# General News

## Saltcedar Biocontrol: Reconciling Risks

Saltcedar or tamarisk (*Tamarix* spp.) is an invasive alien weed in western US riparian ecosystems, and is the subject of a classical biocontrol programme. It sounds a familiar story, and in many ways it is. It illustrates many recurring themes: riparian ecosystems are particularly at risk from invasive alien species; a combination of human impact and other factors give an invader competitive advantages over native species; costs and benefits of the invader need to be assessed; and the taxonomic relationships of a species affect its suitability as a candidate for classical biocontrol.

However, there are points about the saltcedar problem that mark it as special. Famously, it is the first documented instance where an invasive weed, scheduled for biological control, has begun to be utilized to an important degree by an endangered species. To add spice to the story, saltcedar is a problem in the USA, where not only is the debate on the nontarget effects of weed biocontrol continuing to rumble, but the conservation lobby is energetic and effective, and the government is in the process of formulating national policy on invasive alien species management.

The saltcedar biocontrol programme has gone to unprecedented lengths to (1) assess the real costs and benefits of saltcedar, (2) predict the consequences and timescale of the biological control programme on the target weed and native flora and (3) manage the biocontrol programme for maximum benefit and minimum risk, not just to the endangered flycatcher, but to the riparian ecosystem as a whole. The programme, led by Jack DeLoach, began in 1987 at the US Department of Agriculture – Agricultural Research Service (USDA-ARS) Grassland, Soil and Water Research Laboratory at Temple, Texas with partial support from the US Department of the Interior (USDI) Bureau of Reclamation and others. This research was joined by Ray Carruthers and his team of scientists at the newly formed ARS Exotic and Invasive Weed Research Unit at Albany, California in 1998. The Saltcedar Biological Control Consortium, with representatives from some 40 federal and state agencies and private and environmentalist organizations, reviews and advises the programme.

### Wetland Wipe-out

Saltcedars are (mostly) deciduous species from the Old World. They were introduced to the USA in the early 1800s. As the name suggests, these trees can use saline groundwater and they excrete excess salt through glands on the leaves. The foliage consists of cedar-like bracts, and long racemes of insect-pollinated pink flowers produce copious quantities of small windblown seed. One of the some ten species introduced, *Tamarix ramosissima*, was widely planted in the southwest to control riverbank erosion, to form windbreaks and as an ornamental.

From the 1920s, *T. ramosissima* invaded river valleys rapidly and it was soon recognised as a pest. For example, it spread up the lower Colorado River at 20 km/year. By the 1950s it had invaded most suitable habitats along major streams and lakeshores and by 1965 it occupied over one million acres of prime riparian land in the west. It has displaced or replaced native plant communities, degraded wildlife habitat and may be a major contributor to the decline of many native species, including a number of threatened or endangered species.

Riparian ecosystems are amongst the most important for sustaining wildlife, especially in semi-arid regions, providing critical habitat to threatened and endangered plant and animal species. Human activity undoubtedly has had enormous impact, but modified river systems can still provide a functional ecosystem and wildlife value. As recognised by the Convention on Biological Diversity (CBD), riparian ecosystems are particularly at risk of loss of biodiversity, and invasive alien species are one of the biggest threats. In this context, saltcedar invasion is one of the worst ecological disasters to befall western US riparian ecosystems.

An assessment of the environmental and economic costs and benefits of saltcedar in the USA identified a catalogue of negative impacts.

- Displacement of valuable cottonwood/willow (*Populus*/*Salix* spp.), seepwillow (*Baccharis salicifolia*), mesquite (*Prosopis* spp.) and other native plant communities by dense often monotypic thickets of saltcedar up to 7 metres high with up to 100% canopy cover. Grasses and forbs were often essentially non-existent because of a combination of dense shade and saline litter, the latter a consequence of salt excretion by saltcedar foliage.
- Native wildlife species have not evolved with saltcedar and many species (particularly birds) are unable to utilize saltcedar because of its small fruits and seeds, because few native insects develop on it, and because it has unpalatable foliage. Its lack of food, and lack of plant species richness and structural diversity, make it unsuitable for cover or nesting for most species, and those that do use it for this purpose (including most granivores) tend to feed elsewhere. Species of insectivores, cavity dwellers and raptors are essentially absent in saltcedar. Bird species richness and density may be less than 50% of that in native habitat at some times of the year. Altogether 41 threatened or endangered species are harmed by saltcedar, notably birds and fish but also plants, arthropods, amphibians, reptiles and even a mammal, the peninsula bighorn sheep (*Ovis canadensis cremnobates*) in California.
- Great quantities of water are used and water tables are lowered, causing springs to dry up and hence plant and animal life to perish. Sedimentation and narrowing of channels occurs, which alters stream morphology and water temperature, damages or destroys fish breeding areas, and alters the aquatic invertebrate species composition and populations.
- Soil salinity and fire risks are increased. Both of these kill susceptible cottonwood and other plants, while saltcedar survives.
- Recreational use is impeded as a result of many of these impacts.

The benefits appear paltry by comparison. Saltcedar has value as an ornamental or shade tree. Some wildlife species and particularly game birds (for example the white-winged dove, *Zenaida asiatica*) use it for cover or nesting in the absence of native species, although most have to feed elsewhere or on insects from other plants. As we discuss further below, it has become a preferred nesting site for the endangered southwestern willow flycatcher (*Empidonax traillii extimus*) in mid-elevational areas of Arizona. In the absence of other plants, its pollen provides food, notably for honey bees (although the honey produced is low grade) and some insectivores feed on the many adult insects (produced on nearby native vegetation) that visit its flowers.

**Humans Figure**

The staggering success of saltcedar has been ascribed to recent human-induced changes in the ecosystem. Combined with intrinsic biological characteristics of saltcedar, the following factors have provided it with enormous competitive advantage over native plants: (1) Dams affecting spring flooding prevent establishment of native cottonwoods and willows, which produce seed only in the spring, but allow that of saltcedar, which continues producing seeds throughout the summer and after the floods have receded. (2) Prevention of spring flooding also halts annual leach of salt from soil, which favours saltcedars, and salt accumulation on the surface is exacerbated by saltcedar foliage which excretes salt and contributes salt-laden leaves to litter. (3) Saltcedar thickets burn easily. The frequent fires kill only the topgrowth of saltcedar, which rapidly regrows, but kills even large cottonwoods. (4) Feeding by livestock and native deer and elk is destructive of young willows and cottonwoods but less so to saltcedar. (5) Mechanical controls and some herbicides are more destructive of native vegetation than to saltcedar. (6) Growth of native trees is restrained by natural enemies (insects and plant pathogens), while growth of saltcedar is not.

Jeffrey Lovich of the USDI's Geological Survey in Sacramento, California points out that saltcedar has invaded pristine, remote areas, indicating that human influences are not solely responsible for its success. Other factors include, notably, an almost complete absence of natural enemies. ARS scientists propose that importing and releasing appropriate host-specific natural enemies would remove this advantage, and allow saltcedar to be gradually reduced to a less dominant member of the plant community. Classical biocontrol is a logical choice for consideration, and it has a track record of success and safety in natural areas where native flora and fauna need to be protected from nontarget effects of other control measures.

In contrast, both burning and mechanical control by bulldozing destroy native vegetation, but saltcedar is able to regrow because it sprouts from below-ground buds. Fire kills even large cottonwood trees and bulldozing is very expensive. Aerial spraying with Arsenal (imazapyr) or hand-cutting and stump treatment with Garlon (triclopyr) are effective. However, aerial spraying damages native vegetation, and cut-stump treatment is labour intensive and costly. All these methods also allow rapid reinvasion from windblown seed, and these controls must be periodically repeated, multiplying the cost, the damage to native plants, and the disruption of wildlife.

**Classical Candidate**

Saltcedar appears an ideal candidate for classical biocontrol. Although *Tamarix* is a dominant and widespread genus containing 54 species in its area of origin in the Old World, there are only two other genera in this taxonomically ancient family (Tamaricaceae), and only one other family (Frankeniaceae) in the same order (Tamaricales). The relative taxonomic isolation of *Tamarix* has led to the co-evolution of a wide range of host-specific natural enemies. Exploration in the home range of *Tamarix* by the biocontrol programme and overseas collaborators in France and Italy (USDA-ARS European Biological Control Laboratory, EBCL), Israel (Tel Aviv University), China (Chinese Academy of Agricultural Sciences and Xinjiang Agricultural University), Turkmenistan (Academy of Sciences of Turkmenistan) and Kazakhstan (Academy of Sciences of Kazakhstan) began in 1991. The literature and surveys conducted have identified some 26 insect genera of which all or nearly all species are completely specific to *Tamarix*. The catalogue of natural enemies numbers over 300 and the list is incomplete. These insects exert heavy pressure on *Tamarix* in its native range. For example, one report from central Asia noted that it was often impossible to find viable tamarisk seed because of beetle damage, while EBCL scientists describe seedling establishment as rare, possibly owing to damage by plant pathogens.

The bright prospects for biocontrol that this plethora of candidate species holds out are further strengthened by the absence of native *Tamarix* from the western hemisphere, which implies a low risk of non-target effects if *Tamarix* natural enemies were introduced there. The only species of Tamaricales native to North America are six species of *Frankenia*, in the Frankeniaceae. However, these species are uncommon, and one (*Frankenia johnstonii*) is listed as endangered. In addition, one of the introduced *Tamarix* species, the large evergreen *Tamarix aphylla* or athel, has some value as a shade tree and windbreak in the southwest USA. It is not currently considered as a pest in the USA, although it is invasive in central Australia. The saltcedar programme has had to take careful account of these species in screening.

It would be unusual if none of the abundant Old World natural enemies had been accidentally imported with saltcedars. In fact, surveys of *Tamarix* in the USA revealed that one Eurasian leafhopper, *Opsius stactogalus*, (introduced by unknown means) does act as a biocontrol agent, but does not by itself provide effective control. Four other Eurasian saltcedar-specific arthropods have also been recorded in the USA, but none causes significant damage.

From material collected during surveys conducted by overseas collaborators in the native range of *Tamarix*, 21 species have been prioritized for further study. Ten of these species have been imported into quarantine in Temple. In 1994, petitions for field release of two species were submitted to and approved by the Technical Advisory Group for Biological Control of Weeds (TAG) of the USDA Animal and Plant Health Inspection Service (APHIS), pending an Environmental Assessment. These were a leaf beetle, *Diorhabda elongata*, which occurs from China to western Africa, and a mealybug, *Trabutina mannipara*, from Israel.

