshop progressed, a fifth category of beneficial introductions, ranging from pollinators to bioremediation soil additives, was deemed appropriate to the purpose and scope of the revised Code of Conduct, although the existing wording of ISPM No. 3 was not evaluated in depth on this category.

New Issues to Consider

Cross cutting issues discussed included economics and political realities in decision making, factors that influence environmental impact, and the relationship of ISPM No. 3 to other guidelines and agreements.

Intention to introduce a biocontrol agent may throw up conflicts of interest with neighbouring countries. Interpretation of risks is subjective and what one country regards as acceptable another may judge otherwise. The use of *Cactoblastis cactorum* as a biocontrol agent for cactus in the Caribbean has been valuable for those countries that introduced it, for example, despite the subsequent spread of the moth to the southern USA where it is a serious environmental pest. The new perspective is that, although the World Trade Organization's Agreement on the Application of Sanitary and Phytosanitary Measures (WTO/SPS) stipulates a country's right to sovereignty in setting an acceptable level of risk, the CBD puts consideration of other countries' concerns as a responsibility of a country planning the intentional introduction of an organism. The CBD encourages use of biological control, but it is not preparing detailed independent guidance to facilitate trade and release of biocontrol agents, so ISPM No. 3 remains the main international guidance on the subject.

A major conceptual shift was to remove the emphasis on 'exotic' and focus on risk regardless of the source. Participants concluded that the identity, expressed traits and function of a new introduction (species, strain, biotype or isolate) are the critical factors for safety, rather than the agent's geographical origin. Depending on the agent, transfer within a country may be higher risk than from one side of the world to another. For example, *Neochetina* weevils from South America have been introduced to countries throughout the world to control water hyacinth, without any reports of non-target effects. These host-specific biocontrol agents are considered safe since water hyacinth has so few close relatives. On the other hand, the introduction of biocontrol agents against exotic thistles and spurges in the US Plains States is valuable for ranching and biodiversity, but redistributing them into the Rocky Mountain region and further West may bring them into contact with related native plant species against which they were not screened and on which they may have detrimental effects.

These discussions formed the basis of some suggestions for technical support. This was principally in the form of more detailed guidelines which may not need to be approved through the IPPC, but rather could support the process as FAO documents or independent initiatives.

Further Guidance to Support the Revised Code

The workshop participants identified the following areas as essential to implementation of a revised ISPM No. 3 and currently lacking in sufficient guidance either from international fora or as published case studies or tool kits.

- Handling, packaging, transport (include aspects of existing guidelines on import documentation).
- Contingency planning – remedial actions in case of deleterious incidents.
- Case studies of eco-area cooperation for estimating risks from introductions and determining acceptable risk management practices (could benefit countries or regions with conflicting national interests).
- Guidelines on decision making (conflicting interests, participation and consultation), including economics.
- Guidelines for monitoring different kinds of biocontrol agents (including for resistance).
- Guidelines for the sterile insect technique.

The following existing guidelines should be updated.

- Guidelines for determining host specificity (host shifts and any potential hazards posed to non-target hosts).
- Guidelines on risk assessment/analysis/ economic consequences of biocontrol agents, including ideas on ecosystem impact (this should provide an enhancement of the interpretation of dossiers and decisions about data).
- Guidelines on quarantine facilities and containment.
- Guidelines for setting up a classical biological control programme.
- Guidelines on elimination of contaminants and other production issues (including existing guidelines on hyperparasites).

The participants in the consultation also were concerned by the lack of post-introduction monitoring and advance planning for bioremediation should an introduction cause unanticipated impacts. Guidelines alone will not address this serious gap. There must be funding in project budgets or from regulatory agencies charged with protection of plant resources to ensure that baseline data exist and that monitoring of the results of a release, over the appropriate time frame, is incorporated in the future.

In the process of revising ISPM No. 3, the over-arching need to reduce the risk of *unintentional* introductions of pests, including undesired biocontrol agents, in the first place should not be forgotten. Improvements to the overall import decision process and inspection and quarantine capacity could reduce the need for remedial action with biocontrol agents and thereby eliminate the risks involved in their release.

Conclusions and Follow-up

The participants in the workshop concluded that the scope of ISPM No. 3 could usefully be expanded to provide support to a range of non-chemical methods as components of IPM, as well as to introductions of other organisms (apart from plants) into agro-ecosystems, including pollinators and soil organisms. There is no harmonized international guidance for these latter introductions, where risks are potentially greater than those posed by traditional biocontrol agents. An expansion of the Code to address living (but not necessarily self-replicating) organisms and to include these other potential beneficials will make it more useful to IPM initiatives, in which many of the agents are employed. This also could provide a model for management of other invasive pests in non-agricultural systems.

The use of biocontrol agents as a part of IPM is supported not only by the IPPC, but also as part of the implementation of the CBD. Furthermore, national and regional goals of reduced pesticide use will be supported by more detailed and comprehensive harmonized guidance on import and release of biocontrol agents – including biopesticides and beneficials – and informed decision making about the safety of their release. Experience shows that a sound risk assessment and transparent regulations for the transport, import and release of biocontrol agents encourage the use of and investment in these technologies.

The success of upcoming efforts to create an improved 'Code of Conduct for Export, Shipment, Import and Release of Biological Control Agents and Beneficials', as the December workshop proposes, will depend on participation of a wide range of experts and the support of those interested in encouraging agricultural development and protection of biodiversity.

[1]IPPC (1996) Code of Conduct for the Import and Release of Exotic Biological Control Agents. Rome; FAO, ISPM No. 3, 23 pp.

[2]IPPC (2002) Glossary of Phytosanitary Terms. Rome; FAO, ISPM No. 5, 76 pp.

These references may be accessed under the section on publications (ISPMs) at:

www.ippc.int

[3]Kairo, M.T.K.; Cock, M.J.W.; Quinlan, M.M. (2003) An assessment of the use of the Code of Conduct for the Import and Release of Exotic Biological Control Agents (ISPM No. 3) since its endorsement as an international standard. *Biocontrol News and Information* **24(1)**, 15N-27N.

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Rich Vein of DBM Biocontrol Research

Diamondback moth (*Plutella xylostella*; DBM) is a cosmopolitan pest of crucifers, particularly brassicas such as cabbage, and is found throughout tropical, sub-tropical and temperate regions. Current control failures result largely from indiscriminate and excessive use of insecticides coupled with DBM's outstanding ability to develop pesticide resistance.

Early resistance to synthetic pesticides led to the development of IPM based on biocontrol technologies including parasitoid wasps and *Bacillus thuringiensis* sprays. However, DBM proved to be no respecter of green issues and resistance to *B. thuringiensis* was first reported in the field in 1996 and strategies were devised to monitor and manage *B. thuringiensis* resistance in field populations. However, as the first *Bt* crops, which took advantage of the wide variety of toxins synthesized by *B. thuringiensis*, were being deployed, it was also being discovered that the insect was capable of rapidly developing multiple resistance.

In some regions of the world, DBM is now resistant to all known categories of insecticides. Farmers, however, may continue to apply insecticides, often to no avail, but with deleterious effects to themselves and the environment. The need for more alternative control measures is therefore urgent.

A report on an international symposium on DBM biocontrol can be found in the Conference Reports section, this issue. The following series of articles gives just a glimpse of the wide variety of research being conducted to improve DBM biocontrol and its integration with other IPM technologies in different parts of the world.

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DBM Stretching Biocontrol in East Africa

Diamondback moth (*Plutella xylostella*; DBM), a worldwide pest of crucifer crops, has been causing some surprises in Kenya. Reports from export growers that the pest was attacking sugar-snap pea crops during the 1999 season were at first dismissed. However, field observations by the International Centre for Insect Physiology and Ecology (ICIPE) of the damage and the presence of the pest in fields near Lake Naivasha confirmed that it was indeed DBM.

Closer analysis of the larvae attacking peas revealed a new strain, which can survive equally well on both cabbage and peas. More recently, DBM has also been reported attacking mange-tout peas which had been free of the pest at the time of initial reports. The reasons for the switch in host plant are not yet understood, although currently under investigation. [See also *BNI* **22(1)**, 38N-39N (June 2001), Diamondback moth on peas, really!]

The adaptability of DBM has already been well demonstrated in its remarkable ability to thrive in tropical, subtropical and temperate climates around the world. In hot conditions, the pest is able to develop rapidly throughout the year with a new generation emerging every 2-4 weeks. Consequently, pest numbers increase significantly within a very short time. Not surprisingly, over a billion US dollars are spent globally on pesticides each year to control this voracious pest, which is amongst the most difficult of all crop pests to control.

