General News

Cacti, Composites and Creepers

This issue begins with weed biocontrol news, focusing on classical biocontrol initiatives against some invasive weeds in South Africa, Australia, New Zealand and Indonesia, where significant progress is being made against a number of troublesome species.

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Prickly Pair

One of classical biological control's enduring images is of stands of prickly pear cactus (*Opuntia ficus-indica*) in South Africa reduced to brown and withered stumps by cochineal insects (*Dactylopius opuntiae*). There are now signs that two more cactus species are being brought under control there by introduced insects.

The cochineal insect and the cactus moth (*Cactoblastis cactorum*) were imported from Australia, where they had been used in a successful campaign against *Opuntia stricta* (Australian pest pear or sour prickly pear), in the early twentieth century. The moth proved far less effective in South Africa, and this was attributed to predation of the early stages, mainly by ants and baboons. Cochineal insect was an outstanding success in controlling *O. ficus-indica* but, bafflingly, it barely survived on *O. stricta* in South Africa, and certainly had no impact on its control.

Opuntia stricta is native to the southeastern USA, and was probably brought into South Africa by collectors of succulents. A highly adaptable species, it has invaded thousands of hectares, and is particularly invasive in KwaZulu-Natal, the Northern and Eastern Cape and the Kruger National Park. It is a problem elsewhere in the region, including Yemen and Eritrea, and is present in Ethiopia and Somalia. However, biological control of *O. stricta* in these countries presents additional difficulties, because *O. ficus-indica* is a valued crop (albeit with unfortunate invasive tendencies) and thus *D. opuntiae* is not an appropriate candidate for introduction.

The Weeds Research Division of the Plant Protection Institute of South Africa (PPRI) looked at why an insect that could be so successful against *O. stricta* in Australia should be a total failure in South Africa. Looking back through records in the literature, they found evidence that at least 15 shipments of different strains of cochineal insect, collectively identified as *D. opuntiae*, had been introduced into Australia. These had originated from a variety of *Opuntia* species in North America, most of which were low-growing shrub pears similar to *O. stricta*. The cochineal responsible for the spectacular control seen in Australia originated from one or more of these shipments. However, the material shipped onwards to South Africa for *O. ficus-indica* control was almost certainly of central Mexican origin, and had been collected from a different and tree-like species, *Opuntia streptacantha*. That strain was selected for South Africa because of its ability to develop on *O. ficus-indica* specimens that had been sent to Australia for testing purposes. Although morphologically identical, it now appears that the two populations represent different host-adapted strains or biotypes.

A second introduction was made from Australia in 1996, but this time *D. opuntiae* was collected from *O. stricta*. This new colony (the stricta biotype) was compared to the established colony in South Africa (the ficus biotype), and survival and development of each on both *O. stricta* and *O. ficus-indica* were monitored. Results suggested that each biotype survived and developed best on its ‘own’ host, confirming the existence of distinct host races in *D. opuntiae*. Next, each of the *O. ficus-indica* cultivars grown in South Africa was exposed to the stricta biotype, and the results indicated that none of them supported its development.

In May 1997, the stricta biotype was released as infested leafpads onto *O. stricta* near Pretoria and in the Kruger National Park. The results have been spectacular: dense stands of cactus have collapsed, and surrounding plants are heavily infested. Despite their limited mobility, the insects have spread more than 100 m in the two years since release. All indications are that the newly introduced strain will control *O. stricta* as effectively in South Africa as in Australia.

Another import by admirers of succulents, harrisia cactus (*Harrisia martinii*) from South America is succumbing to an introduced mealybug. Harrisia is invasive in South African pastures, especially in the warmer parts of the country. It propagates mainly by seeds, which are dispersed by fruit-eating birds. Consequently, seedlings germinate mostly under trees and along fences where they may remain unnoticed for many years in tall grass and dense bush because of their trailing growth habit. Discarded segments root readily, so new infestations are also found on rubbish dumps.