ARS scientists and cooperators have observed large stands of *T. ramosissima* in Kazakhstan and Turkmenistan completely defoliated by *D. elongata*. In China, it has the potential to kill young plants grown to control blowing sand. In no-choice-quarantine tests, larvae fed and developed on *Frankenia* as well as on *Tamarix*, but in multiple-choice selection tests in large outdoor cages, adults were not attracted to *Frankenia* and rarely laid eggs on it. In similar experimental cages at the release site in Colorado, only slight feeding was observed on *Frankenia* in spite of the presence of hundreds of starving adults and larvae that had defoliated the saltcedar plants. In Tunisia, no *D. elongata* were found on *Frankenia* growing adjacent to *Tamarix* that was heavily attacked. These tests, plus the fact that in most areas *Frankenia* grows in different habitats some distance from saltcedar, indicate that *Frankenia* in nature will not be damaged by *D. elongata*. In quarantine and outdoor cage tests, athel was fed on and oviposited on more than *Frankenia*, but still much less than on saltcedar. ARS scientists concluded that *D. elongata* is unlikely to damage athel, though some feeding may occur.

The mealybug, *T. mannipara*, proved to be highly host specific in quarantine tests at

Temple. Feeding or survival was observed only on *Tamarix,* among 23 genera and 36 species of plants tested. Populations on *T. ramosissima* increased 20 fold from the first to the second generation and killed the test plants, but populations declined on athel. The females are wingless, but the neonate nymphs may be windborn, as are similar mealybugs. In Israel, *T. mannipara* was collected beside the Dead Sea, an area hotter than any in the USA, and without frost. The cooperator in Israel predicted that it would survive in the USA only in the more southern areas of the saltcedar infestation. In 1994, TAG recommended its release but clearance for release still awaits US Fish and Wildlife Service (FWS) approval and the Environmental Assessment.

**Flycatcher in the Ointment**

One endangered bird subspecies, the southwestern willow flycatcher (*Empidonax traillii extimus*), seriously complicated the biocontrol programme against saltcedar. In 1995, as the environmental assessments were being prepared for the first two biocontrol agents of saltcedar, this flycatcher was placed on the Federal endangered species list.

Saltcedar was documented in the decline of the flycatcher subspecies when it was placed on the endangered list. It probably exacerbates most mortality factors of the flycatcher and reduces reproductive success by a half. Saltcedar has been implicated in flycatcher decline attributed to a range of factors including loss of native habitat, brood parasitism by the brown-headed cowbird (*Molothrus ater*), fires, food, lethal high temperatures, possible increased stress on females, inappropriate nest tree selection and lowered reproductive success.

Paradoxically, however, in one part of saltcedar's adventive range, at mid-elevational areas in Arizona, the flycatcher has begun nesting extensively (and exclusively at some sites) in saltcedar, as its natural willow nest trees have been displaced. It may be highly attracted to nest in saltcedar because the branching structure seems to act as a super-normal stimulus. Concern was expressed that the soil had become so saline and water tables so deep that if saltcedar were to be removed, other vegetation would not return and this would threaten the flycatcher further, even though present flycatcher nesting sites appear to be within acceptable limits for the native cottonwoods and willows. Approval of the Environmental Assessment necessary for approving the biocontrol agent releases had to await resolution of possible effects on this flycatcher.

**Managing Biocontrol**

Concern about the timescale of control, and whether this would allow native vegetation to recover quickly enough to prevent adverse effects on fauna currently dependent on saltcedar, and indeed whether saltcedar-induced or other changes to the environment might prevent the native vegetation recovering or surviving at all, was not focused exclusively on the southwestern willow flycatcher.

Concern is based to some extent on a misconception that the control insects might eradicate saltcedar very quickly. In fact, biocontrol has never resulted in the eradication of a weed, and it is not going to reduce saltcedar stands overnight. The biocontrol team anticipates (extrapolating from dispersal rates of related chrysomelids) that dispersal will not be rapid, but will be in the order of tens or hundreds metres per year. Thus it would take them 10-20 years to reach the flycatcher saltcedar nesting sites that lie 200 to 800 miles (320-1440 km) from the beetle release sites, and that is discounting the effects of ecological barriers that may prevent them ever from reaching there by natural dispersal. Where the beetles do reach, the biocontrol team expects saltcedar control to be gradual. Based on observations in quarantine and in the area of origin of the beetles, they expect it to reach a maximum of 75-80% after 10 or more years. This will allow ample time for the concurrent recovery of willows and other native plants without loss of habitat for the flycatcher and other wildlife species that utilize saltcedar.

Various early manual saltcedar clearance and native re-vegetation schemes had a poor success rate, and this led to concerns about the fate of post-biocontrol saltcedar-degraded habitat. However, early schemes suffered because little experimentation had been conducted to develop appropriate management techniques. Mortality was high owing to a number of factors including poor site selection for replanted species, improper planting methods and irrigation, and failure to protect from the depredations of livestock and wildlife browsers and weed and insect damage.

Studies since have given more promising results. Clearance of saltcedar from small streams and around desert springs has been widespread in recent years. Native plant communities have recovered quickly and naturally where water was available and salinity levels were acceptable. Extensive natural inundations in the 1980s and 1990s may have serendipitously leached salt and even cleared saltcedar in other locations, making conditions ideal for willow and cottonwood reestablishment.

Controlled flooding is a key management technique for promoting site suitability, particularly in areas of high soil salinity. It prepares substrates, distributes seed, dilutes salt, and creates a higher water table, which tips the balance in favour of cottonwoods and willows and away from saltcedar. This is being used to good effect, for example, in the Bosque del Apache National Wildlife Refuge on the Rio Grande in New Mexico. Mechanical clearance of saltcedar is followed by flooding, the waters being allowed to recede as cottonwoods are producing seed. Cottonwood has now replaced the saltcedar, and southwestern willow flycatchers, previously absent, are now nesting in the area in both willows and saltcedar. At Roosevelt Lake in central Arizona, which has the third largest population of breeding flycatchers, the flycatcher bred in monotypic stands of saltcedar at the Salt River inlet but reproductive success was much lower than in mixed saltcedar/willow habitat 20 miles (32 km) away on the other side of the lake. In 1996, floods raised the level of the lake and willows revegetated naturally and extensively as the waters receded; many flycatchers now are nesting in the willows. Studies elsewhere in New Mexico found that good bird habitat was reinstated within 3-5 years of saltcedar removal and re-vegetation. Manual re-vegetation methods that produce 95% survival and continued growth of cottonwoods, willows and other native plants in riparian areas have been developed by the USDA-ARS Plant Materials Center at Los Lunas, New Mexico.

Although there are areas where the salinity is too high and water table too low for re-establishment and growth of cottonwoods and poplars (but probably not for other native species), these areas are small and none has been identified in the southwestern willow flycatcher breeding sites. Even in the most degraded habitats, however, the situation may improve as saltcedar begins to decline. A study of the Pecos River in New Mexico showed that water table levels rose, and in west Texas that salinity levels fell, following saltcedar removal by herbicide treatment.

The role of water in the success of control and re-vegetation is nicely illustrated by beavers, who provided (presumably!) inadvertent biocontrol when they moved into one saltcedar-infested site in Colorado. They cut saltcedar to build their dams but fed little on it. When the pools flooded, the willows returned abundantly but the saltcedar did not because of the high water table, and the beavers then fed on the willows.

**Reaching Resolution**

After a period of being quagmired, the southwestern willow flycatcher issue was resolved and the biocontrol programme was able to resume. In June 1998, Scott Stenquist of the Refuges Division of FWS in Portland, Oregon called a meeting to reach compromises that would resolve these issues and allow the biological control programme to proceed under some mutually acceptable conditions. Several of the National Wildlife Refuges in the USA have saltcedar infestations that seriously damage wildlife habitat. Measures were agreed upon to safeguard the flycatcher in those areas where it was nesting in saltcedar. Proposed research sites within 200 miles (320 km) of such habitats or that shared watersheds were closed down. Initial releases of biocontrol agents were required to be made into cages and monitored for the first year, and at sites that were separated by ecological barriers from flycatcher saltcedar nesting sites. Cages could be removed after 1-2 years, but intensive monitoring would continue for several years to assess (1) effects of the agents on saltcedar and any attack on nontarget plants, (2) rate of dispersal in habitats with varying levels of saltcedar infestation, (3) native vegetation recovery following saltcedar control and (4) wildlife recovery after vegetation recovery.

With this agreement in place, and approval by the FWS in June 1999, *D. elongata* was released in large (3 × 3 × 2 m high) field cages in six western states (California, Colorado, Nevada, Texas, Utah and Wyoming) in July and August 1999. *Diorhabda elongata* fed and reproduced, and overwintered at five of the eight more northern sites. During 2000, these beetles increased to high populations at all five of these sites and completely defoliated the saltcedar. Cages at the other three sites were restocked and two new sites were established. The field-cage studies indicated that in the more southern areas (north Texas and central California), beetles may enter an aestivo-diapause in mid-summer when daylight drops below 14 hours, thus reducing the seasonal cycle to one or two generations and reducing the effectiveness of the beetle. Testing a population from Tunisia that is active all summer is planned.

In May 2001, beetles were released from field cages in Texas and Colorado at eight sites; two sites in California will remain in cages until 2002.

Currently, three additional insect species are being tested in quarantine at Temple and Albany: a foliage-feeding weevil from France (*Coniatus tamarisci*) that has been recommended for release by TAG, a leaf beetle from Israel (*Cryptocephalus sinaita*), and two gall midges (*Psectrosema* spp.) from France and Kazakhstan. Top priority insects still being tested overseas include another mealybug and a moth from Israel, a psyllid and a stem-galling moth from Kazakhstan, a leaf-tying moth, a root-galling weevil and a scale insect from China, and another stem-galling moth, another gall midge and a seed pathogen from France.

The process of revegetation continues to be studied. One experiment currently being conducted by the US Geological Survey in western Colorado, to mimic the effects of the biological control through herbicide application and vegetation recovery, is being closely monitored. The USDI Bureau of Reclamation, Denver, Colorado has initiated a large programme to study the revegetation potential in critical areas.

Although the flycatcher paradox caused a 4-year delay in the progress of the biocontrol programme, the events since show how biocontrol scientists can work with conservationists to plan and execute a programme to manage invasive alien weeds while ensuring the safety of threatened species in the same ecosystem. It is clear that nature reserves set up to protect ecosystems will need management to prevent loss of biodiversity through invasive alien species. The saltcedar programme illustrates some ways this can be achieved.