DBM has developed resistance to all commonly used pesticides and, as a result, farmers are increasingly using a cocktail of chemicals and spraying more frequently or with higher doses. Any improvement in control is transient as populations develop wider spectrum resistance and higher resistance thresholds. Increased spraying leaves behind pesticide residues that are harmful not only to producers and consumers, but also to the environment. Overuse of synthetic chemicals also drives up production costs.

Intercropping with repellent plants, such as tomato, has been reported to be effective in Kenya and the use of neem (*Azadirachta indica*) has been shown to achieve slow but effective control.

The discovery of the pea-feeding strain of DBM at Lake Naivasha, a key area for Kenya's thriving high-value horticulture export sector, highlighted the need for more effective control measures for the pest, but it is not only a problem for this industry. Apart from the quixotic Naivasha population, DBM in Kenya is confined to crucifers, and these are staple vegetable crops for smallholder farmers. Indeed, the Kiswahili name for the ubiquitous kale, *sukuma wiki* meaning 'stretch-the-week', indicates its importance as a cheap and popular vegetable for the daily menu.

The focus of an ICIPE-led project is to improve biological control of the pest in eastern and southern Africa. One major activity was the assessment of indigenous parasitoids, evaluating what control they exert and whether this could be improved. Surveys have recently been carried out in co-operation with national research institutions in Ethiopia, Kenya, Tanzania and Uganda to determine key indigenous parasitoid species and the level of parasitism of DBM in East Africa. The results confirmed observations made earlier in unsprayed fields where overall levels of parasitism by indigenous parasitoids of only 10-15% were recorded.

A cosmopolitan species, *Oomyzus sokolowskii*, was found to be one of the important indigenous natural enemies, together with *Diadegma mollipla* (only recently distinguished from *D. semiclausum*; see *BNI* **22(1)**, 6N-7N (March 2001), Diadegma dilemma). The results indicated that more efficient parasitoids from other countries should be introduced. Three species were under consideration: *D. semiclausum* has now been introduced (see below) and *Cotesia plutellae* and *Diadromus collaris* are still under scrutiny.

Use of parasitoids for the control of DBM is not new. *Diadegma semiclausum*, which originated in the UK, has been used widely. It was taken to New Zealand in the early 20th century and from there was introduced to Malaysia and Taiwan. It is now found throughout most of Southeast Asia, where it has been shown to perform particularly well in temperate highland conditions, but it had not been introduced to East Africa until it was introduced from Taiwan in 2001.

Cotesia plutellae was recorded in all four countries but in very low numbers. Elsewhere, this parasitoid is known to be very effective and, in recent years, has been used to control DBM in St Helena [see *BNI* **22(4)**, 76N (December 2001), Biocontrol of diamondback moth in St Helena]. The South African strain is also known to parasitize at effective levels in the lowveld (low-altitude, hot, mostly semi-arid areas) so an agreement has been signed with the Plant Protection Research Institute of South Africa to work on the biology of *C. plutellae* in South Africa. It is hoped that the South African strain of this species may be introduced into the semi-arid regions of East Africa.

Over the last year, populations of DBM at four selected pilot sites in Kenya and Tanzania were assessed every 2 weeks and samples collected for estimation of parasitism along with climatic data over a period of a year. These records will allow impact assessment of releases of *D. semiclausum* imported from Taiwan. *Diadegma semiclausum* has now been released at all four sites, and indications from the first releases suggest establishment. The parasitoid has spread considerably and sharply increasing parasitism rates are being recorded. Releases in all major production areas of Kenya are planned for 2003 and impact monitoring will be conducted for at least one year. Additional pilot sites will then be established in lowland areas in preparation for introduction of parasitoid species adapted to higher temperatures, such as *C. plutellae* from South Africa.

It is unlikely that one parasitoid will prove totally effective even within one pilot site. However, as different species parasitize the various larval and pupal stages of DBM, it is hoped that a combination of parasitoids will achieve the greatest level of control in crucifer crops as well as decreasing the pest numbers attacking peas.

The benefits of DBM biocontrol in East Africa could be considerable. ICIPE has just completed probably the first ever *ex-ante* economic impact assessment for a biocontrol introduction with a very positive outcome. Preliminary analysis suggests that, in Kenya alone, the cost:benefit ratio for introduction of *D. semiclausum* is better than 1:30, and even this is likely to be an underestimate. The analysis took only cabbage into consideration, when kale actually occupies more than 50% of the crucifer production area in Kenya.

Adapted from: Löhr, B. (2003) Diamondback moth: biocontrol and a preference for peas. *Agriculturalist on-line* 03/1 (a WREN *media* publication)
www.new-agri.co.uk/03-1/develop/dev02.html

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Bright Ideas for DBM Viral Agent

Prospects for control of diamondback moth (*Plutella xylostella*; DBM) with a baculovirus isolated from it have been brightened by the discovery that its action is enhanced in the presence of certain chemicals.

Naturally occurring entomopathogenic viruses are attractive candidates for insect biocontrol as they are relatively easy to produce and apply, at least on a small scale. However, infected hosts may survive long enough to inflict significant damage before finally succumbing to the virus. The process of developing a successful viral agent includes:

- Identifying a potent host-specific pathogen
- Maximizing its efficacy and viability under field conditions
- Developing mass production and application systems

More than a decade ago Martin Shapiro and colleagues from the US Department of Agriculture – Agriculture Research Service (USDA-ARS) discovered that certain fluorescent whitening agents (similar to those used in detergents) could not only protect a virus from the harmful effects of sunlight but also improve its killing power. This technology was patented (1992) and was licensed by such companies as American Cyanamid, DuPont, and BASF. More recently the USDA-ARS team obtained a baculovirus from the DBM and have tested different brighteners as potency enhancers. The activity of the DBM virus was increased by as much as 400% by such brighteners as Blankophor HRS in the laboratory. In small-scale field tests, Martin Shapiro and Robert Farrar demonstrated that the DBM virus could also work in the field and research is continuing with colleagues at Clemson University to develop more effective formulations.

Meanwhile, Arthur McIntosh (USDA-ARS Biological Control of Insects Research Laboratory, Columbia, Missouri) who isolated a multiple nucleopolyhedrovirus (MNPV) of DBM, in a sample from China, and Charles Kariuki (Kenya Agricultural Research Institute; KARI), conducted research studies to determine the best lepidopteran cell lines for the production of the DBM MNPV. Both *in vivo* and *in vitro* production of this baculovirus is feasible but is dependent on the particular situation. *In vivo* production can be readily accomplished because there are available several insect host species (*Trichoplusia ni, Heliothis virescens* and *Spodoptera frugiperda)* in which to propagate the virus. However, this method is labour intensive and requires a large area for rearing facilities. On the other hand, *in vitro* production requires expertise in insect cell culture and large-scale propagation of insect cells. *In vitro* production of baculoviruses has the advantage of producing a cleaner product free from contaminating microbes since the process is conducted under aseptic conditions. McIntosh and Kariuki have shown that insect cell lines from the three species above can produce reasonably high levels of the DBM MNPV. Commercialization of this virus, once formulated, would allow a quality controlled product that is competitively priced and the technology could become a standard option for IPM. Several baculoviruses for the control of Lepidopteran insects have been successfully produced commercially but to date the MNPV of DBM has not.

A recombinant virus using the wild-type MNPV of DBM has been produced by BASF (formerly American Cyanamid) but has not been commercialized either. It contains a spider toxin gene (AaIT) that, when expressed in the host, causes faster mortalities compared with the wild-type virus.

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Integrating DBM Biocontrol and Botanical Pesticides

Crucifer vegetables, such as cabbage, cauliflower and broccoli, are important cultivated crops and are widely grown in many parts of the world. They are frequently attacked by a variety of pests, and one of the most important is the diamondback moth (*Plutella xylostella*; DBM). Biological control is widely recognized as a major component of DBM management strategies, particularly where chemical control has failed. However, as a sole method of pest control in a particular target crop it is seldom sufficient. Therefore, biological control must be integrated with other control tactics to obtain a successful outcome.

A collaborative project between Wageningen University (the Netherlands), the International Foundation of Science (Sweden) and ARC-PPRI (Agricultural Research Council– Plant Protection Research Institute, South Africa) is investigating the possibility of combining biocontrol with the use of botanical extracts for IPM of DBM.