Two insects indigenous to South America and specific to the cactus have been released in recent years. One of them, *Hypogeococcus festerianus*, has, since its first introduction in 1983, been distributed around the country by PPRI researchers as well as resource conservation inspectors from the National Department of Agriculture (NDA). The mealybugs, which were key to controlling the cactus in Australia, attack mainly the young growing tissues of the cactus, and a toxic substance they inject causes the growing tips to become contorted, fruit production to be reduced, and gradual die-back of the stems. Results suggest that all releases of the mealybug in South Africa, at some seven locations, have resulted in establishment. Adult mealybugs are sessile, and the young crawlers move only slowly and rely on the wind for dispersal. It has always been assumed that manual redistribution of infested material would be necessary. However, the dispersal rate of the mealybug during 1998-99 has called this into question. Infestations have spread between patches of cactus separated by several hundreds of metres of dense vegetation, and this cannot be ascribed to wind alone. Unwitting help from birds or rodents feeding on the cactus fruits is suspected.

In the past, the NDA have relied heavily on chemical control (MSMA) to combat the cactus. Although active in distributing the mealybug, they apparently did not have enough faith in biocontrol to discontinue spraying. Now, instead of insisting that landowners treat infestations with MSMA, they are supplying them with starter colonies of the mealybug and showing them how to disperse the insect manually. Chemical control is still used on small isolated infestations, and biocontrol on large and dense stands.

Sources: *Plant Protection News* Nos. 53 & 54 (Summer & Autumn 1999).
The newsletter of the Plant Protection Research Institute, a member body of the Agricultural Research Council, South Africa.
Further information: Hoffmann, J.H.;

Moran, V.C.; Zimmermann, H.G. (1999) Integrated management of *Opuntia stricta* (Haworth) Haworth (Cactaceae) in South Africa: an enhanced role for two, renowned, insect agents. *In*: Olckers, T.; Hill, M.P. (*eds*) Biological control of weeds in South Africa (1990-1999). *African Entomology,* Memoir No. 1, pp. 15-20.

Klein, H. (1999) Biological control of three cactaceous weeds, *Pereskia aculeata* Miller, *Harrisia martinii* (Labouret) Britton and *Cereus jamacaru* De Candolle in South Africa. *In*: Olckers, T.; Hill, M.P. (*eds*) Biological control of weeds in South Africa (1990-1999). *African Entomology,* Memoir No. 1, pp. 3-14.

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Leaner Chromolaena

Chromolaena odorata (Siam weed or triffid weed) is a perennial shrub native to South and Central America and belongs to the Asteraceae, a family famous for its attractive flowers and invasive weed species. In recent decades it has become a serious weed in the humid tropics of Southeast Asia, Africa and some Pacific islands. It spreads rapidly in forestry, pasture and plantations, reaching a height of 3 m in open situations, and up to 8 m in forests.

In Indonesia, a biological control programme has been underway since 1990, financed initially by the European Union (EU) and since 1993 by ACIAR (the Australian Centre for International Agricultural Research). Releases of the moth *Pareuchaetes pseudoinsulata* have been made since 1992 in north and central Sumatra, Java and more recently in West Timor. The gall fly *Procecidochares connexa* has been released since 1995 at several sites in Sumatra, Java, West Timor, Irian Jaya and other eastern Indonesian islands.

Surveys conducted in 1998 found that the moth was widely established over an area between Banda Aceh on the northern tip of Sumatra, through Aceh and Sumatera Utara provinces, to Riau in the centre of the island. The moth is thought to be absent only from the extreme northwest and the mountainous interior. It is found at least 500 km south of the original release sites at Pematang Siantar. The moth has caused considerable damage to *Chromolaena* stands and large areas have been left defoliated in seasonal outbreaks, whilst low level populations have been maintained on young plants and regrowth throughout the rest of the year. As a result of this, there has been a significant and noticeable reduction in the abundance of the weed in the lowland areas near P. Siantar. This remarkable achievement marks the most rapid progress against this weed anywhere in the world in terms of area controlled.