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## Europe Acts on Invasive Alien Weeds

Classical biological control has never been used against a weed in Europe. This may seem extraordinary, given the number of biocontrol agents sent from Europe to control weeds of European origin in other parts of the world. It was largely to service this need that the Commonwealth Institute of Biological Control (now part of CABI Bioscience), CSIRO (Commonwealth Scientific and Industrial Research Organisation, Australia) and the US Department of Agriculture established biological control research stations in Europe, so Europe is not short of biocontrol experts. But while it has a long history of (albeit inadvertently) exporting weed problems as European nations explored and colonized other parts of the world, its explorers, naturalists and horticulturists also brought back many exotic species to Europe, some as food plants and some as ornamentals. Collectively they improved an impoverished diet and added colour and variety to gardens, and until recently adverse impacts were few.

Giant hogweed (*Heracleum mantegazzianum*) was not a species that crept into Europe unnoticed, far from it. There was great excitement when it was first introduced from the Caucasus region of western Asia in the early 19th century as the temperate zone's answer to the giants being discovered in the tropics. Initially it gave little cause for concern and considerable cause for admiration, but during the last 30-60 years it has become invasive and troublesome throughout central and northern Europe. In many ways it is the archetypal invasive alien weed: an escapee from gardens, spread by human activities, and its spread exacerbated by recent changes in land-use patterns in European landscapes.

It was in Britain for some 150 years before it really broke cover. In the mid 19th century, it was offered by one nursery as "... one of the most magnificent plants in the world". Even then, its habit of spreading by seeding was noted, and by the beginning of the twentieth century sporadic outbreaks were occurring. It took longer for the phototophytotoxic effects of furocoumarins in the sap to be recognised. They produce burn-like weals on the skin and make it hypersensitive to bright sunlight and liable to redden and blister, causing rashes which can persist for many months after contact. Giant hogweed is one of only two plant species prohibited for cultivation under the UK Wildlife and Countryside Act 1981. Herbicide treatment is the main weapon currently used in the UK against the weed, but it has had little impact on its extent and distribution. Cutting is widely practised but is ineffective because plants regrow, and is hazardous to the manual workers involved.

In Germany, giant hogweed's impact on native species (owing to its suppressive nature) and incidents of injury regularly hit the media headlines. Approaches to control are varied and include herbicide application, intensive soil tillage, grazing by sheep, cutting plants, digging out roots and cutting seed heads. Less conventional approaches, such as applications of salt or herbicidal oils and even flamethrowers have been tried. Control, however, remains poor to non-existent.

In Denmark, giant hogweed spread from one site where it was offered for sale in the 1970s to invade adjoining fields, and is now recognised as a major problem. So far it has been countered by mechanical/chemical measures, with grazing and cutting also variously used. By January 2003, all municipalities and counties are requested to cease herbicide use. For many of them giant hogweed is the only plant against which they are still using herbicides, and they urgently need alternative viable management solutions.

**Policies for Invasives**

Similar stories emerge from other countries affected by giant hogweed: signs of increasingly rapid invasion but little or no policy or effective control. Why, though, should giant hogweed become an invasive issue now, when the plant has been with us for so long? Partly this can be explained by the ecology of invasion. Following introduction, there is a lag phase while the new species establishes itself in its new environment and it spreads only slowly. Only a small minority of non-native species goes on to become problematic invaders, and even for these the lag phase can continue for many years. But this is followed by a phase of exponential spread, by which time containment and control have become difficult and often uneconomic. Giant hogweed in Europe has reached the exponential phase of spread.

This, however, is not the whole explanation, for European agricultural policies are also involved. These, and the enormous cost of the financial support they provide to farming, are a subject of oft-heated discussion for governments and farmers elsewhere, and for Europe's taxpayers. Their impact on invasive problems is less well known.

The European Union (EU) Common Agricultural Policy (CAP) was devised to support European farming. On the one hand, it was intended to ensure that European farming was able to compete on the world stage, and that the declines that threatened starvation during the wars of the first half of 20th century (when Europe was cut off from imported food) would never be repeated; on the other hand it provided support to farming communities, which formed a large and important sector of the electorate in a number of member countries. However, when rotational 'set-aside', was introduced in the CAP reforms in 1992, it encouraged farmers to leave fallow large areas of land, including land along rivers and steams, in return for subsidies; in 1993-94, 6.4 million hectares were set aside throughout the EU area. In addition, extensive building development has taken place on former 'green' cultivated agricultural land. Both habitats are prone to invasion by alien species, and human activity promotes further spread. In these and other habitats (national parks, nature reserves, gardens, hedgerows, roadsides, railroad embankments and ditches), native plants are now being out-competed by giant hogweed. The problem is worst in disturbed environments, but the weed is encroaching even in less disturbed habitats. Climate change is likely to provide a further advantage for the invasive. The next round of CAP reforms will begin in 2004. Revisions that place less reliance on subsidies and more on remuneration for participation in land stewardship and conservation schemes would allow invasive alien species (IAS) issues to be addressed.

Worldwide, IAS have achieved a high profile in recent years, and there are multi-faceted and interlinked reasons for this. Most important is the enormous increase in the *number* of species being moved globally in recent decades, which has led to an increase in emerging invasive alien problems. Natural barriers to species movement have been breached through increased trade and travel, while land-use change and global warming facilitate the establishment and spread of these species.

The global threat from IAS was highlighted at the UN Conference on Alien Species in Trondheim, Norway in 1996. This landmark meeting, convened in response to a call from the Convention on Biological Diversity (CBD) for Parties to take action on IAS, recognised IAS as the second greatest threat to biodiversity after habitat destruction. All signatories to the CBD have an obligation under Article 8(h) to "prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats and species."

Current IAS problems in Europe are not confined to weeds, nor to terrestrial situations. Aid during the recent Balkan conflicts is believed to have been the route of introduction of the western corn rootworm, *Diabrotica virgifera virgifera* from the USA, which threatens maize production across large parts of southeastern Europe and is rapidly spreading northwestwards; an outbreak of the North American grey squirrel has caused fierce debate in Italy; European crayfish are under threat from a fungal invader; and the marine alga *Caulerpa taxifolia* is overwhelming the native marine flora and fauna of parts of the Mediterranean Sea. IAS cause a multitude of problems and conflicts of interests across all sectors. Europe has recognised the threat and has begun to act.

The Standing Committee of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention 1979) is the main legal institute of the Council of Europe for conservation issues. Article 11 paragraph 2.b specifically requires "each Contracting Party … to undertake to strictly control the introduction of non-native species". Since 1989 the Standing Committee has carried out a wide range of activities to strengthen implementation by signatories. In 1997 it issued Guidelines on the Introduction of Organisms belonging to Alien Species, which identified a framework of provisions addressing all the main aspects of IAS. The EU's Pan-European Biological and Landscape Diversity Strategy defines conservation policies. These are implemented through regulations or directives, which are binding instruments for member states. It has ranked IAS as having the fourth most significant impact on biodiversity in Europe and directed the European Community to take measures to prevent detrimental effects from them and to control, manage and wherever possible remove the risks they pose. The European section of the IUCN/SSC (World Conservation Union/Species Survival Commission) Invasive Species Specialist Group (ISSG) and the Council of Europe's Directorate of Culture and Cultural and Natural Heritage, in a contribution to the sixth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA 6) of the CBD in Montreal in March 2001, noted that despite all these efforts to provide instruments for addressing IAS issues, application remains uneven, and at the European level a regional strategy and common policy are still lacking.

**Model for Europe**

It is against this background that a Europe-wide initiative is being prepared to provide a model of invasive species management and to research the use of weed biological control agents in Europe. Giant hogweed has been singled out as the model system by partners in the Czech Republic (Academy of Sciences), Denmark (Forest and Landscape Research Institute), Germany (Centre for Environmental Research and Justus-Liebig University of Giessen, Landscape Ecology and Environmental Planning), Switzerland (CABI Bioscience and University of Berne, Zoological Institute) and the UK (CABI Bioscience). If current negotiations under the EU Framework 5 programme are concluded successfully, work should start in late 2001 or early 2002.

The overall objective of the project is to develop an integrated management strategy that comprises effective, practicable and sustainable means of controlling an alien non-agricultural weed. This will provide a generic control strategy to safeguard

Europe's biodiversity from the increasingly serious threat of other IAS. In addition to the effective control of giant hogweed, a concept would be produced which would serve as a template by which other exotic species could be controlled or prevented from reaching the invasive phase.

To facilitate this, the project is going to focus on the more specific objectives of:

- providing simple and practical management methods to decrease the abundance and prevent further spread of giant hogweed; this will prevent displacement of native plant and animal species and thus conserve European diversity
- evaluating biological control as a sustainable control strategy for invasive alien weeds in Europe, using giant hogweed as a case study
- developing concepts for managing similar invasive alien weeds which are having a serious impact on biodiversity in Europe, taking into consideration conflicting human-related activities

Giant hogweed is a considered a good model because it has all the common characteristics of most invasive alien weeds: it is a tall (up to 4 m in height) herbaceous plant, perennial with a varying but short life span; it is typically dominant and widespread over a large geographical area; it infests essentially non-agricultural land; and it is dispersed by human intervention and along corridors. There are, however, a number of interesting aspects to giant hogweed that call for research if management is to be successful.

The taxonomy of the species is poorly understood, but it is crucial that this is clarified if biological control is to be a viable option. Giant hogweed populations are uniform in Central Europe, but types have been reported in northern Europe, and hybridization between it and native *Heracleum* may have occurred. The situation is even more complex in its area of origin in the Caucasus, which is also a region of high diversity within the genus. The links between the taxonomy of the plant in its native and adventive areas are therefore poorly understood. This will be studied using molecular marking techniques, to help ensure that proposed strategies for control are sustainable in the context of the genetic variability of the weed.

Knowledge of biology and ecology has gaps, notably in understanding germination and patterns of spread. Geographical variation in life history and other characteristics also need investigating, in both the native and adventive range. Annual potential seed production will be assessed in a novel study of age structure and spatial distribution in natural and semi-natural habitats, which can be used to assess likely impact of biocontrol agents attacking different life stages. The invasion ecology of non-agricultural weed populations in relation to control is poorly researched, as is invasion at the continental level. These need to be better understood if management is to succeed, a problem that will be addressed by modelling, use of GIS and knowledge built up at the national level.

Extensive surveys in both the adventive and native range of the weed will be conducted for insect and pathogen natural enemies. Preliminary surveys indicated no species of potential in the introduced range, but material new to science in the Caucasus. However, before introduction of biocontrol agents can be considered, risks and benefits need to be considered. In particular, possible nontarget effects (on humans, animals, environment, etc.) will be compared with possible benefits (sustainable long-term control, reduced management costs and herbicide application, etc.) of biological control. Perhaps above all, this project provides a unique opportunity for a coordinated European initiative to assess the suitability and feasibility of classical weed biological control for Europe.