DBM was first documented as a pest in South Africa on cabbages in 1917. Several species of parasitoids attack it in the field and can be abundant in the crop. Despite this, control of DBM in South Africa still remains heavily dependent on synthetic insecticides, which have a negative effect on natural enemy populations, resulting in an escalating pest population. DBM is also notorious for its ability to develop resistance to pesticides; it was the first pest to develop resistance to DDT and is also the first documented pest to show resistance to microbial *Bt* (*Bacillus thuringiensis*) sprays in the field.

Many farmers in developing countries can ill-afford synthetic chemicals, and in particular the extra burden of cost imposed by spraying higher doses and more frequently in an effort to combat this intractable pest problem. The negative impact of pesticides and the increasing difficulty encountered in controlling DBM kindled an interest in alternative control solutions, particularly the use of plant extracts. These, in combination with biocontrol using locally abundant natural enemies, are well suited to low-input IPM systems.

Plants, herbivores and herbivore natural enemies are connected through an intricate array of chemical linkages. The plant kingdom is by far the most efficient producer of chemical compounds, synthesizing many products that are used in defence against herbivore attack. Extracts prepared from plants have a range of properties, including insecticidal activity. Of 1800 plant species reported to possess pest control properties, 82 were found to be active against DBM. In particular, preparations from two members of the Meliaceae, neem (*Azadirachta indica*) and syringa (*Melia azedarach*), excited interest because they have been found to be compatible with biocontrol in other systems. Neem does not grow in South Africa, but the closely related and exotic syringa tree is common throughout the country and could provide a useful locally-available source of raw material for extract production. However, before this is considered, more information is required on the impact of the extracts on the pest population and how this relates to the natural enemies.

Understanding the interactions between the plant-produced chemicals, DBM and its parasitoids is at the heart of the project now underway. Members of the plant family Cruciferae are chemically linked by the almost universal presence of glucosinolates, which are considered their first line of defence against herbivore attack. The complex tetranorterpenoids found within the Meliaceae are thought to function as feeding deterrents in a similar way.

Crucifer-feeding specialists such as DBM have turned the tables on the plants, and make use of the glucosinolates and their volatiles to recognize and locate suitable host plants. In fact, secondary chemicals such as glucosides and volatile mustard oils actually stimulate feeding by crucifer specialists. Such chemicals play an important, if not major, role in host plant selection by herbivores.

The Meliaceae are best characterized by the production of linonoids, a group of modified triterpenes. Neem, for example, contains upwards of a hundred of them in its different tissues. Many of these are biologically active against insects and act as anti-feedants. Much anecdotal evidence exists on the insecticidal, repellent or deterrent properties of neem and syringa extracts. This project is examining their effects on DBM. Results so far indicate that extracts of both trees are effective against DBM. They significantly reduce the survival of larvae feeding on cabbages that had been treated with extracts. Death appears to be mainly a result of the anti-feedant effects. The larvae do not feed on the treated plant and therefore die from starvation. However, in lower doses some feeding does take place and direct toxicity appears to play a role. In addition, DBM larvae given a choice between treated and untreated sides of leaves prefer to remain on the untreated side. It seems that neem and syringa extracts mask the attractant properties of the cabbage plant to the larvae.

Additional experiments are underway to investigate whether the adult moths can still detect their host plant if the plant is treated with botanical extract. In these experiments the moths will be given a choice between a treated plant and an untreated plant and the number of eggs oviposited by the moth on these plants will be counted.

Plants produce a different set of chemicals in response to herbivore attack. Natural enemies can make use of these volatiles to locate their hosts in or on the damaged plant. Previous studies with DBM feeding on cabbage have demonstrated that *Cotesia plutellae* has this ability. However, it is not yet known whether the volatile chemicals produced by neem and syringa affect this host location behaviour, although it is clearly important to find out if botanicals are to be successfully integrated with biocontrol. Experiments carried out to assess the impact of neem and syringa extracts on the two DBM parasitoids most commonly found in the field in South Africa, *Cotesia plutellae* and *Diadromus collaris*, showed that they did not have a negative impact on parasitoid survival. Preliminary results from field trials suggest that the parasitoids are still able to find their hosts and the host plant despite the botanical spray.

Although initial results suggest that biological control and the use of botanical pesticides can be integrated, it is as yet unclear whether the botanicals will actually enhance biological control. Further experiments will investigate these aspects. Experiments will be carried out under glasshouse conditions, where treated plants will be exposed to the two parasitoid species and the levels of parasitism on the different plants will be calculated. Behaviour of the parasitoids will be observed in a wind tunnel to see whether they can discriminate between treated and untreated plants. In addition to this, field trials are underway to investigate levels of parasitism in the field for the different treatments and to observe parasitoid behaviour under natural conditions.

Results from this research will help in understanding the relationships that are important in the IPM of DBM. It is hoped that the outputs can be used to benefit resource-poor farmers in South Africa and beyond, through the improvement of biological control and a reduction in the use of chemical pesticides.

Adapted from: Charleston, D. (2002) Can biological control and botanical pesticides be integrated in pest management programmes? *Plant Protection News* (*Bulletin of ARC – PPRI*) No. 60, pp. 7-9.

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Trap and Zap for DBM Control

Delivery systems can be as crucial to the success of microbial control as the agent itself. For the last decade, researchers at Rothamsted Research (formerly IACR-Rothamsted) together with collaborators in Australia, Kenya, Malaysia, Mexico and New Zealand, have been developing a 'lure and infect' delivery system for fungal pathogens of the diamondback moth, *Plutella xylostella* (DBM). Sex pheromone is used to attract male DBM into a chamber where they are infected with the fungal pathogen, *Zoophthora radicans*. This fungus has considerable potential for DBM control. It occurs naturally in DBM populations worldwide, but usually does not reach epidemic proportions until late in the season, by which time the crop has been damaged. If epidemics could be induced earlier while pest populations are still small, damage could feasibly be kept below the economic threshold. To make this approach possible, an effective method for disseminating the pathogen within early season DBM populations is needed. This is the purpose of the pheromone traps: they bring male moths to the fungus, and when the moths leave the traps they act as dissemination vehicles for the pathogen. By distributing traps in fields soon after susceptible brassica crops are planted, pest populations could be targeted before their numbers reach damaging levels.

This elegant solution has required some careful trap design. Traps baited with a synthetic female sex pheromone lure male moths inside, but once inside the trap the males have to be contaminated with sufficient fungal inoculum to guarantee infection and they must carry the disease to the remaining population. Once habituated to the pheromone, the males leave the trap and return to the crop where they die and produce more infective fungal spores. Each dead male, which remains attached to the plant, then acts as a source of infection that can spread rapidly to other larvae and adults. A simple and cheap trap was designed that operated successfully in small-scale field trials in Kenya and the principle has been evaluated in a large field-cage trial in Australia. The challenge now is to optimize trap design to make them suitable for the geographic regions in which they will be used and evaluate their effectiveness in actually reducing DBM populations on a field and farm scale. This is one of the goals of a new European Commission funded research project entitled '*Mi*crobial Pest *Co*ntrol for *S*ustainable *P*eri-urban/Urban *A*griculture in Latin America (Cuba and Mexico)' or '*MiCo SPA*' for short. This project is coordinated by Judith Pell (Rothamsted Research) with field evaluation of autodissemination undertaken by Richard Vickers (CSIRO) in Australia with complementary evaluations in Mexico and Cuba.

Autodissemination as a pest management tool will be compared with other microbial control strategies for DBM and other pests (conservation and inundative/spray augmentation) to identify and optimize approaches most suitable in peri-urban/urban vegetable production. Alongside this, the interactions of fungi in pest populations on crops will be elucidated and quantified in laboratory, semi-field and field experiments. These data will be used to parameterize epidemiological models in order to identify the key factors affecting establishment and efficacy. Production and quality control of fungal control agents will be optimized and the mechanisms by which virulence can be maintained will be identified. Participatory socio-economic surveys will be made to identify restrictions and enabling mechanisms for the uptake of fungal control agents and the technology delivered to stakeholders through workshops, manuals and publications.

Safe and effective control strategies as alternatives to expensive and often environmentally damaging pesticides are urgently required for key pests such as DBM. The development of fungi as microbial control agents offers potential in this regard, but there are many hurdles to be overcome. This project addresses some of the major limitations to uptake of fungal control agents: an incomplete knowledge of the parameters affecting transmission, lack of field and farm-scale evaluation and quality control problems in production, formulation and application.