The gall fly is also established and spreading in lowland areas of Aceh, and is now present throughout an area of at least 60 km in all directions from the closely placed original release sites in this province of northern Sumatra. Around the research station at P. Siantar, the gall fly is present for at least 100 km in all directions, except at higher altitudes. Above 500 m it has spread much more slowly, and above 1000 m survives only in warm and sunny sites. Where there are large populations, severe damage is caused to the plant and at the release site at Biruen in Aceh (where the moth is still absent), the gall fly has reduced the abundance of *Chromolaena*. Nearer P. Siantar, it is difficult to separate the effects of the two agents, but the fly is more abundant than the moth on the isolated plants or bushes to which the weed infestations have now been reduced.

The moth has not established at release sites in west Java, but the gall fly is established and spreading, and is already resulting in control of the weed at several sites. The gall fly is now also established at release sites in many of the eastern Indonesian islands, including Flores, Lombok, Sumba, South Sulawesi and Irian Jaya, and is spreading well at sites in West Timor where it has been established for three years. Parasitism has remained low, and no parasites have been recorded at most sites with the exception of Java and Sumatra where an *Ormyrus* sp. occurs.

Testing of a third agent, the nymphalid *Actinote anteas*, has been completed, and first field releases have been made. It is hoped that this butterfly may enhance the current poor control in the dryer areas such as eastern Indonesia. This species also feeds on the related invasive weed species *Mikania micrantha*. The ACIAR project will continue until at least the end of 2000, during which time it is hoped that control can be extended into eastern Indonesia and Papua New Guinea.

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In southern Africa, *Chromolaena odorata* is continuing to spread and poses an increasing risk to biodiversity, agriculture and forestry. Three new candidates have been, or are being, assessed for their host-specificity. *Actinote ?thalia pyrrha* from Brazil is very damaging to *C. odorata*, but shows little preference for *C. odorata* over two indigenous *Mikania* species. It will thus not be considered for release at present, although the situation following the release of a congeneric species in Indonesia will be followed to see whether it has an impact on mikania weed there. A second Brazilian species is more promising: oviposition and larval development results for no-choice tests on the curculionid stem borer *Lixus aemulus* suggest that the host range of this species does not include indigenous or economically important species in South Africa, although adult testing is not yet complete. Finally, results of multiple choice tests for a leaf-mining agromyzid, *Calycomyza ?flavinotum,* from Jamaica suggest that this species may be completely specific to *Chromolaena odorata.*

Two more insect species have been prioritized and are currently in culture in South Africa: the stem-tip galling curculionid *Conotrachelus* sp., for which host-specificity testing will start this summer (November onwards), and the root-boring flea beetle *Longitarsus* ?*horni.* In addition, a strain of the pathogen *Mycovellosiella perfoliata*, currently in culture in South Africa, will be tested for host specificity this summer. South African research is also focusing on several other aspects. The strain of the gall fly used in Indonesia has been imported on three occasions, but does not seem to develop well on the South African *Chromolaena odorata.* Although there is continuing interest in obtaining and testing strains of the fly, efforts are underway to identify the area of origin of the South African strain of the weed. Macromorphologically, the closest match found so far is with plants collected in parts of Jamaica. Now, DNA analysis is to be undertaken to compare the South African form with plants from here and other parts of the Neotropics. *Pareuchaetes pseudoinsulata* was released in KwaZulu-Natal in 1989 but failed to establish. Following the success of the moth in Ghana (where it was re-released from 1991-93 by James Timbilla of the Crops Research Institute, and has since established, spread and reduced *C. odorata* populations), and more recently in Indonesia, releases have been made again using much larger numbers of moths. Since the beginning of the wet season in November 1998, more than 300,000 larvae and several thousand adults have been released at two sites close together in Northern Province. Initial post-release evaluation has found substantial damage to *C. odorata* and subsequent generations of larvae in the field. It remains to be seen whether this species, multivoltine in its native Trinidad, can survive the dry winter in South Africa. However, should it fail to do so, the congeneric *Pareuchaetes insulata* from Florida may be better adapted. Approval for its introduction has been given, and initial releases of this species will be made along the coast of KwaZulu-Natal.

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Source: *Chromolaena odorata Newsletter* No. 13. Sponsored by the Chromolaena Network and the Chromolaena Working Group.
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For details of the Fifth International Workshop on Biological Control of *Chromolaena odorata* to be held in South Africa in October 2000, see *BNI* **20(3)**, 82N (September 1999).