While biological control may be considered in the long-term, it is fundamental to this project to provide a management strategy with more immediate impact. Presently applied mechanical and chemical control methods will therefore be assessed, together with possible measures to reduce and prevent further spread of the weed and other invasive alien weeds. The resultant knowledge and experience will be integrated to produce best practice guidelines and an integrated control strategy. Finally, and crucially, this information will be disseminated to practitioners across Europe to allow them to implement effective and economically sound control measures.

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## Global Lantana Biocontrol Initiative

Prized for their attractive, multicoloured flowers, perennial woody shrubs of the genus *Lantana*, native to the tropical and sub-tropical Americas, were imported into Europe from the mid-17th century onwards. During the 18th and 19th centuries, over 600 cultivars were bred by selection and crossing, and unknown numbers were taken all over the globe. Many polyploid hybrids in this species complex, known collectively by the misnomer '*Lantana camara* L.', became a major pan-tropical weed. Spread by birds, lantana invades pastures, forestry plantations, riverbanks and treed parts of natural ecosystems. It forms impenetrable, prickly thickets that obstruct access. It secretes phytotoxic allelochemicals and out-competes indigenous plants, threatening biodiversity. On the Pacific islands, for instance, the list of invasive alien plants threatening biodiversity is headed by lantana. The leaves and stems of some varieties are also toxic to cattle and cause serious economic losses to farmers.

Chemical and mechanical controls are effective in the short term, but the weed readily re-infests the land as coppice growth and seedlings. In addition, land values in grazing areas are often so low that conventional means of control are uneconomic, whilst in natural ecosystems and national parks the use of chemicals and machinery can also be highly damaging to the environment.

Biological control was therefore sought, intermittently, throughout the 20th century. To date, 38 natural enemies, most of them insects, have been released in 32 countries against the range of weedy varieties of lantana. So far, the impact on the weed has been measurable, especially in hot and humid areas, though generally localized and sporadic and, overall, inadequate. Many factors appear to hinder successful biocontrol. On the one hand, DNA studies suggest that *L. urticifolia* and *L. tiliaefolia* could be important parents of the weedy hybrids, yet the biocontrol agents were sometimes collected from other *Lantana* species, and often released in small numbers, on less-preferred varieties, in climatically unsuitable areas, and colonized by local natural enemies. On the other hand, the target weed's polyploid hybrid genetic composition also certainly confers markedly heterogeneous varietal resistance to natural enemies, and phenomenal powers of compensatory growth.

The biocontrol battle against this notoriously difficult weed was therefore pursued with renewed determination from 1994, in collaboration between ARC-PPRI (Agricultural Research Council, Plant Protection Research Institute) of Pretoria, South Africa, and QDNR&M-AFRS (Queensland Department of Natural Resources and Mines, Alan Fletcher Research Station) of Brisbane, Australia. At present, funding is from state organizations in both countries, and the South African Department of Water Affairs & Forestry's *Working for Water* (WfW) Programme is also mass-rearing new agents for distribution.

The strategy includes renewed surveys in lantana's native range to try and broaden the suite of available agents, so as to attack additional niches on the plant and more varieties of lantana, and cope with a wider climatic range and periodic leaflessness. A number of insect and fungal candidates are currently being investigated in quarantine in South Africa, Australia and the UK. Information and starter colonies of new agents will be made available free of charge to responsible organizations worldwide.

The international collaboration recently bore its first fruit: the first new agent released was the leaf-feeding lantana mirid, *Falconia intermedia*. The Australians had found *Falconia* to be promisingly narrowly stenophagous but rare in Mexico. The South Africans then found *Falconia* causing extensive damage to lantana in Jamaica, and imported it into South Africa in 1994. Since then, it has been subjected to rigorous safety testing. In the laboratory, although immature stages were able to develop on South African species of a closely related genus, *Lippia*, adults preferred to land, feed and oviposit on lantana during choice tests. It was concluded that *F. intermedia* is unlikely to have any significant impact on the indigenous species in the field in South Africa, and it was approved for release there in April 1999.

So far, more than 16 million mirids have been released by the WfW implementation programme, mainly in the Northern Province and Mpumalanga. One year into the release programme and after the first winter, good signs of establishment were recorded from small (1000 nymphs or adults) releases throughout the lantana problem areas in South Africa. However, there was a question mark against how the mirid would perform, because its home range in Jamaica is tropical, whilst in South Africa lantana grows in a wide range of climatic regions varying from subtropical to temperate. All the mirid's life stages are leaf-feeding, and it seemed unlikely that it would persist in the colder and drier regions where lantana is predominantly leafless during winter. Indeed, although low numbers of mirids were recorded during the winter months, populations failed to persist in frosted and drought-stricken areas. On the other hand, releases made in the subtropical areas, particularly near Tzaneen (Northern Province) were followed by rapid population growth, and extremely high populations persist. Where mirid numbers are high, their impact can be dramatic: plants suffer severe chlorosis and leaf abscission and barely flower, whilst emerging seedlings are heavily attacked. Impact on lantana in subtropical areas of KwaZulu-Natal Province is expected to improve when *Falconia* are supplied fresher, from two new mass-rearing stations being set up in closer proximity to the infestations.

The mirid failed to multiply noticeably or exert any marked impact at some sites that were neither frosted nor drought-stricken, and this may be due to some local lantana varieties being somewhat resistant. In the laboratory, *Falconia* showed a statistically significant 20-fold range in reproductive performance on five Australian varieties of lantana, which could be ranked from highly susceptible to virtually totally resistant. Regardless of the possible varietal resistance that is a characteristic feature of lantana, it appears likely that the lantana mirid will always form an important component of the solution to lantana, and for that reason it was also released in Australia, in September 2000.

The failure of the mirid to persist where winter leaf loss occurs is a problem that may be best addressed by developing further agents that attack other parts of the plant or can bridge periods of leaflessness. Several other candidate agents are undergoing host specificity and potential impact studies. Three leaf-chewing chrysomelids, *Alagoasa decemguttata, Omophoita albicollis* and *Charidotis pygmaea*, have been rejected as unsuitable for release in Africa, but a fourth, *Alagoasa quadrilineata*, is still being tested. The herringbone leafminer, *Ophiomyia camarae*, a suitably specific agromyzid that causes leaf abscission, will be released in South Africa as soon as permission is granted. In addition, permission is about to be requested to release a petiole-galling brentid weevil, *Coelocephalapion camarae*, which has been shown to be acceptably host-specific for Africa, and highly damaging. Promising candidates that attack other niches on the target plant are currently under investigation in Australia (the stem-boring cerambycid beetle, *Aerenicopsis championi*) and South Africa (the flower-galling eriophyid mite, *Aceria lantanae* and the root-feeding flea-beetle, *Longitarsus* sp., which would be the first real root-attacker released). A stem-sucking membracid, *Aconophora compressa*, which is established in New South Wales and Queensland, Australia, has been rejected for use in Africa, as it prefers to attack some African *Lippia* species in the laboratory. However, this stem-sucking bug seems likely to make a valuable contribution in Australia, as it survives the dry winter, even on plants void of leaves.

Pathogens are being considered alongside the new insect biocontrol agents. CABI Bioscience has been assessing the life cycle, biological parameters and host specificity of a potential biocontrol agent, the rust *Prospodium tuberculatum* from Brazil for AFRS and PPRI. The rust was shown to infect only *Lantana camara*, and to cause severe defoliation in the process. Encouragingly, it infected a number of the weedy *L. camara* varieties present in Australia, particularly the most widespread and invasive 'common pink', though, unfortunately, none of the varieties from South Africa. In February 2001, permission was granted by the Australian Quarantine Inspection Service (AQIS) to introduce the rust into Australia, making it the first pathogen to be released in Australia against lantana. First shipments of the rust to AFRS were made in June and July 2001.

The rust will be reared through one generation in quarantine to ensure that it is a pure culture (a mandatory requirement of AQIS). Cultures will then be bulked up in the glasshouse. First releases are planned for later this year in Queensland and northern New South Wales (either side of the border between the two states) once there has been enough rain to ensure adequate leaf wetness. There are large areas of lantana in native forests with moist situations in gullies and on stream banks in this area, which should give the pathogen the best chance of establishment.

Permission is awaited to release the first lantana pathogen in South Africa: the leaf-spot fungus, *Mycovellosiella lantanae* var. *lantanae*. It was isolated from diseased leaves collected in South, Central and North America between 1987 and 1997, and tested at the ARC-PPRI Weeds Pathology Laboratory in Stellenbosch. It was found to be suitably specific, and pathogenic to several weedy varieties of lantana found in South Africa. An experiment to investigate the compatibility of *Falconia* and *Mycovellosiella* will be undertaken in quarantine within the next 2 months.

The performance of these pathogens will be watched with particular interest as another promising candidate is awaiting further testing: a Peruvian isolate of the widely distributed Neotropical rust, *Puccinia lantanae*. This isolate has exceptional potential to debilitate *L. camara*, since it infects all the aerial parts of the plant (laminae, petioles and stems) thereby causing dieback of whole branches. In addition, although it appears to be specific to *L. camara*, it is capable of infecting a broad range of the invasive varieties of the weed.

Any organization wanting to suppress lantana is invited to join (free of charge) the informal Lantana Biocontrol Working Group. Potential active collaborators are encouraged to make contact now with any or all of the people named below for more information.

Sources:
Baars, J.R. (2000) A cure for lantana at last? *Plant Protection News* No. 57 (Summer 2000), 8-11.
CABI *Bioscience* website:
Studies on the rust *Prospodium tuberculatum*, a potential biological control agent for lantana weed (*Lantana camara*) in Australia.
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## Cane Toads, Possums and GM

The cane toad (*Bufo marinus*) is one of the biocontrol scientist's least favourite creatures. This has nothing to do with its unfortunate appearance, but all to do with the fact that it is probably the most spectacularly disastrous (and well-known) case of biological control gone wrong.

Cane toads were introduced into Australia in 1935 to control economically damaging beetle pests in Queensland's sugarcane fields. This they failed to do, because the intended prey were either too infrequently on the ground and thus within reach of the toads, or present in cane fields only when there was insufficient cover for the toads. The beetles still have pest status in sugarcane, although new biocontrol measures using *Metarhizium*-based biopesticides against canegrubs are showing promise [*BNI* **19(1)** (March 1998), 5N. Sugarcane biopesticide.] Cane toads, however, did not fade quietly away but thrived. They are indiscriminate omnivores, eating more or less anything that fits in their mouths. They feed voraciously on insects, frogs, small reptiles and even birds and mice. On the other hand, the toads themselves are highly poisonous. The poison, which is released from glands on the skin, in particular from a well-developed cluster of these glands on the shoulder of the toad, is highly toxic and lethal to most domestic and native animals that ingest it. Dollops of toxin can also be fired up to 2 m if the toad is roughly treated, which is the greatest threat to humans as the toxin in contact with the eyes causes intense pain and temporary blindness.