Success in the project will lead to low-input, reliable and safe microbial alternatives to pesticides that can be produced locally and to a high quality for use by all farmers. The project aims to improve capacities in microbial control in Mexico and Cuba, particularly in the evaluation of potential fungal biological control agents, mass production and quality control and strategies for promoting adoption of the technology. It is anticipated that the research will lead to the development of important tools for subsistence farmers in developing countries to use in integrated pest management and that the lure-and-infect technology will be useful wherever DBM is a problem.

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Second Diadegma for Southeast Asia

Vegetable production is a vital agricultural activity in many countries in Southeast Asia. Intensification of production systems to meet the growing demand for fresh and processed vegetables has brought with it intensive use of chemical pesticides. This in turn has led to major problems of pesticide poisoning of farmers and farming families, environmental pollution, secondary pest outbreaks, and the development of resistance of insect pests to a wide range of insecticides. Diamondback moth (*Plutella xylostella*; DBM) is a prime example.

Introduction of synthetic pesticides and farmers' growing reliance on them caused DBM to become a serious pest in many parts of Southeast Asia in the 1950s. Resistance to successive groups of compounds has bedevilled control ever since, with intensive use of insecticides, including some normally regarded as relatively harmless to non-target organisms, preventing hymenopteran parasitoids from exerting control and thus contributing to outbreaks.

Replacement of synthetic chemicals by *Bacillus thuringiensis* (*Bt*) based insecticides and the actinomycete-based compound abamectin as the principal chemical control agents led to a significant improvement in DBM control, however. In highland areas, this change facilitated the establishment and population increase of introduced hymenopteran parasitoids (*Cotesia plutellae, Diadegma semiclausum* and *Diadromus collaris*) which in turn contributed to control. They were demonstrated to be particularly effective where linked with farmer IPM training programmes which ensured farmers understood how to make best use of biocontrol. In this, a pivotal role was played by the FAO which, through its Inter-Country Programme for Development, set up a vegetable IPM training initiative involving seven countries in the region. The Farmer Field School (FFS) model originally developed in rice was adapted for vegetables. Farmer studies at Dalat in Vietnam, for example, led to an understanding of the selective action of *Bt* sprays in managing DBM. With the information from experiments and pilot studies, farmers were able to contemplate organizing village-wide activities to conserve the population of *Diadegma semiclausum*.

Maximizing the contribution of natural enemies to DBM control was also important for managing insecticide resistance, for it was not only synthetic insecticides that DBM could combat. Resistance to *Bt* var. *kurstaki* in DBM was first recognized in 1992 (in Malaysia), and records of resistance to the more recently available strain *Bt* var. *aizawai*, and abamectin, followed soon after. An IPM strategy based on maintaining robust populations of DBM natural enemies and using minimal *Bt* sprays when necessary allowed the emerging resistance to be managed. In the Cordillera Highland of the Philippines, for example, an Asian Development Bank funded project, led by CABI *Bioscience*, used the FFS approach to promote this approach. Farmers learnt how to decide whether to apply *Bt* and release *D. semiclausum* cocoons based on the populations of DBM and its natural enemies they found in the field. They built small shelters in the field, resembling miniature birdhouses, named 'Diadegma Hotels', in which they placed the cocoons to enhance their survival.

Diadegma semiclausum is not, however, effective in the hotter lowland areas of Southeast Asia, and there DBM remains a serious constraint to vegetable production. Yet these lowland areas are often the main source of fresh vegetables for the region's expanding city populations, and are also ideally sited for the development of export vegetable sectors.

A related species, *D. insulare*, has provided good control of DBM build-up in warmer climates elsewhere, for example in the southern USA. It can parasitize up to 90% of a larval population. The parasitized larvae eventually die, so curtailing population growth, but a more immediate impact is that parasitized larvae inflict less damage as they consume 80% less food than unparasitized individuals.

A project led by CABI *Bioscience* in collaboration with the Malaysian Ministry of Agriculture, the Malaysian Agricultural Research and Development Institute (MARDI), and the Universiti Kebangsaan Malaysia, under the FAO Vegetable Inter-Country Programme, has been assessing the parasitoid's suitability for Asian lowland conditions. They have undertaken quarantine studies (including host specificity testing which showed it did not develop on silkworm, *Bombyx mori*), and refined rearing methods. A culture was established from insects sent from the University of Florida, USA, and has been maintained in Malaysia. In collaboration with the Plant Protection Department and the National IPM Programme in Vietnam, a total of 3400 *D. insulare* pupae were shipped to Vietnam in late 2002.

Mass rearing *D. insulare* presents a particular challenge. US methods for mass rearing were adopted and adapted for local conditions. Features found key to maximizing successful parasitism and the female:male ratio included:

- Timing the DBM culture to ensure that appropriate life stages were available for parasitoid exposure.
- Increasing lighting levels (cloth cages let insufficient light through).
- Plant rearing DBM larvae (artificial diet rearing led to microsporidian infection).
- Minimizing handling of DBM larvae.
- Limiting numbers of DBM larvae presented per parasitoid exposure (to ensure maximum parasitization).

With the project now at an end, a viable culture is being maintained at the CABI South-East Asia Regional Centre (CABI-SEARC). Areas that would profit from further research are:

- Refinement of culturing and mass-rearing techniques to ensure that a secure laboratory population is available for redistribution in Southeast Asia, should countries in the region indicate a demand for the parasitoid. This would include studies on temperature adaptation, to see whether colonies could be maintained under net-house and/or glasshouse conditions.
- Investigating interactions between *D. insulare* and *D. semiclausum*. As *D. semiclausum* is successfully established in the Cameron Highlands of Malaysia and has proved an effective control agent there, hybridization of the species (particularly if there are negative consequences) would need to be excluded before field releases of *D. insulare* in Malaysia could be considered.

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Cabbage Pests in Trinidad & Tobago

In 2001/2002, the National IPM Network of Trinidad and Tobago conducted field surveys and participatory rural appraisals (PRAs) in several cabbage-growing areas as a prelude to the implementation of a pilot Ecological Crop Management Project in Trinidad. The objective of the surveys was to determine the current status of biological control in various pests of cabbage. The PRAs were undertaken to collect information on farmers' crop production and protection practices in order to determine the interventions to be tested in validation trials that were to follow. The activities were undertaken jointly by CABI-CLARC (Caribbean and Latin American Regional Centre) and the Ministry of Agriculture, Land and Marine Resources.

During field surveys, the main pest of cabbage throughout Trinidad was the diamondback moth (DBM), *Plutella xylostella* (locally known as 'see-through' because of the windowing effects of feeding by early instars). Larvae and pupae were collected in the field and brought back to the laboratory to rear out natural enemies. On all but two occasions, no natural enemies were recorded, most certainly due to the prophylactic 'cocktail' calendar sprays, often consisting of 1-2 broad-spectrum insecticides and one fungicide, applied to the crop. Two natural enemies reared out of parasitized DBM were the eulophid *Oomyzus sokolowskii* (a gregarious larval/pupal parasitoid) and the braconid *Cotesia plutellae* (a solitary larval parasitoid). Both parasitoids were introduced to Trinidad in the 1970s and had become established in the major cabbage growing areas. The surveys showed that these natural enemies were still around, but present is such small numbers as to be undetectable and therefore inadequate and ineffective.

Comprehensive information was collected during the PRAs, and only that pertaining to pests and pest management practices of farmers is presented here. Pests that required control in the seedling stage were cut worms (*Agrotis* spp.) (locally known as 'tyre worms') and mole crickets (*Scapteriscus* sp.). DBM was present throughout the cropping season. The budworm *Hellula phidilealis* was an occasional pest, but pesticides that were used for DBM control apparently kept this insect under check. Other pests identified by farmers as being occasionally important were the cabbage looper (*Trichoplusia ni*) and whitefly (presumably *Bemisia tabaci*). While some diseases like soft rot and peppery leaf spot were occasional problems, varieties currently planted in Trinidad have been bred for tolerance to diseases. Thus, while diseases are not a major problem, farmers continue preventative, calendar application of fungicides.

Towards the end of 2002, a fungus, identified as *Paecilomyces tenuipes*, was found infecting DBM larvae inside cabbage heads. The fungus has been isolated and is currently being tested in laboratory bioassays and field trials to determine its efficacy and the conditions under which its activity can be enhanced.