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Mist Clearing?

Mist flower (*Ageratina riparia*) is another invasive member of the Asteraceae, an aggressive fast-growing plant that produces an abundance of flowers and thence seeds, which are dispersed by wind and water. It is slightly toxic to grazing animals and is allelopathic. Native to Central America, it has become a serious weed in many countries throughout the world, and was the subject of what is considered an outstandingly successful control programme in Hawaii in the 1970s. Mist flower is now abundant in the North Island of New Zealand, and careful consideration went into planning a biological control programme, based on data from Hawaii. [see Morin *et al.*, (1997) *BNI* **18(3)**, 77N-88N.].

In 1999 the first agent, the white smut fungus *Entyloma ageratinae*, was released at nine sites in the Auckland, Northland and Waikato Regions, and a comprehensive monitoring system has been set up to track its progress. Release sites are being checked at regular intervals to determine the spread of the fungus between plants and patches of plants. After 4-6 weeks smut spores and secondary infections were found at all release sites, so establishment looks promising. After 7-10 months, seven of the release sites were re-examined and the fungus was found to have spread to plants up to 700 m from the release point. At four of these seven sites, plants within several metres of the release point were found to have suffered severe (80-100%) defoliation, and although regrowth and mist flower seedlings were developing on and between the defoliated plants respectively, both were found to be infected by the white smut.

A survey has also been conducted in the Waitakere Ranges Regional Park to estimate current percentage ground cover of mist flower there, and this procedure will be repeated annually to assess any changes in mist flower populations. In addition, a questionnaire has been devised to ask the public where they have seen mist flower infestations throughout the country, and the answers will be used to construct a distribution map that can be used to track any changes in distribution of the weed and its introduced natural enemies.

Plans are also continuing to introduce the gall fly *Procecidochares alani*, which feeds in mist flower stems and is expected to be a good back-up for the fungus, potentially being effective in drier areas where the fungus is less able to provide good control. Testing has convinced Landcare Research that the fly is highly host specific. Apart from mist flower, it laid eggs only on the closely related Mexican devil weed (*Ageratina adenophora*), but on this species the resulting larvae did not develop properly and no galls were formed. Additional testing of 25 plant species significant to New Zealand was completed this year, and the results suggest that the fly is safe to release in New Zealand. An application for permission to release the gall fly has been submitted to the Environmental Risk Management Authority (New Zealand).

Source: *Patua Te Otaota – Weed Clippings.* Biological Control of Weeds Annual Review 1998/99. Manaaki Whenua – Landcare Research, New Zealand Ltd, PO Box 69, Lincoln, New Zealand.

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Seeds of a Weed Problem?

Another member of the Asteraceae that looks set to join the ranks of other invasive species in this family is *Campuloclinium macrocephalum*. A native of Brazil, it was first recorded in South Africa in the 1970s, although the date of its arrival in the country is unclear. It was probably brought in as a garden ornamental plant, but it is now spreading throughout Pretoria and its environs. *Campuloclinium macrocephalum* is a herb with a perennial rootstock and several erect stems, up to 1.3 m high, regrowing each season from a rhizome. In summer numerous pink to light-purple flowerheads appear at the stem-tips. Each flowerhead, which is about 25 mm in diameter, consists of hundreds of florets, each of which matures to produce tiny one-seeded fruits about 5 mm long with tufts of bristles that aid dispersal by wind. Underground, the rhizome is made up of numerous nodes along its length, each of which is capable of producing a new plant. Dense leaf cover at soil level in the early growth stages shades out other species, and it may be that the roots also exude allelopathic substances. Its apparent unpalatability to livestock means that it will gradually replace more palatable species.

Campuloclinium macrocephalum does not appear on any weed list yet and very little information is available about it. But PPRI scientists say that this is a rare instance of a weed problem developing before everyone's eyes, while it is still possible to prevent it from turning into a disaster where it invades grasslands. In 1987, it took a concerted effort to find a specimen of this plant, but since then the population has increased exponentially. Amongst its more worrying attributes is its ability to invade even climax grassland and wetland habitats, whilst farmers in the Pretoria area have begun to complain about degradation of their pastures owing to this weed.