Competition for food and breeding grounds may have reduced populations of some native frogs (but not tree frogs as the cane toads do not climb). Competition from cane toads is most likely to displace species where they are also under pressure from man and grazing animals. Especially at risk are animals that rely on waterholes during the dry season. Cane toads are more adaptable than native amphibians to varying water salt levels (hence their other common name, 'marine' toad), and can survive and breed in brackish water and in very small pools, although unlike many native species they are unable to 'shut down' and aestivate during dry conditions.

With an almost unlimited food supply, favourable environmental conditions and no effective predators, cane toad populations grew (reaching up to ten times the density found in their home range in Venezuela and Brazil), and began to spread across Australia. They now rank as one of Australia's worst invasive alien species. These large (up to 15 cm long), heavily built amphibians have now colonized more than half of Queensland and the northern parts of the Northern Territory and northern coastal New South Wales, and their spread across the top end is continuing relentlessly. Inter-state quarantine measures have intercepted them a number of times on the Western Australia border. Their profile was raised further in March 2001 when they were reported from a remote part of the Kakadu National Park, a world heritage site comprising almost 20,000 km of tidal flats, floodplains, lowlands and plateau, and home to a wide range of rare and/or endemic species.

There are some encouraging signs that old populations have declined after the initial explosion. Some predators are learning to avoid eating them, while a number are apparently able to cope with them. The keelback snake (*Styporynchus* (= *Amphiesma*) *mairii*) can detoxify the venom, while white-tailed rats (*Uromys caudimaculatus*) and some birds such as ibises (*Threskiornis* spp.) and crows (*Corvus* spp.) have learned to flip the toad on its back to avoid the venom and eat only the non-toxic inner organs.

**Control Metamorphosis**

Various control measures have been attempted over the years. Historically, manual measures have been used most. Chemical compounds such as 3% chloral hydrate and various local anaesthetic agents have been recommended, but most people do not normally keep these compounds in their kitchen cupboards. Dettol has been used and most amphibians are very sensitive to phenolic compounds. Freezing remains the most popular unofficial euthanasia method (as dormancy is initiated by cold so the animal dies in its sleep), but official approval of this is qualified. In New South Wales, freezing is recommended only if toads have first been put in an ordinary fridge at 4ºC until they are flaccid, after which they can be put in a freezer. Fencing 50 cm high is recommended to keep toads out of ponds intended for native fish and frogs, and birdwire of 1-cm diameter mesh will exclude them. Methods of biological control of cane toad are being investigated as part of a wider project administered by CSIRO Sustainable Ecosystems, which is looking at the impact and control of the cane toad in Australia.

Interest first focused on natural enemies from the pest's home range. Ranaviruses were found in cane toads in Venezuela. However, laboratory studies at CSIRO's Australian Animal Health Laboratory (AAHL) demonstrated that although these were lethal to cane toad tadpoles, they also killed one species of Australian native frog. The team also found that some Australian cane toads and native frogs had already been exposed in the wild to a ranavirus apparently very similar to the Venezuelan viruses, which are known to cause death and disease in fish and amphibian populations. Thus they cannot be used in unaltered form as species-specific biocontrol agents. The team also identified two fungal pathogens lethal to cane toads and other amphibians, and one of these is thought to be responsible for frog fatalities in Australia and Panama.

At the end of 2000, the Australian government made available Aus$1 million from the Natural Heritage Trust to investigate what gene technology had to offer. The 2-year project has two objectives: (1) to identify a gene critical to toad development, which if manipulated would interfere with metamorphosis and prevent the transition from tadpole to adult, and (2) to develop a means of distributing the gene effectively through the toad population.

Because so many aspects of the immature tadpole and adult toad are different (the immune, digestive and circulatory systems), it is thought likely that a suitable gene can be found. The aim would be to cause the gene to be expressed at the 'wrong' stage of development, say an adult gene to be expressed at the tadpole stage. The tadpole's immune system would recognise the protein as 'foreign' and initiate an immune response to it. The antibodies formed in the larval (tadpole) stage would bind to the protein as it begins to be expressed during metamorphosis and the expectation is that this would interfere with normal development of the adult. There is a precedent for this in bullfrogs, *Rana catesbeiana*, where inoculation of adult haemoglobin into larvae prevented most from developing into adults. The idea to use this finding for cane toads came from Dr Zjelko Zupanovic, who was working on an earlier cane toad project (at CSIRO, AAHL) but has since returned to his native Croatia.

Importantly, the target gene will be selected so that an immune response against it will only affect the development of the cane toad (the only toad species in Australia) and not native Australian frogs. The identification of a suitable gene will be a little like looking for a needle in a haystack, and recent advances in technology will aid the identification of a unique cane toad gene. For example microarray technology, with the aid of computers, allows thousands of genes to be analysed at one time.

Distribution of the gene provides an equal challenge. The team at AAHL is researching the possibility of using a naturally occurring ranavirus as a carrier for it. The gene would be inserted into the virus. When it infects the cane toad tadpoles the gene would be expressed as part of the viral DNA. Before it could be used though, the virus must be attenuated, or weakened, so it does not adversely affect other amphibian species.

This is not a short-term fix, and the first 2-year project is designed to show that the concept can work. It may take 10 years to develop a product, and conduct risk assessments and public consultations before a release can be considered. Until then, the cane toad population needs to continue to be monitored and assessed and where the impact of toads is assessed to be high, they will have to be controlled as best they can by currently available methods. Successful control will, in the long run, depend on a variety of safe and sustainable strategies, of which genetic manipulation may be one.

**Possum Poser**

Public acceptance of biotechnology is seen as an important feature of the Australian cane toad research. It is interesting in this context to look at recent results from New Zealand, where possum fertility control using genetic manipulation is being researched [See *BNI* **21(4)** (December 2000), 89N-93N. Mammal biocontrol: the hunt continues.].

The question of how the public would react to gene technology being used to control a pest species was tackled by Landcare Research, New Zealand. A team conducted a nationwide telephone survey (1000 people) in March-April 2001. They asked interviewees for their views on possums, current control methods and two potential fertility control techniques, one of which would use genetic modification (GM). The first method is based on a bait containing protein from possum eggs, which induces an immune response in females so that they subsequently react against their own eggs and this decreases their fertility. The second aims to curtail the possum's sex drive with a bait containing a hormone-toxin complex that acts on the brain to inhibit production of breeding hormones.

Results showed that an overwhelming majority of respondents (96%) perceived possums as a problem, and 70% rated fertility control as acceptable. Acceptance of fertility control was higher than acceptance of the existing control measures of leg-hold traps (29%) and poisoning (31%).

Respondents were also asked to rate delivery of a transgene via the following carriers: baits containing either a GM plant or a GM bacterium (both would be killed to preclude the possibility of either spreading) or two self-replicating methods using either live GM virus or GM parasitic worms which would spread naturally from possum to possum. The results were polarized, with each rated as acceptable by at least 30%, and unacceptable by at least 30%. However, people were clearly fearful of viruses, with far more rating them as unacceptable than acceptable, and the GM plant bait delivery system was acceptable to more people (43%) than any other method.

As found in previous surveys, men were more enthusiastic (i.e. less risk-averse) than women about possum control for all control methods (but particularly poisoning) and delivery systems. A significant difference was not found for any other breakdown of respondents (e.g. rural *vs* urban).

Landcare Research has undertaken not to pursue any research avenues the public says clearly it does not want. The results of this survey are indicative of support for the approach that Landcare Research is adopting: interfering with fertility through a GM plant bait. It will repeat the survey in about 2 years time to see whether attitudes change. If the current research timetable goes according to plan and the public approve, limited field trials using GM carrot bait could take place in 3-4 years time.

For further information see the following websites:
http://www.csiro.au/page.asp?type=faq&id=CaneToadControl
http://www.landcare.cri.nz/science/possums/
http://www.landcare.cri.nz/information_services/media/images/preliminary_report.pdf

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## New Canadian Biocontrol Network

A Research Network on Biologically Based Pest Management and Control has been established to speed the introduction of natural pest control products in greenhouses, tree nurseries and managed stands in Canada. Co-led by Raynald Laprade and Jean Louis Schwartz (University of Montreal), the network will stimulate collaboration by bringing together more than 40 scientists from university and government laboratories. Funded by the Natural Sciences and Engineering Research Council, it will form the nucleus for expanding the biocontrol network in Canada.

Co-led by Jacques Brodeur (University of Laval) and Mark Goettel (Lethbridge Research Centre), part of the research programme will look into interactions between plant pests and diseases and their natural enemies. Introducing a beneficial species may have negative impact on other beneficials already in the system. By bringing microbials into the equation, Mark Goettel hopes that the network will facilitate an increase in the choice of natural controls, and quite quickly in some cases. For example, several fungi are available for use in glasshouses in the USA, but not yet in Canada. By using insect, bacterial, fungal and viral agents in a coordinated way to control pests and diseases, greenhouse and tree nursery growers will be able to reduce or eliminate pesticide use while protecting their crops.

A major aim of the network is the development of innovative tools for discovery and testing for glasshouse pest management, including DNA-based technologies, cell mode-of-action based technologies and more research at the microbial level (reflecting

Agriculture and Agri-Food Canada's mandate to support innovation for growth and environmental health).

The glasshouse industry worldwide has long been at the cutting edge of biological control in agriculture. Releasing biological control agents is the method of choice for many glasshouse pests. The main goal of the network is to increase collaboration and communication between pockets of greenhouses and area-focused researchers across the country. Pest problems vary across the country, but there may be common solutions. However, because a glasshouse is a contained and manageable system, it may also provide a model for more open farming and forestry systems. Once the network is fully functional, Mark Goettel hopes it will stimulate investment in and expansion of biocontrol research in other sectors.

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## Philippines Home to Leafminer Parasitoids

Although *Liriomyza* leafminers are not new to the Philippines, they did not achieve important pest status until late 1999. This change in status has been attributed at least in part to the use of broad-spectrum insecticides (often applied to control other pest species such as thrips, aphids and mites), which decimates the natural enemy fauna and leads to outbreaks of leafminers. Because leafminer parasitoids are not easily visible to the naked eye, farmers are generally unaware that they exist, let alone of their role in suppressing leafminer populations, so the adverse effects of insecticide use remain under-estimated.