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UK Needs to Warm to Azolla Biocontrol

The floating fairy fern, *Azolla filiculoides*, is a common invader of water bodies in the UK, Europe and western Asia. The plant is capable of colonizing nitrogen-deficient waters owing to the ability of its symbiotic blue-green algae to fix nitrogen, and has a remarkable growth rate. It covers slow-moving and static water bodies with dense mats several centimetres thick, and in hot conditions these can double in size in 4-5 days. However, its main advantage in areas where it has been introduced is the lack of natural enemies.

Azolla filiculoides, which is native to the Americas, was first recorded in the UK in the mid 19th century, and has been brought in as a popular ornamental water plant ever since. Despite recent warnings about *Azolla*'s weedy tendencies and a Royal Horticultural Society ban at its flower shows, it continues to be imported and sold by garden and aquatic centres around the country and, like so many garden plants, has escaped into the wider environment, becoming a problem on ponds, lakes, rivers and canals throughout the UK.

By blocking out the light, *Azolla* mats displace native plants and reduce the oxygen content of the water, which in turn has a negative impact on the aquatic fauna. The mats also increase siltation, block drainage systems and filters, and impede the use of waterways for recreational purposes. They can even be mistaken as *terra firma* by cattle, and cases of drowning have been recorded. The weed is thus seen as a menace by anglers, flood defence organizations, boat owners, countryside managers and conservationists alike.

Mechanical control is largely ineffective, because the fern easily breaks into fragments which spread and grow into new plants. In addition, millions of spores are produced annually which are released in autumn and germinate the following year. The dwindling numbers of herbicides licensed for use on water coupled with public opposition to pesticide use means an alternative approach is needed.

This is not the first time *Azolla* has caused problems outside its native range. In South Africa it was first recorded in 1948 and over the next 50 years became widespread in the country. However, it was its increasing abundance in conservation, agricultural, recreational and suburban areas during the 1990s that stimulated action against it. Under a biological control programme, the Plant Protection Research Institute (PPRI) collected a weevil, *Stenopelmus rufinasus*, from a related species, *A. caroliniana*, in Florida, USA. Following host specificity testing, it was released in 1995 and was an instant success. The weevil controlled the weed at some two-thirds of sites within a year, and although some resurgence occurred, the weevils were able to relocate the regrowth and keep it under control. [See *BNI* **22(1)**, 2N-3N (March 2001), *Azolla* biocontrol in South Africa.]

Because of the success of the South African programme, *Azolla* was seen as a promising target for a biocontrol programme by scientists in the UK working for CABI *Bioscience* and the Centre for Aquatic Plant Management (CAPM). A chance discovery by one of them whilst dog walking confirmed that the weevil was already living quietly in Berkshire, in southern England, effectively controlling the weed. This was not the first time that the weevil has been reported in the UK, indeed it has been spotted by enthusiastic entomologists on no fewer than 15 occasions, the earliest dating back to 1921. The scientists surmised that the weevil must have been accidentally introduced on imported plants as it has cropped up repeatedly in different parts of the country. Given the duration of its stay within the UK it would now be considered ordinarily resident. This raised a new question: why can *Azolla* still be a problem more than 80 years after the first weevil introduction?

To try and begin to answer this, CABI *Bioscience* and CAPM scientists conducted surveys of known *Azolla* infestations throughout southern England. They found that in 2002, the weevil had caused a sudden decline in the weed across the Southeast and had virtually wiped it out in some places. One intention was to find an *Azolla* infestation that had not been attacked by weevils, and obtain permission to carry out a controlled release so the efficacy of the agent could be studied. However, the weevil was always one step ahead of the survey team. In one instance an infestation which had been described by a water manager as the worst *Azolla* mat he had ever seen had, in a matter of weeks, been reduced to fragments by weevils. Even maintaining a culture of weevils in the glasshouse became a challenge since every collection of apparently 'clean' *Azolla* turned out to be swarming with larvae within a few days.

The scientists suggest that incomplete control in many sites is due to climatic conditions. The recent mild winters in the UK, coupled with an early spring in 2002, could be the key to the success of the weevil in southern England this time around. The weevil used so successfully in South Africa was imported from Florida, and in both of these places they would not be exposed to the sort of winter they would usually face in the UK. Interestingly, most UK records of the weevil have been from the milder south. Difficulties of overwintering could be compounded by the isolation of many water bodies in the UK as the weevils may not be efficient at finding scattered infestations, distributed over long distances.

It could also be the case, however, that observers who have reported heavy infestations of the weed have not connected any subsequent decline with a control agent. To the untrained eye, the brown patches that indicate weevil feeding could be confused with the characteristic reddening of the plant in late season and when under stress.

Funding is being sought to further study this phenomenon on a larger scale in the coming year and it is hoped that the habits of the weevil in the UK can be determined and the information gained then used to enable this biocontrol agent to be added to the declining armoury of aquatic weed control techniques. CABI *Bioscience* scientists have developed procedures for overwintering the weevil using specially designed rearing units. This facility enables the production of large numbers of healthy weevils for release early in the season in order to prevent the *Azolla* from getting out of hand.

The scientists are confident that the spectacular levels of control offered by this weevil will help to raise the profile of biological control in the UK. Provided permission is granted for release, this would be the first classical weed biological control agent to be effectively used in the UK and might go some way to changing the public perception as to the safety and effectiveness of biological control agents.

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IPM Systems

This section covers integrated pest management (IPM) including biological control, and techniques that are compatible with the use of biological control or minimize negative impact on natural enemies.

Implementing IPM against Parasitic Weeds in Africa

An emerging partnership on *Striga* and *Orobanche* control in cereal-legume systems aims to overcome obstacles to effective IPM of these parasitic weeds in Africa. Cereals and legumes are principal staples, important saleable commodities and sources of animal feed. The crops are often rotated and intercropped and are damaged by similar parasitic weeds, which may sometimes cause total crop failure. Over the last 30 years, researchers have developed, tested and proposed many IPM technologies to control them. However, these IPM options have never become widely nor effectively adopted by farmers in Africa, and this has contributed to the increasing importance of *Striga* and *Orobanche* in their fields.

Now, the Systemwide Program on IPM (SP-IPM), the Pan African Network for Striga Control (PASCON), the Global IPM Facility (GIF) and the Semi-Arid Food Grain Research and Development Program (SAFGRAD), established by the African Union, have teamed up to develop a common field programme dedicated to achieving impact at the community level by breaking down barriers, promoting inclusiveness and focusing on action. They are working in close collaboration with the Agricultural Departmental Group of the FAO Regional Office for Africa (FAORAFA). Each partner has pilot site experience to contribute on IPM for control of *Striga* in maize, sorghum, millet and cowpea in sub-Saharan Africa, and/or *Orobanche* control in faba bean and chickpea in North Africa.

As a first step in the consultative planning process, an Africa-wide IPM Partnership Workshop, 'Towards effective implementation of parasitic weed IPM in cereal-legume cropping systems in Africa' was held on 29-31 October 2002 in Cotonou, Benin. At this meeting, 31 representatives of national programmes in 12 countries and with four programmes/networks reviewed progress and identified elements for a common field programme.

Technical reports revealed that there was a good history of inter-institutional collaboration with donor interests, which has produced a rich basket of researcher/farmer evaluated IPM options, but field implementation of the options has been limited. IPM research that is productive in outputs yet unproductive for farmers has been widely recognized as a shortcoming that needs to be addressed – indeed, the SP-IPM was set up to tackle it. Workshop participants agreed that the main challenge ahead was to ensure that the IPM options are translated into real improvements in parasitic weed control on farms. The partners resolved to fine-tune existing IPM options and diversify them. They also aim to look at a number of joint learning and extension approaches (Farmer Field Schools, Local Linked Learning, and Mushrooming Farmer Clusters) to see what lessons can be drawn that could support implementation activities.

Participants recognized that further research was needed in some areas, notably seed ecology, strain variability and biological control, but noted that these are outside the immediate objectives of the field programme and need to be pursued by partners under separate initiatives.

For step 2 in the consultative process, a technical team of representatives from partner organizations has been asked to draft a comprehensive field programme. This process will be hosted by INRA (Institut National de la Recherche Agronomique), Morocco following interactions with the Forum for Agricultural Research in Africa (FORA) and its network of organizations.

In step 3, SAFGRAD will host a stakeholder workshop in Burkina Faso to discuss the field programme with a broader range of stakeholder groups, including policy makers, farmer organizations and support groups, commodity networks, research institutions and donor representatives.