Currently, landowners are urged to control the weed by manual means throughout the growing season to limit infestation size and spread. No chemicals are yet registered for it, although informal testing has begun. However, it appears to be a promising candidate for biological control. During exploration for natural enemies of other invasive species, a PPRI scientist making a cursory examination of *C. macrocephalum* in Brazil found two moth species, a fly and a midge developing in the flower heads, while a damaging rust fungus was seen on a herbarium specimen collected in Brazil. The Weeds Research Division is ready to undertake research on biological control of this weed once funding is obtained.

Source: *Plant Protection News* No. 54 (Autumn 1999). The newsletter of the Plant Protection Research Institute, a member body of the Agricultural Research Council, South Africa.

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Speedy Seed Fly

The South African shrubs boneseed and bitou bush (*Chrysanthemoides monilifera* spp.) are serious invaders of natural ecosystems in eastern and southern Australia, and have been the subject of biological control attempts since 1987. Seven insect species have been released during this time. A moth, *Comostolopsis germana*, is widely established in the field and is causing damage, but a more recent introduction, the seed fly *Mesoclanis polana*, has had a spectacular rate of spread.

The seed fly is extremely difficult to breed in the laboratory and was released in Australia from material field collected in South Africa, after it had been subjected to screening for diseases. In August 1996, 124 adult seed flies were released in northern New South Wales (NSW). Surveys conducted two years after the release found that all bitou bush plants along 1200 km of the NSW and Queensland coast, up to 600 km from the release site, were infested with the seed fly, and seed production was dropping substantially as a result.

Other promising agents are still being assessed in South Africa. A *Tortrix* sp. is the most damaging agent discovered so far, and application for its release has been submitted. The insect has undergone extensive field testing in South Africa. This caterpillar defoliates growing tips and mature branches, and can cause premature plant death. Field studies in South Africa also indicate that a rust fungus, *Endophyllum osteospermi,* has considerable potential (particularly against boneseed). A method of inoculation has been developed and host specificity testing is almost complete.

Sources: AQIS Bulletin February 1999.
CSIRO Weed Management Program
Homepage: http://www.ento.csiro.au/research/weedmgmt/program.htm

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In New Zealand, boneseed is widely established, especially in northern and eastern areas. In recent years it has begun to spread its range from traditional urban and coastal areas to inland pasture and conservation areas, and prospects for biological control are being assessed. At least four of the agents identified in South Africa on behalf of the Australian programme may be suitable for New Zealand, including the lepidopteran species *Tortrix* sp. and *C. germana*, the fungus *E. osteospermi* and the seed-feeding fly *Mesoclanis magnipalpis*.

Source: *Patua Te Otaota – Weed Clippings.* Biological Control of Weeds Annual Review 1998/99. Manaaki Whenua – Landcare Research, New Zealand Ltd, PO Box 69, Lincoln, New Zealand.

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Mass Attack on Hawkweed

The hawkweed *Hieracium pilosella* is a perennial species native to Europe that has become a serious weed in New Zealand grassland and pasture. The threat comes not just from seeds, but from stolons, long runners that are the means of vegetative reproduction and spread through new areas.

Two agents have been released against it in 1999. The hieracium gall wasp (*Aulacidea subterminalis*) which damages the stolons was released in South Island in February, and the hieracium plume moth (*Oxyptilus pilosellae*) which damages the centre of the rosette plants was liberated in the same area in March.

The Hieracium Control Trust are planning to apply for permission to release three further agents at the same time: a gall midge which attacks the leaves (*Macrolabis pilosellae*), a root hover fly (*Cheilosia praecox*) and a crown hover fly (*Cheilosia psilophthalma*). Final testing of these species is expected by Christmas this year, but early results suggest that all three species are quite specific to hieracium and safe to introduce to New Zealand.

Source: *Patua Te Otaota – Weed Clippings.* Biological Control of Weeds Annual Review 1998/99. Manaaki Whenua – Landcare Research, New Zealand Ltd, PO Box 69, Lincoln, New Zealand.