Extensive surveys and intensive sampling of leafminer-infested leaves in pesticide-free vegetables, ornamental crops and weeds by the Potato Leaf Miner Task Force (PLMTF) from the Department of Agriculture, Regional Field Unit, Cordillera Administrative Region revealed that leafminer parasitoids are numerous in the Philippine highlands of the Cordilleras, with at least ten species recorded so far. The team was led by Dr Ravindra C. Joshi (Department of Agriculture-Philippine Rice Research Institute) and included Dr Elizabeth A. Verzola and Mr Nicasio S. Baucas (Department of Agriculture-Regional Field Unit-Cordillera Administrative Region).

The parasitoids were identified by Dr John LaSalle, CSIRO Entomology (Australia) as: *Asecodes delucchii* (a palaearctic parasitoid found recently in Southeast Asia), *Cirrospilus ambiguus* (known from Taiwan, Africa and recently in Southeast Asia), *Diglyphus isaea* (widespread throughout the Palaearctic Region and North Africa), *Hemiptarsenus varicornis* (an Old World parasitoid which is common in Southeast Asia), *Neochrysocharis formosa* (a common cosmopolitan parasitoid), *Neochrysocharis okazakii* (known from Japan and China south to Indonesia), *Pnigalio katonis* (an Asian parasitoid), *Quadrastichus ?liriomyzae* (now known from China to Southeast Asia), *Opius* sp. 1 and *Opius* sp. 2.

*Diglyphus isaea* is the predominant parasitoid reared from leafminer-infested leaves in the Cordilleras. Its high occurrence in the Cordilleras is quite puzzling, as it was not previously recorded from Southeast Asia. It is commonly used as a biological control agent in Europe, and its presence could be due to an introduction with infested host plants, mass release of adults, or a natural spread of this species south from China.

Further surveys will be conducted, focusing on finding predators of the adult leafminer fly and larva. The parasitoids already identified in the Cordilleras will be studied in more depth to determine the leafminer species and stage attacked; their spatial, temporal and seasonal dynamics; species composition and competition; and crop preferences.

The aim of this work is to help farmers to preserve 'friendly wasps' and cut out unnecessary and expensive interventions to control leafminer damage on potato, celery, cut flowers and other economically important crops in the Cordilleras. The team plan to work with farmers to familiarize them with the natural enemies, and show them how to conserve them. Towards this end, an extension pamphlet for farmers on leafminer parasitoids is already in press.

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## Beech Surveys on a Major Scale

Surveys in Crown-owned royal woodlands in the UK are the first step in a project that will be searching across Europe and western Asia for natural enemies of the beech scale *Cryptococcus fagisuga*. The scale is a highly invasive alien insect in North America, where it has severely damaged and continues to threaten the native beech, *Fagus grandifolia*. The scale facilitates attack by fungal pathogens (beech bark disease) resulting in tree deformation. Only a small proportion of trees shows a degree of resistance.

As part of a management initiative for the scale, the USDA (US Department of Agriculture) Forest Service is investigating the potential for classical biological control. Surveys were conducted during earlier work, but the only extensive exploration for natural enemies was done in Germany and northern France and only generalist insect predators were found. These areas represent only a small proportion of the extensive known range of the scale in the Old World, and they may not even fall within the true centre of origin of the scale.

The USDA Forest Service has asked CABI Bioscience to make more representative and extensive surveys for potential biocontrol agents throughout the known range of the beech scale. The surveys will be centered within the two main regions where the scale has been recorded: Europe and western Asia. The European beech, *Fagus sylvaticus*, occurs through much of Europe, although replaced by the subspecies *F. sylvaticus* ssp. *orientalis* in the Balkans. This same subspecies also occurs throughout western Asia. Surveys will focus on two areas in each region to encompass the entire range of the scale and both tree hosts. Surveys in England, Hungary/Romania/Bulgaria, eastern Turkey and Iran are planned. Natural enemies collected during these surveys will be identified and assessed for potential as biocontrol agents.

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## Sunn Pest is a Cereal Killer

The sunn pest, a complex of pentatomid bugs, is responsible for the application of pesticides costing US$ 40 million on up to 15 million hectares of wheat and barley annually. Sunn pest occurs in a broad sweep across North Africa, through the Middle East to central Asia. It causes economic damage in the Middle East (Syria and Jordan), through Iran and Afghanistan, and in the newly independent states of central Asia (Tajikistan, Uzbekistan and Kazakhstan). It reduces crop yield, lowers seed germination and decreases grain and flour quality. In extreme cases, wheat damage can be so severe that the harvest is lost.

Research into the pest has a long history, and has been aimed at developing an integrated management strategy based on biological control. ICARDA (International Centre for Agricultural Research in Dry Areas) and the University of Vermont (USA) have been key to progress made so far with additional input by Simon Fraser University (British Columbia, Canada).

Now a DFID (UK Department for International Development) funded project, managed by ICARDA has given new impetus to the search for a solution. Also collaborating with ICARDA are the Plant Pest and Diseases Research Institute, Tehran, Iran, and the Plant Protection Research Institute of Adana, Turkey, CABI Bioscience and NRI (the Natural Resources Institute, University of Greenwich, UK). Additional institutes from Syria and Turkey are also significant collaborators.

Scientists from ICARDA and the University of Vermont have isolated over 200 strains of entomopathogenic fungi from sunn pest in west and central Asia. These included more than 100 *Beauveria bassiana* and nearly 60 *Paecilomyces farinosus* isolates. Following assessments to find the most promising strains, the aim now is to develop an effective biopesticide. To this end, mass production methods are under development and field trials to determine the effectiveness of selected isolates are in the planning stage.

The project is also looking at how to optimize pest management decision making, and investigating compatible options such as the development of sex pheromone traps and the use of egg parasitoids.

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## Mikania Management Calls for Biocontrol

A report* from Kerala Forest Research Institute (KFRI), India presents the findings of a DFID (UK Department for International Development) funded project to assess the severity and impact of *Mikania micrantha* in the Western Ghats and to develop a management plan for it. It concludes that mikania is a growing threat in this part of India, and suggests that classical biological control holds the best prospects for a sustainable solution

Mikania is thought to have been introduced to India in the 1940s as ground cover in tea plantations, and is now a serious invasive weed. It first appeared in the Western Ghats in the 1980s and surveys conducted during this project confirmed that mikania-invaded areas are widespread in Kerala, where the weed poses a threat to natural forests, forest plantations and agricultural/agroforestry zones. It has not yet spread into other States. In Kerala, invasion was most common in moist-deciduous forest. Some 75% of teak plantations surveyed there were affected, with young teak suffering most from the effects of the weed. In agricultural systems, intensive weed management keeps infestations down, but mikania was found in 92% of surveyed sites. Plantain, pineapple, cassava and ginger were the worst-affected crops. Data collected from permanent sample plots in Kerala over the period of the project suggest that infestation is on the increase in all ecosystems.

Mikania thrives in forest areas where the canopy is open, and invasion is low at higher altitudes (over 1000 m above sea level). *Mikania micrantha* was the only *Mikania* species recorded in the surveys. Eight new pathogens were recorded on it, but all proved to be opportunistic pathogens and therefore to have little potential as biocontrol agents. Herbicide trials in forest plantations showed triclopyr + picloram to give best results. Herbicide treatment was more cost-effective than manual methods (sickle weeding or uprooting) as a short-term control measure in this situation.

Socio-economic studies found that cost escalation was the most important economic impact in forest and agricultural situations. Intensive weed management kept impact on productivity and profitability down in agricultural land, but in forests both were reduced drastically because weeding is not carried out regularly. Infestations also make harvesting of non-wood products such as bamboos an onerous task.

The report argues that current control options such as manual weeding and herbicide applications are expensive, unacceptable and likely to be ineffective in the long run. Moreover, herbicide use is environmentally damaging. It concludes that classical biological control offers the best hope of environmentally benign, cost-effective, sustainable and safe control.

*Sankaran, K.V.; Muraleedharan, P.K.; Anitha, V. (2001) Integrated management of the alien invasive weed *Mikania micrantha* in the Western Ghats.
Final report of the research project KFRI/283/97 August 1997– December 1999.
KFRI Research Report No 202, 51 pp.

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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.*

## Managing the Coffee Berry Borer

The coffee berry borer (*Hypothenemus hampei*, CBB) is arguably the world's worst insect pest of coffee and has caused heavy losses costing millions of dollars worldwide. It has been spread through trade from its central African centre of origin across Africa, Asia and Central and South

America. An innovative project funded by the CFC (Common Fund for Commodities) with supervision of the ICO (International Coffee Organization) and implemented by CABI Bioscience and in-country partners has been working to develop locally relevant and affordable integrated management systems for CBB based on biological and cultural methods. Participating countries include Colombia, Ecuador, Mexico, Guatemala, Honduras, Jamaica and India. The US Department of Agriculture (USDA) is also funding rearing work in Mississippi. Here we highlight major achievements of the project so far.

CBB damage is caused by the female, which bores into coffee berries to lay her eggs, producing legless white larvae that then feed on the beans for up to 3 weeks. The economic damage is twofold:

- premature fall of berries and hence total loss of these to production
- damaged berries are retained on the tree until harvest, making them of lower commercial value by reducing weight of the bean and downgrading the quality and affecting the flavour of the coffee

As most of the pest's life cycle is passed within the coffee berry, chemical control is difficult. It is also costly (often pushing the cost of production above the value of the crop) and hazardous (endosulfan, generally regarded as the most effective chemical in use, is a Category 1 poison). Natural enemies have been identified in CBB's region of origin in Africa. Two bethylid parasitoid species (*Cephalonomia stephanoderis* and *Prorops nasuta*) have been imported into a number of Latin American countries (Mexico, Guatemala, Honduras, El Salvador, Nicaragua, Colombia, Ecuador and Brazil), and at least one has established in each. A braconid parasitoid (*Heterospilus coffeicola*) has been under study in Uganda under a separate project, but there are no plans currently to introduce it elsewhere. Native pathogens (*Beauveria bassiana* strains) are locally important as natural controllers in CBB's introduced range and further work on these is planned. So far, though, biocontrol agents by themselves have been at most moderately effective. Biocontrol interest currently is focusing on the eulophid *Phymastichus coffea*, which is being supplied to countries under this project.

Manual control (picking infested berries) is labour-intensive and hence expensive, but is still the key recommendation for CBB control. The development of more (cost-) effective technologies is seen as crucial. A main feature of this project has been its introduction of Farmer Participatory Research (FPR) to the coffee sector. FPR involves farmers directly in the development and testing of new technologies. This approach has proven successful for solving the complex problems presented by information-intensive management techniques such as IPM in other crops. Developed in rice in Southeast Asia, it has been adapted, for example, for cotton and vegetables, but until now not for coffee. The project has looked at how FPR can help smallholder coffee farmers manage CBB.