The next step will be to implement the programme in the field. Through this carefully constructed and coordinated offensive, the partners hope to promote the adoption of locally available IPM options by farmers and achieve a significant reduction of the parasitic weed seed bank in the soils. If this can be achieved, a real breakthrough may be made against the stranglehold that *Striga* and *Orobanche* have on cereal and legume crops in Africa.

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IPMEurope Changes

Changes in the management of IPMEurope, the network for coordinating European support for IPM policy and implementation in developing countries, have been announced. The Chair for the coming year is Trond Hofsvang (Norway), with the newly-created post of Vice-Chair filled by Nicola La Porta (Italy). He will then take over as Chair for the following year. The Secretariat has moved to GTZ, where it will be managed by Petra Schill (GTZ), with funding from the European Commission to support IPMEurope core activities.

The recently re-designed and re-launched website of IPMEurope is now at:

www.IPMEurope.org

A new addition to the site is pages covering European developments on rodent research and management implementation, including links to key collaborators within and outside Europe.

There is also a new proposal for a Task Force to collaborate on 'Subsistence farmer innovation', and comments and expressions of interest are invited. IPMEurope already operates other task forces (Food quality and safety, Advanced biotechnology and Biopesticides) and invites input into these, and suggestions for others. IPMEurope describes a Task Force as 'a priority mechanism for delivery of IPMEurope outputs… either by improving understanding or through the delivery of development.'

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Training News

In this section we welcome all your experiences in working directly with the end-users of arthropod and microbial biocontrol agents or in educational activities on natural enemies aimed at students, farmers, extension staff or policymakers.

Learning to Manage Leafminer Flies with Environment-Friendly Practices

The emergence of the potato leafminer (*Liriomyza* spp.) as a serious pest in the Cordillera Highlands of the Philippines highlighted farmers' needs for relevant and practical information on how to manage this pest. A Potato Leaf Miner Task Force (PLMTF) was set up in the Department of Agriculture – Regional Field Unit – Cordillera Administrative Region, and it has been researching the nature of the leafminer problem in the region, developing practical solutions, and pioneering methods for disseminating the information to farmers.

The first leafminer outbreak on potatoes in late 1999 led to damage on more than 1000 ha of crops in Benguet Province. Farmers repeatedly applied pesticide 'cocktails', to no avail. Since then, four species have been identified from the region: the predominant species is *L. huidobrensis*, and *L. trifolii*, *L. sativae* and *L. chinensis* are also found. They have since been recorded infesting some 15 cultivated and ornamental plants.

Leafminers had previously been regarded as pests of minor importance. The increase in their pest status was attributed at least in part to the use of broad-spectrum insecticides against other pests (thrips, aphids and mites). This decimated the natural enemy fauna and precipitated the leafminer outbreaks.

The challenge was to show farmers that spraying against leafminers is not merely ineffective, but counterproductive, because the complex of natural enemies found in the Cordillera Highlands can, in combination with compatible management measures, provide far better control than pesticides. Surveys of leafminers in the region indicated that there was a complex of at least 10 parasitoid species that attacked them. A major hurdle that had to be overcome, however, was the small size of the parasitoids, which meant that farmers remained unaware of their existence and activity against the leafminer.

Over the last 3 years, the PLMTF has developed information packages for farmers, which they have made available both on a website* and on CD. The package comprises:

- 'Primer on leafminers', which introduces farmers to what leafminers look like (including how to distinguish between species), reasons for their importance as pests, damage symptoms (on different crops and ornamentals), recorded host plants for each leafminer species in the Cordilleras, their life cycle, and options for leafminer management (see below).
- A video, 'Knowing more about leafminers: their way of life and how to manage them'.
- A photo gallery of leafminers and their parasitoids, and leafminer damage.
- Three modules to provide training in (1) identification of leafminer flies and their natural enemies in the field using hand lenses, (2) collecting, preserving and shipping specimens, and (3) conserving natural enemies in the field for leafminer management.
- A parasitoid key: 'Farmer's guide to identify natural enemies of leafminer'.
- Comics, which convey messages in a form farmers are familiar with; comics are a popular medium for public education in Southeast Asia.

The website and CD also include:

- Results of surveys in six provinces in the Cordillera in 2000-01.
- A database of some 125 leafminer-related published papers, as downloadable pdf files.
- An international directory of leafminer researchers – and a call for other researchers to make contact.

These knowledge-based materials and training materials were the product of the knowledge gaps identified when the PLMTF conducted a knowledge, attitude and practices (KAP) survey of the farmers in the leafminer outbreak areas. The print and audio-visual media were geared for non-specialists with resultant information for leafminer management made available in simple and easy-to-understand language/form.

The training created awareness about the importance of the leafminer natural enemies and ways to detect their presence in the farming world. In addition, it increased skills on the conservation of the natural enemies. The impact of the training and the knowledge-based materials became evident through a reduction in leafminer damage.

Learning about Leafminers

The identification training module shows users first where to find leafminer flies, and how to distinguish the flies from other insect groups they may encounter. It then introduces the four leafminer genera and shows how they differ, and looks at how infestations of the four *Liriomyza* species present in the region can be told apart – both from examining the adult flies and from the structure and location of the larval mines. Next, it introduces natural enemies, and explains in general terms how they can be distinguished from leafminers. This topic is expanded on in the parasitoid key, which also provides an illustrated guide to the natural enemies farmers are likely to encounter. The training module also explains how to tell whether natural enemies are present in a leafminer infestation.

The next module points out that one of the best ways to get acquainted with the different groups of insects is to go out and collect them. Rearing the immature stages to adults and handling and preparing them for preservation and storage provide experience that cannot be learned from textbooks. It describes where to look for the insects and the equipment and techniques needed for collecting, rearing, preserving and shipping them – and also how to record collecting data.

The last module describes different ways in which natural enemy populations may be encouraged and leafminers discouraged, and how to estimate levels of parasitism in their fields.

- Maintaining grass margins around fields provides a source of alternative hosts for natural enemies, and also pollen as food for adult parasitoids. In contrast, broad-leaved weeds should be removed as these can be alternative hosts for leafminers.
- Broad-spectrum insecticides should be eschewed. Insecticides should be selected and used with care, and avoiding early-season spraying allows natural enemy populations to build up.
- Natural enemy populations can be augmented by collecting infested material, rearing out the insects and releasing any adult parasitoids in the field.

Managing without Insecticides

The farmers' primer outlines management options that should be implemented at different stages of the crop cycle.

During planting, the emphasis is on firstly increasing pupal mortality through flooding, hoeing, exposing pupae to sunlight and practising agricultural hygiene and secondly minimizing leafminer infestation by using clean and/or resistant planting material, and removing any infested leaves that appear at an early stage.

The growing crop is more tolerant to leafminers if adequately watered. At this crop stage, monitoring and trapping are stressed. Sticky traps are advocated, both for monitoring adults moving in from surrounding crops and for mass trapping in the early phase of crop growth when the pest is at its most destructive. In general, this method has wide acceptance among farmers. Similarly, plastic trays placed under plants monitor and catch pupating larvae as they emerge from the leaves and drop to the ground. The real value of such traps on leafminer populations, damage reduction, beneficial arthropods and yields, and in detecting development of insecticide resistance is being evaluated.

A second strategy advocated at this stage is conservation of natural enemies. If parasitism approaches 50% or more, the chances of the leafminer population being kept below economic levels are excellent. Lastly, caution with nitrogenous fertilizers is suggested as they increase not only plant vigour but also leafminer larval survival and pupal size.

Harvest and post-harvest precautions centre on good sanitary and ploughing practices, and cold treatment of produce post-harvest. In addition, phytosanitary certification of produce can help prevent spread of leafminers between areas.

Specific advice to deal with outbreaks countenances integrating use of carefully selected chemicals with other IPM options. Given the widespread resistance of leafminers to organophosphate, carbamate and pyrethroid groups, and the toxicity of many insecticides to parasitoids, the options are limited. Farmers are advised to consider insect growth regulators (IGRs) and information on their use is given. Leafminer incidence decreased dramatically with their introduction and they are potentially compatible with natural control agents because of their low toxicity and host specificity.

What Next?

The PLMTF intend to come out with a revised version 2 of the leafminer CD, which will include the following new products and information:

- A simple video entitled 'Killing action of natural enemies of leafminers' / 'War against leafminers'. This will follow the simple extension philosophy of 'seeing is believing'. It will use both film of natural enemies in action and animation to show farmers and extension agents the role of natural enemies.
- Email/contact addresses of leafminer researchers/scientists on a global scale. The aim is to initiate global networking between leafminer-interested individuals and stimulate discussion board-mediated sharing of knowledge and experiences, which will enhance exchange of information about leafminers and learning from the experiences of others.
- An updated information database of all published and unpublished information on leafminers.
- A village-level technology promotion programme for managing leafminers on vegetable and cut flowers using biocontrol approaches.
- A one-page 'Leafminer flash: what's new' information exchange available as an email newsletter, to connect individuals interested in information on leafminer flies.

The team is keen to see this work, which was initiated to help farmers in one region of the Philippines, widened so farmers elsewhere can benefit. They call for appropriate international organizations to develop a mega-project to build on these initial efforts, perhaps under the umbrella of the CGIAR's SP-IPM (Systemwide Program on IPM).

*The PLMTF site is at:

www.bsu.edu.ph/leafminers/main.htm

However, power failures have meant significant interruptions in the service. In addition, the vast amount of information that needs to be made available on-line in the future will exceed the server's capacity. The PLMTF team is therefore pleased to say that the site is now co-hosted by Global Potato News at:

www.potatonews.com/leafminers/leafminers.asp

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Announcements

Are you producing a newsletter, holding a meeting, running an organization or rearing a natural enemy that you want other biocontrol workers to know about? Send us the details and we will announce it in BNI.

Armoured Scale CD

A new CD-ROM* on armoured scale insects (Diaspididae) provides illustrated information on the biology, distribution and taxonomy of armoured scales of economic and quarantine importance. It reproduces illustrations from out-of-print publications that have long been inaccessible to most workers, and provides an extensive bibliography.

Armoured scale insects are important agricultural, horticultural and forestry pests but are difficult to identify. This CD-ROM enables entomologists working in agriculture, horticulture and forestry and plant quarantine inspectors to identify the most important species for themselves. It contains guidance on preparation and a pictorial key to adult females of 100 species in 48 genera, detailed information on their taxonomy, and information on their host-plants, biology and ecology, economic impact, natural enemies, distribution and common names. Diagnostic characters and distribution and host-plant information are provided for a further 85 similar species.

For users in developing countries, it provides information that would otherwise be accessible only via time-consuming and costly library loans, if at all. For workers in museums, the CD-ROM saves repeated trips to the library.

Mac and Windows versions are available. Contact the publishers for details of system requirements.

*Watson, G.W. (2002) Arthropods of economic importance - Diaspididae of the world. CD-ROM. Price: €129.95 or

UK£77.95 (not incl. tax) + P&P.
ISBN: 90 75000 48 0

Orders: ETI Information Services Ltd,
83 Clifton Road, Wokingham,
Berkshire RG41 1NJ, UK
Email: orders@eti.uva.nl
Web:
www.eti.uva.nl/Products/CD-catalogue.html

Or: UNESCO Publishing,
7 Place de Fontenoy,
75352 Paris 07 SP, France
Web: www.unesco.org

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Brighton Conference Moves North

Glasgow in Scotland is playing host on 10-12 November 2003 to the annual British Crop Protection Council (BCPC) conference. Along with the move to a new venue comes a change in the conference programme, which will no longer run with the alternate year themes of Weeds and Pests & Diseases. The event will be called The BCPC International Congress – Crop Science & Technology 2003.

The programme reflects the new mission of BCPC and will encompass three key themes:

- Crop protection
- Crop production and the food chain
- Environment and regulation

The primary focus of the Congress will be European, but it will continue to address topics and issues relevant to global interests. The tone will be set by a plenary session of four keynote lectures:

- The impact of genomics (new technologies) on agriculture and the food chain (Peter Lillford, University of York, UK)
- Manipulation of crop production through input technology (Ian Crute, Director of Rothamsted Research, UK)
- Public perception of crop production (Christine Bruhn, University of Davis, California, USA)
- Agriculture in the environment, how it fits into the ecosystem (Dick Potts, former Director, Game Conservancy, UK)

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Ghent Crop Protection Symposium

The 55th International Symposium on Crop Protection takes places in Ghent, Belgium on 6 May 2003. It will focus on new developments in all aspects of crop protection.

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Web: http://allserv.rug.ac.be/~hvanbost/symposium

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Invasive Weeds Meeting

A preliminary call for abstracts has been announced for the IPINAMS/EMAPI7 Conference (Invasive Plants in Natural and Managed Systems: Linking Science and Management and the 7th International Conference on the Ecology and Management of Alien Plant Invasions), which will be held on 3-7 November 2003 in Fort Lauderdale, Florida, USA. The deadline for submission is 5:00pm EST 1 May 2003, via the electronic form at:

www.esa.org/ipinams-emapi7/

The goals of the conference are to promote scientific exchange among invasive plant researchers, provide interchange between scientists, managers and volunteers for efficient invasive plant management, and foster interdisciplinary cooperation on the science and management of invasive plants.

The success of the conference will lie in sharing research, management, and policy activities related to invasive plants. National and international speakers have been invited to address a series of topics in the plenary sessions, symposia, and workshops. Contributed poster and (a limited number of) oral presentations are encouraged to complement the invited presentations.

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Conference Reports

Improving Biocontrol of Diamondback Moth

The diamondback moth, (*Plutella xylostella*; DBM) is the most cosmopolitan of pests and has spread, in part naturally by wind aided movement, and by the hand of man, to all those parts of the planet where crucifers are grown as crops or exist as wild plants. It is resistant to many pesticides and some biologically based toxins. Hence biological control has been used both as a component of IPM programmes designed to manage *Plutella* and on its own to reduce DBM populations to an acceptable level. The results have been varied, with good success in some areas and complete failure in others. How can the biological control of DBM be improved? A global problem caused by a pest equally damaging in developed and developing countries merits a global approach.

The Symposium 'Improving Biocontrol of *Plutella*' sprang from an idea put forward by Garry Hill (formerly with CABI *Bioscience*, now at HortResearch, New Zealand), and Dominique Bordat of CIRAD (Centre de Coopération Internationale en Recherche Agronomique pour le Développement) in 1999. Sixty-one delegates from 25 countries attended the CIRAD/US Department of Agriculture International Symposium held in the southern French town of Montpellier on 21-24 October 2002.

The organization of the Symposium was somewhat unusual. After a day and a half of talks by keynote speakers on the current status of *Plutella* in different parts of the world, pathogens as biocontrol organisms, classical systematics of parasitoids, the importance of polyDNA viruses in the pest /parasitoid relationship, and results of characterization of DBM and its natural enemies, everyone took part in a one-day workshop 'Develop and Prioritize the Major Research Questions Concerning Improved Biocontrol of DBM.'

Participants were divided in advance into five groups of ten people. Each group consisted of a geneticist, an entomopathologist and an ecologist, a mix of nationalities, a bilingual speaker and facilitator to moderate the group discussions. The relaxed surroundings enabled participants to express themselves freely and strongly on matters regarding the improvement of biological control of *Plutella*.

Recommendations included improving taxonomic methods using on-line keys and genetic characterization, improved exchange of information, and dependable methods for rearing and applying biological control agents. A report on the workshop sessions will constitute one chapter in the book of keynote contributions due to be published and sent free to all registered colleagues.

The meeting attracted ten posters from Africa, seven from Asia, three from South America and Europe respectively, with two each from Oceania and North America. The quality and content of the posters was very high and many were from areas little represented at mainstream meetings.

The organizers thank the Director of the CIRAD La Valette campus for facilities. They also thanks the Scientific Committee and Horticultural Department of CIRAD (Flohr), the Region of Languedoc Roussillon, INRA (Institut National de la Recherche Agronomique) and the USDA Agricultural Research Service for financial support.

By: Dominique Bordat & Alan Kirk

Source: CIRAD/Flhor, Montpellier, France http://dbm2002.cirad.fr/en/welcome.html

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New Books

Non-indigenous Species in European Waters

Invasive alien species (IAS) are one of the major threats to global biodiversity and impose enormous costs to all kind of human ventures, such as agriculture, forestry, fisheries and tourism. As the risks of IAS to ecosystems are becoming more and more evident and broadly acknowledged, the rate of IAS introductions, due to a massive increase in volume and pace of global trade and travel, is becoming overwhelming and difficult to manage. While the world grows smaller with globalization, global biodiversity shrinks, and the uniqueness of localities and islands is lost forever owing to the harmonization processes. Though knowledge on IAS is rapidly growing, large and fundamental gaps still exist.