**Working with Indian Farmers**

From India comes news of an IPM package for smallholder coffee growers that reduces CBB infestation from more than 50% to less than 5%. This is cause for celebration not only amongst farmers, for coffee is a key export earner for India and the sector employs 400,000 people directly. Smallholders are responsible for 60% (175,000 tonnes) of total annual production. Coffee is also instrumental in preserving forest ecosystems in traditional coffee-growing areas, while in non-traditional areas it is helping reduce deforestation caused by shift cultivation.

CBB arrived in India in Tamil Nadu in 1990, and spread rapidly through the main coffee cultivation areas of the Western Ghats, which cover southern Karnataka, Kerala and Tamil Nadu. Severe outbreaks with infestation rates of more than 50% were reported in some areas.

Since 1998, the ICO/CFC project in India, implemented by CABI Bioscience and the Indian Coffee Board has used a participatory approach in farm communities. A total of 52 1-ha IPM pilot plots were set up on holdings of different sizes (from one to more than 100 ha) in three CBB-infested areas, Wayanad, Karnataka and Tamil Nadu. The main interventions prescribed for CBB management were:

- timely harvest
- thorough and clean harvest
- collection of gleanings
- removal of infested berries
- removal of off-season and left-over berries
- use of picking mats (placed under the tree to collect the picked berries)
- drying coffee to the standard test weight
- early disposal of coffee produced
- spot spraying of endosulfan where necessary as a last resort
- biological control methods
- maintenance of trap plants around the drying yard
- use of CBB traps

Cultural controls worked best, especially new interventions such as picking mats. CBB incidence was assessed regularly (every 1-2 months) by systematic sampling. The on-farm experimentation provided an insight into aspects crucial to CBB management. This was particularly true in the smallholder sector, where plot owners who participated in prescribed interventions and data collection gained substantial knowledge. Group participatory-style gatherings were held at many IPM plots, to share experience gained in IPM techniques and demonstrate them to neighbouring farmers. The meetings included question-and-answer sessions, practice in field identification, and discussion and reinforcement of IPM technologies to be adopted.

Amongst aspects investigated in on-farm experiments were:

1. The use of various trap designs and lure combinations. A 1:1 combination of methyl and ethyl alcohol attracted most CBB, with high catches made in some circumstances (in one case 600 in one day). However, a comparison of trap catches with estimates of CBB populations indicated that percentage catch may be very low: in one trial with 109 traps/acre (270/ha) the catch was calculated as only 0.7%.
2. The extent of emergence of CBB during drying, and migration and reinfestation of nearby coffee trees. The results of life-table experiments indicated that CBB can remain alive through the first week of drying and that significant numbers of CBB emerge from the berries and fly to the five rows of coffee nearest the drying yards. A battery of alcohol traps placed around the yards and regularly serviced during the harvesting season could be an effective procedure to monitor or even protect against reinfestation of plots.
3. Biopesticide applications. Poor control was achieved in field trials with *Beauveria bassiana*. Best control of 24% compared poorly with 80% using endosulfan or 70% with chlorpyrifos.

Over the 2 years of the project, 80 bimonthly training and dissemination workshops were held in Kodagu, Chikmaglur, Wayanad and Tamil Nadu zones. Other activities included follow-up extension visits, village meetings, conventions and workshops, training programmes and mass contact and media programmes.

By working in collaboration with researchers and extensionists, smallholder coffee farmers have made progress in CBB management that will lead to improved livelihoods in this sector. The project adapted and built on farmers' pest control knowledge. As a result, not only have CBB levels been reduced to less than 5% in many areas, but in most cases farmers have been able to reduce and even stop use of synthetic insecticides, which has beneficial effects on both health and the environment. It is also clear that significant progress has been made with both confidence-building in farmers to manage CBB and facilitating the involvement of women.

**Listening to Colombian Farmers**

In Colombia, collaboration between smallholder farmers, extensionists and researchers from the coffee growers federation FNCC (Federacion Nacional de Cafeteros de Colombia) has produced a novel model of farmer-scientist interaction.

Researchers focused initially on getting to know the areas the project was to work in (spread through three departments) and gaining the trust of the farmers. They achieved this through visits with local extension agents over a 4-month period. They then made individual visits to 113 farmers to identify gaps in farming knowledge. Such visits were informal as the scientists met the household and walked over the farm, but the outcome of each visit was used to fill in a pre-designed form.

Participatory Rural Appraisal (PRA) diagnostic sessions were held in each of nine communities to identify problems and solutions, and to 'brainstorm' CBB control ideas to research. This also helped the researchers to assess farmer knowledge. Extension agents subsequently provided farmer training to fill in the identified gaps and this process was evaluated. Finally, agreement was reached on what and how to test. Farmers suggested some interventions, but most were proposed by the scientists, although farmers subsequently modified some of the techniques during testing. The results were presented by farmers in a farmer-scientist workshop. Practical demonstration rather than 'talk and chalk' will be used to train extension agents in the most promising techniques.

At the PRAs, the following were identified as major causes of CBB problems:

- old and unproductive coffee trees
- groves were reinfested from neighbouring farms where control measures have not been applied
- communities were disorganized
- control measures were expensive (although exact cost was unknown)
- unharvested berries left food for CBB
- labour shortage
- generalized pesticide applications

Farmers tended to suggest botanical insecticides as novel solutions, which they had heard about from NGOs or other farmers. Cenicafé (the research branch of FNCC) included these in the research agenda, but they proved no more effective than water. However, farmers were enthusiastic about suggesting modifications to the scientists' ideas, mostly to make them easier to implement and reduce cost. Their role was also fundamental in evaluating the suitability of IPM technologies at an early stage. For example:

1. A novel sampling method (a Cenicafé method coded 'EBEL') was rejected as too time consuming. It was both salutary and useful for scientists to get such advance critique before more time was spent in finalizing an ultimately inappropriate technology.
2. Farmers were initially enthusiastic about equipment designed for trapping CBB in coffee groves, and these were trialed by 39 farmers, who put 1-5 traps in each productive plot. But the traps turned out to be difficult to service (the alcohol lure evaporated quickly, the water was smelly to change and counting trapped CBB was unpopular). CBB populations were relatively low during the experiment so few were caught and many farmers abandoned the traps.
3. Farmers adopted and continued to use trap covers in coffee washing stations, which prevented CBB escaping from harvested berries and reinfesting neighbouring groves. A group of 45 farmers was shown how to modify their processing equipment by covering parts of it with plastic covers smeared with axle grease, engine oil, etc. These proved highly effective. They were easy to monitor and service, and trapped thousands of CBB. Adoption of this measure rose to 80% of participating farmers in the next 18 months.

Farmers were demonstrably enthusiastic about the participatory approach to solving CBB problems, and felt encouraged to continue experimenting. They organized themselves into small groups (with often inspirational names) for this purpose. Scientists, on the other hand, gained knowledge of farmer conditions. For example, they now understand the value farmers place on their own time and labour, and this will inform their research in the future.

The project has also had a positive effect on community interaction (identified as a problem in the PRA). Whether this can be sustained and whether the lessons learned can be applied more widely are questions currently being addressed.

The results so far, however, are encouraging. Although many ideas originated by participatory research do not work, failures are generally identified early on, and only a few are taken through development to final product. This, however, is more efficient in time and money than developing and promoting a smaller number of scientist-originated technologies that may be, but more often are not, ultimately adopted.

**Natural Enemies: Many Hands**

Collaboration between countries has been the key to making advances in parasitoid rearing and release, with the result that more than one million *Phymastichus* wasps have been released in Colombia, 300,000+ in Honduras, 200,000+ in Guatemala and 6000+ in Mexico. In Ecuador, first releases were carried out in April 2001, after delays due to flooding. Cultures have also now been established in Jamaica, and releases are expected to begin soon.

Joint work by the US Department of Agriculture (USDA) laboratory at Starkville, Mississippi and staff from the Colombian project is leading to methods for rearing large numbers of both host and parasitoid with low labour costs. Whether the costs are sufficiently low to make augmentative releases economically feasible will be assessed before the end of the project.

USDA has been the key partner in developing automated, artificial diet-based rearing methods for CBB. A pilot facility run by Dr Portilla (seconded from Colombia) now produces 30,000-50,000 adult CBB per day and could produce more if this becomes necessary. Cenicafé maintains a strong culture of *Phymastichus* in Colombia and has supplied Ecuador, Honduras, Guatemala and India with shipments. Parasitism rates of 60% have been achieved during rearing using a semi-artificial diet including industrial agar as a substrate for CBB hosts (compared to 70% in coffee beans). A successful method to automate collection of CBB from artificial diet has also been developed.

More than one million wasps have been released in Colombia. Although parasitism rates recorded so far are low (0-28%; mean 6.3%), so are CBB populations (3% falling to 2.5% post-release). But there is evidence that the wasps have established and are in at least the third post-release generation.

The Colombians have also provided shipments of *Phymastichus* to other countries, and training for their staff. As a result, cultures of *Phymastichus* have been established in Ecuador, Guatemala, Honduras, Mexico, Jamaica and India. Encouraging releases totalling more than half a million wasps altogether have been made in Ecuador, Guatemala and Honduras. Jamaica has made excellent progress on culturing and releasing *Cephalonomia*, as a result of close collaboration between the Jamaican Coffee Board and CARDI, and is progressing with *Phymastichus*. In 2000, releases of 50,000 *Cephalonomia* were made at three sites in the Blue Mountain region.

From Guatemala comes evidence that *Phymastichus* is adapting to field conditions. Field studies were conducted on a 10-ha plot of arabica coffee at 700 m above sea level (masl) with 40% shade cover and 16% infestation of CBB; 10,000 wasps were released at the central point of each plot. Samples taken at 15-day intervals indicated rapid dispersal over the 10-ha plot in 90 days. Further studies on adaptability indicated a relatively high level of parasitism, with 46%, 15% and 23% recorded at 700, 850 and 1040 masl; in robusta plantations parasitism rates of 21-33% were recorded. Such high rates of adaptability and dispersal are encouraging.

A possible new indigenous biocontrol agent has been found in Honduras; a eulophid, *Horismenus* sp., was identified as an adult endoparasitoid.

Management of *Phymastichus* rearing and experimentation by countries has been demonstrably extremely productive in Latin America. There is clear evidence that training has been effective and as a result an enhanced capacity in culturing, release and evaluation of parasitic wasps has been created in the region.

The project is due to finish at the end of 2001, and a final workshop will be held in London in May 2002 to evaluate and disseminate the outputs. At this stage it seems clear that most of the objectives of the project will be met. However, because of the deep and continuing coffee crisis the sustainability of many of the project activities is in doubt. During the remaining months of the project, intensive efforts will be made to look for ways to build on the work of the project.