This excellent book* gives the first comprehensive overview of IAS in aquatic systems in Europe. The editors have notched up a considerable achievement in bringing together all the significant workers on aquatic IAS as authors. As they state in their preface, more than 100 scientists have synthesized the available information on aquatic bioinvasions. The book gives excellent broad coverage. Geographically, it covers the whole of Europe and it also deals with all aquatic environments, from freshwater systems, to brackish areas and marine water bodies. Generally, most chapters are very well written and represent the current state of knowledge on the topics. The key objective of the editors, to summarize the present status and impacts caused by non-indigenous aquatic species, is completely realised, indicating thereby also the gaps in current knowledge.

After two introductory chapters on bioinvasions in European waters, the question of which are the non-indigenous aquatic species is addressed in a series of chapters on the different taxonomic groups. These span all types of organisms associated with the aquatic environment, from protists (an only marginally known component of ballast water), to algae and vascular plants, to one of the worst invaders – the comb jelly *Mnemiopsis leidyi*, to polychaetes, to crustaceans such as crayfish, to molluscs – e.g. the wood boring cryptogenic shipworm, to alien freshwater fish, and birds and mammals. This full-breadth coverage of all major taxonomic groups indicates the diversity of IAS. The subsequent chapters identify the various vectors for bioinvasions. This diversity of taxonomic groups and pathways renders prevention and management of IAS complicated, since such efforts may need to target many or all of them. All major pathways for aquatic IAS are listed and some are discussed in more detail, especially ballast water and ballast tank sediments, which are responsible for mass introductions, and also aquaculture as a vector for farmed organisms as well as for hitchhiking species. Next, 16 regional overviews of biological invasions in European waters illustrate the geographical extent and the ecological and economic problems caused. That only three papers are presented under the heading of ‘impacts’ is somewhat misleading in the sense that known impacts are mentioned in other chapters, too. However, it also uncovers a lack of knowledge of environmental impacts owing to difficulties in demonstrating direct and (particularly) indirect subtle effects on native species in ecosystems. The next two papers discuss the need for improved risk assessment and describe a risk-based methodology to assess aquatic IAS in ballast water. Under the ‘treatment measures’ heading, current knowledge on options for ballast water treatment is summarized. Finally, the editors give advice on where to look for more information, describing databases on aquatic alien species not only for Europe but for the rest of the world too. The book is completed with an extensive reference list. Unfortunately, there is no index to provide swift guidance for readers interested in particular species. The structure of the book as papers also does not facilitate cross-referencing.

Written primarily for an audience with aquatic interests, this book is recommended to all people involved with IAS, because many problems described are similar in terrestrial systems. Furthermore the marine and freshwater examples broaden the mind and give a more complete picture of the topic. It is a scientific book, thus the readers will primarily be scientists and students. While the title of the book indicates the European focus, IAS scientists and managers from other continents will also find a wealth of information. The chapter about ‘…control techniques for ballast water’ serves as an example; ballast water is a global challenge, three of the seven authors are Australian, and the evaluation and discussion of promising techniques is universal. Another example are the chapters devoted to the zebra mussel, which is regarded as one of the worst invaders in North America and indeed the chapter of its impacts is written by three Americans. This gives the book a more global perspective, but also highlights the lack of knowledge in Europe. The editors asked non-European authors to fill some essential gaps in European research, in particular on impacts, risk assessment and management of IAS. In conclusion, I hope that the book will find a wide readership within the community interested in IAS. The book is also a stimulus to understand and manage IAS instead of being disheartened by the number of invasions.

*Leppäkoski, E; Gollasch, S.; Olenin, S. (*eds*) (2002) Invasive aquatic species of Europe. Distribution, impacts and management. Dordrecht/Boston/London; Kluwer, 583 pp. Price €145/UK£93/US$139.
ISBN 1 4020 0837 6

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Economic and Environmental Costs of Alien Species

The rising tide of concern about alien species is supported by a limited number of estimates for national or global economic impact of alien species. Two frequently quoted figures are one estimate that economic damage associated with non-indigenous species and their control in the USA amounts to US$137 billion ($1.37 × 10^{11}$) a year[1], and another combined estimate of US$336 billion ($3.36 × 10^{11}$) for Australia, Brazil, the British Isles, India, New Zealand, South Africa, and USA[2]. This book* provides the background to these estimates.

The book consists of an introduction and 17 chapters, three of which have been previously published[1,2,3]. The chapters cover Australia (three chapters on plants, vertebrates and invertebrates), Brazil (one chapter on pathogens), the British Isles (three chapters on plants, vertebrates [Great Britain only] and arthropods and plant pathogens), India (one chapter on plant pathogens), New Zealand (three chapters on weeds, vertebrates and insects), South Africa (two chapters on plants, including[3] and invertebrates), USA (one chapter on all groups[1]), and a global perspective (plants, animals and microbes[2] and human diseases).

Reviewing the list of chapters, some inconsistencies are obvious: not all groups are covered for all areas; invertebrates, arthropods or insects may be covered; diseases are inconsistently covered; the British Isles or Great Britain are covered (for anyone who is not British or Irish, it may be worth pointing out that the British Isles comprise two main islands, Ireland and Great Britain, and two political entities, Ireland and the United Kingdom of Great Britain and Northern Ireland – I wouldn't labour this point except that the British Isles are sometimes included as a nation in this book). These inconsistencies should not detract from a valiant effort at compiling the available information on economic and environmental impact.

The contributors to the book mostly try to address both environmental and economic costs of alien species. Inevitably, perhaps, the former tends to be descriptive, sometimes anecdotal. There are many useful referenced summaries from the six areas to describe research results on environmental and economic impact of aliens. Coverage of economic aspects of damage and control is more comprehensive. On the converse side, the beneficial results of introduced alien species, such as crops and livestock, although raised, are beyond the scope of the book. However the benefits of biological control are discussed for Australia, South Africa and New Zealand.

The authors acknowledge that often the data can only be considered estimates, and sometimes very rough estimates in the face of conflicting numbers and approaches. For example, a 1993 Office of Technology Assessment estimated the cost of zebra mussel in the USA at US$300,000 per annum, while this book uses a 1997 estimate of $5 billion per annum. Again, for the City of Swansea to control Japanese knotweed is estimated at UK£9.5 million, but they actually spent £140,000 over 6 years; in this case this book goes with the actual expenditure to estimate the costs associated with this weed. Doubtless, we could all find details to question and pick over, but the cumulative totals in this numbers game are undeniable.

Based on *per capita* costs of alien species in these six areas, extrapolated globally, this book concludes that the economic cost of alien species is 5% of the global economy (US$1.4 trillion, i.e. $\$1.4 \times 10^{12}$). This estimate and the estimates cited at the beginning of this review are likely to be heavily used in the future; this book provides the justification for these numbers. It also provides a fully referenced snapshot to a large proportion of the world literature on environmental and economic impact of alien species. Unfortunately, I found the index unreliable several times; hopefully I was just unlucky with these examples, otherwise locating or relocating information may not be as straightforward as one would like. As a source book on impact of alien species this is a valuable reference book, which those dealing with alien species will want to have available.

[1]Pimentel, D.; Lach, L.; Zuniga, R.; Morrison, D. (2000) Environmental and economic costs associated with non-indigenous species in the United States. *BioScience* **50**, 53-65.

[2]Pimentel D.; McNair, S.; Janecka, J.; Wightman, J.; Simmonds, C.; O'Connell, C.; Wong, E.; Russel, L.; Zern, J.; Aquino, T.; Tsomondo, T. (2001) Economic and environmental threats of alien plant, animal, and microbe invasions. *Agriculture, Ecosystems and Environment* **84**, 1-20.

[3]van Wilgen, B.W.; Richardson, D.M.; Le Maitre, D.C.; Marais, C.; Magadlela, D. (2001) The economic consequences of alien plant invasions: examples of impacts and approaches to sustainable management in South Africa. *Environment, Development and Sustainability* **3**, 145-168.

*Pimentel, D. (*ed*) (2002) Biological invasions: economic and environmental costs of alien plant, animal, and microbe species. Boca Raton/London/New York/Washington DC; CRC Press, 369 pp. Price UK£91/US$129.95. ISBN 0 8493 0636 4

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