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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.

## DBM Biocontrol Symposium

An international workshop on improving biological control of diamondback moth (*Plutella xylostella*, DBM) will be held in Montpellier, France in the autumn of 2002. Organized by CIRAD (Centre de Coopération Internationale en Recherche Agronomique pour le Développement), EBCL (US Department of Agriculture – Agricultural Research Service European Biological Control Laboratory) and CABI in association with the International Organization for Biological Control (IOBC) Plutella Working Group, it will look at the status of DBM biological control around the world, the taxonomy and role of natural enemies, and the importance to biological control of variability of populations.

To register for further information, contact:
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Website: http://www.dbm2002.cirad.fr

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## European Whitefly Studies Network

The success and growth of the European Whitefly Studies Network (EWSN) during its 2-year European Community (EC) FAIR 6 Concerted Action Grant (CT98-4303) has assured a future for the network. The concerted action programme ended in March 2001 with a workshop and an international whitefly symposium.

Over the 2 years of the programme, EWSN steadily attracted additional support from organizations, industries and individuals concerned with whiteflies and their control. This enabled a rapid expansion of membership, activities and outputs, which raised EWSN's profile worldwide. The network will now continue as an independent organization, principally supported by Syngenta and Koppert Biological Systems, with the additional support from a number of other commercial associates.

EWSN comprises a highly motivated team of whitefly researchers and industrialists, providing, collating and disseminating information on all aspects of whiteflies and associated crop problems. In the near future, for example, a complete database of whitefly parasitoids will be compiled and made available through EWSN. The network has already created a Resource Pack, distributes the EWSN newsletter and has developed a website. [See also Conference Reports, this issue.] The network has also recently announced its affiliation with the *Bemisia Newsletter*, which will be published in future as part of the EWSN newsletter.

The next meeting to review developments in research and crop protection will be held in Agadir, Morocco on 19-20 March 2002.

For more information about publications, activities and membership contact:
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Website: http://www.jic.bbsrc.ac.uk/hosting/eu/ewsn/

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## Pacific Entomology Conference

The 10th Pacific Entomology Conference, sponsored by the Hawaiian Entomological Society will be held in Honolulu on 25-26 February 2002.

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## Latin-American Weed Biocontrol Course

The 'First Latin-American Short Course on Biological Control of Weeds' is being organized by the University of Florida and the Universidad Nacional Agraria de Nicaragua. It will be held at the Hotel Barcelo in Montelimar, Nicaragua on 24-28 June 2002.

For more information and registration, contact the course coordinator:
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Or visit the website:
http://biocontrol.ifas.ufl.edu

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## African Sustainable Agriculture Course

The Sustainable Agriculture Centre for Research, Extension and Development in Africa (Sacred Africa) is an NGO that works with rural farmers to improve their lives through increased agricultural production and income while protecting and enhancing the environment. In collaboration with partners, SACRED has organized a Regional Course in Sustainable Agriculture to be held in Western Kenya on 29 October-2 November 2001.

The course, which will be facilitated in a participatory and lively way, targets project managers, extensionists and researchers from East and southern Africa. It will be limited to 30 participants and will cost Ksh 15,000 per participant from Kenya and US$ 500 for those from elsewhere in East and southern Africa. Fees will cover food, accommodation, tuition and educational materials.

The course will include: an introduction to sustainable agriculture (principles and practices); agriculture and natural resource management problems and opportunities in the region; the role of participatory community development in agricultural development; sustainable soil fertility management; gender issues in agriculture and natural resource management; working with communities to facilitate development; agricultural marketing and home-based processing for rural development; researching with farmers; using farmers as extensionists; focusing on poverty in our work; and collaboration, networking and team work.

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## Coffee Futures

This sourcebook*, which deals with some of the critical issues confronting the coffee industry, was published to coincide with the 2001 World Coffee Conference in London in May. The book was not intended to provide a comprehensive treatment of each topic, but rather to inform and stimulate discussion. It features 20 contributors from the full spectrum of the industry. Technical developments such as mechanical harvesting and GM coffee are assessed. Coffee diseases and health implications for human consumers are outlined, together with measures farmers/producers can take to minimize the contaminants. Of particular interest to *BNI* readers, there is a strong emphasis on the future prospects for coffee smallholders. Economic problems and gaps in knowledge are identified. The roles of a variety of measures from participatory research to telecentres in plugging the gaps are examined. What is meant by 'sustainable' is explained in the context of coffee production, and illustrated by describing some of the methods used for raising healthy coffee and managing pests and diseases. Coffee diseases are seen as a particular threat, and these are dealt with in detail. Some possible ways forward are considered for those who hope to continue making a living from coffee, including speciality, organic and bio-diversity friendly production. Finally, the role of smallholder coffee in biodiversity conservation is highlighted.

*Baker, P.S. (*ed)* (2001) Coffee futures: a sourcebook of some critical issues confronting the coffee industry. Cenicafé, Colombia/CAB International, UK;
The Commodities Press, 111 pp. Pbk.
ISBN 958 33 2356
Available (price US$28) from:
Julius Jackson, CABI *Bioscience* (UK),
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# Conference Reports

## Whitefly Meetings

The 1st European Whitefly Symposium was held at Ragusa in Sicily on 17 February – 3 March 2001. The conference attracted some 200 delegates from around the world, and 113 papers on many aspects of whitefly-related research and control were presented. Sessions covered systematics, general biology, population dynamics, whitefly-virus interactions, natural enemies and biological control of whiteflies, and whitefly control and integrated pest management. The meeting presented a good opportunity for whitefly workers to gather, exchange news and views, and hear about the most recent developments in research on this key pest.

The European Whitefly Studies Network (EWSN) held its final workshop as an European Community (EC)funded concerted action during the symposium, on 26 February 2001. Some 70 members reviewed the network's activities since it began in March 1999. Developments from previous workshops were evaluated, and the coordinators of the three working group meetings summarized their achievements and outputs.

A key function of EWSN is dissemination of information, and the success of this was highlighted. The EWSN Resource Pack holds detailed protocol sheets on all areas of whitefly research and these are regularly added to and updated. They have been designed from information supplied by members and cover an extensive range of techniques from the field collection of specimens through to laboratory methods for identifying whitefly-transmitted viruses. The EWSN newsletter and website provide further avenues for promoting communication between whitefly workers.

The newsletter is currently sent to almost 2000 locations worldwide.

Presentations by the coordinators of the five discipline groups (virology, epidemiology, systematics, natural enemies and plant protection) reviewed research developments and intra- and inter-discipline collaborations and outputs. Finally, representatives from Syngenta and Koppert Biological Systems discussed the benefits that their companies had gained from involvement with EWSN.

Although the EC Concerted Action Project has now ended, EWSN is set to continue as an independent organization.
[See Announcements section, this issue].

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## *European Organic Farming*

A landmark conference has pushed organic agriculture towards the top of the European political agenda. 'Organic Food and Farming: Towards Partnership and Action in Europe' was held in Copenhagen, Denmark on 10-11 May 2001. It was arranged and organized on the initiative of the Danish Minister of Food, Agriculture and Fisheries, Ritt Bjerregard, who gave the opening address.

The meeting aimed to make substantial progress in the development of an Action Plan for organic farming in Europe. The Plan will feed into proposals to make fundamental reforms of the European Union (EU) Common Agricultural Policy (CAP). The proposals hope to change the current policy, which is based on farm subsidies, to a policy based on payments dependent on participation in land stewardship and conservation schemes.

The conference was attended by a long list of European ministers and other leading political figures who gave clear support to the proposed Action Plan. This was the message of addresses given by Poul Rasmussen, Prime Minister of Denmark, and Margareta Winberg, Renate Künast, Wilhelm Molterer and Bjarne-Håkon Hansen, Ministers for Agriculture of Sweden, Germany, Austria and Norway, respectively. Speeches made by Friedrich-Wilhelm Graefe zu Baringdorf, Chairman of the Committee on Agriculture and Rural Development of the European Parliament, Corrado Pirzio-Biroli, Head of Cabinet, DG Agriculture, European Commission, Elliot Morley, UK Parliamentary Secretary for Agriculture, Evangelos Argyris and Tomás Zidek, Vice-Ministers of Agriculture of Greece and the Czech Republic, respectively, and comments by Branko Bosnjakovic, Regional Advisor for the Environment at the UN Economic Commission for Europe indicated their strong support.

Also attending the conference were experts in all aspects of organic policy, production and research, including Gunnar Rundgren (IFOAM, International Federation of Organic Agriculture Movements) and Peter Goemelke (Danish Agricultural Council) who presented papers. Nine themes were discussed in depth: organic agriculture as a part of the Common Agriculture Policy; trading organic products; organic standards, certification and legislation; organic farming and multifunctional contributions to the environment; processing and marketing of organic products; organic food and farming in the new market economies of the central and eastern European countries; the European Action Plan: process and content; communicating with consumers; and research as a tool for development in the organic sector.

Key issues for European organic farming were identified relating to: making organic farming a key element of CAP reform; justifying organic farming in terms of beneficial environmental impact; encouraging fair processing and marketing development; strengthening consumer trust and understanding; removing barriers to trade; developing standards and regulation; disseminating research findings and information to farmers/producers; and developing a regional plan for central and eastern Europe. The process of Action Plan development was also outlined and the need for it to be integrated with other international policy initiatives stressed. These outcomes will form the political, economic, social and scientific justifications for the Action Plan. The Plan will be completed within 2 years, and its proposals will form the basis for CAP reforms to be negotiated from 2004. Judging from this conference, the degree of political support for the Action Plan bodes well for it to be influential.

Twelve European countries (Austria, Denmark, Estonia, Germany, Greece, Ireland, Lithuania, Norway, Switzerland, Sweden, the Netherlands, and the UK) together with the Committee of Agricultural Organizations in the EU (COPA), the European Community of Consumer Cooperatives (Euro Coop), the European Environmental Bureau (EEB) and IFOAM endorsed the conclusions of the conference, which were encapsulated in the Copenhagen Declaration. This highlights the importance of organic farming for solving many problems relating to food production, the environment, animal welfare and the rural development. It notes that organic farming provides major opportunities for farmers and producers, and calls for its further development in Europe. It lays out activities to be undertaken under the Action Plan over the next 2 years: to analyse barriers to and opportunities in the sector; to develop a consensus- and market-based strategy involving all stakeholders in Europe; to consider all aspects of organic food production; and to look at opportunities for organic development in the context of CAP and other international agreements.

More information and the conference papers are on the CABI organic-research.com website at:
http://www.organic-research.com/research/papers/offconf.htm

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