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Bearded Wonder

Size has proved no object when it comes to taming old man's beard (*Clematis vitalba*) in New Zealand. This woody climber is also known as 'traveller's joy' in its native Europe, and agents released for its control in New Zealand certainly seem to have the wanderlust.

Unlike their hosts, biological control agents are often painfully slow at finding their way around. For this reason, scientists at Landcare Research now focus early on in biocontrol programmes on developing methods for aiding the reluctant travellers. However, expected problems with the dispersal of the tiny (1-2 mm) old man's beard leafminer (*Phytomyza vitalbae*) did not materialize. The leafminer was first released in 1996, and while Landcare Research were diligently working out harvesting methods for its redistribution, the leafminer was quietly dispersing all by itself and is now colonizing most of the old man's beard infestations in New Zealand. Old man's beard leaf fungus (*Phoma clematidina*) has also shown a surprising turn of speed, and has been recovered at sites up to 200 km from the nearest known release sites, and this during the dry season. The moisture-loving fungus may have more surprises in store when wetter weather arrives. A third agent, old man's beard sawfly (*Monophadnus spinolae)* has been released at one site, but establishment has yet to be confirmed and more releases are planned for next year.

Source: *Patua Te Otaota – Weed Clippings.* Biological Control of Weeds Annual Review 1998/99. Manaaki Whenua – Landcare Research, New Zealand Ltd, PO Box 69, Lincoln, New Zealand.

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Green Giant

Bridal creeper (*Asparagus asparagoides*) is one of seven species of *Asparagus* to have become naturalized in Australia, and it has invaded native vegetation in Victoria, South Australia, Western Australia, New South Wales, Queensland and Tasmania. It shoots after autumn rains, and rapidly scrambles over/up understorey vegetation, forming dense blankets. However, most of the plant's biomass is underground, in the form of dense tuber mats. The plant senesces with the onset of summer. The fruits are eaten by birds which then disperse the seeds. By these means the plant has the ability to invade undisturbed habitats Surveys in its native South Africa have turned up a number of promising agents, including a leafhopper (*Zygina* sp.), a leaf beetle (*Crioceris* sp.), a seed-feeding wasp (*Eurytoma* sp.) and a rust fungus (*Puccinia myrsiphylli*). The leafhopper was approved for release in May 1999 and has been released in nursery sites across southern Australia.

Host testing of the rust, which causes considerable damage to the creeper in South Africa, is complete, and application for its release is being sought from the Australian quarantine and inspection service. Host testing of *Crioceris* is well advanced, and will shortly commence for *Eurytoma*.

Source: CSIRO Weed Management Program Homepage: http://www.ento.csiro.au/research/weedmgmt/program.htm

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Also native to South Africa, climbing asparagus (*Asparagus scandens*) is a problem in bush remnants and urban areas in New Zealand, where it kills trees by ring-barking them and also prevents regeneration by forming a carpet of creeper more than 2 m thick. Birds can drop seed into dense bush giving rise to new infestations. It is already widespread in many areas of North Island. Herbicidal controls are of limited use in native forests. No biological control programme has been conducted against this weed anywhere else in the world, and no agents have yet been identified. Of agents identified in the Australian programme for bridal creeper, only the wasp is likely to attack climbing asparagus, and this species may also harm the fruit of cultivated asparagus. However, damage to climbing asparagus was noticed during the Australian exploratory work for agents for bridal creeper, and further work would be needed in South Africa to follow this up.

Source: *Patua Te Otaota – Weed Clippings*. Biological Control of Weeds Annual Review 1998/99. Manaaki Whenua – Landcare Research, New Zealand Ltd,
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Tortoise Beetle to Tame a Wildcat

The release of a tortoise beetle in March 1999 near the Grootvadersbosch, the largest remaining area of indigenous forest in northern South Africa, marked an important step in a programme to control cat's claw creeper (*Macfadyena unguis-cati*). This was the first release of an agent against cat's claw anywhere in the world.

Fast-growing, frost-hardy and drought tolerant with masses of yellow trumpet-shaped flowers in spring, cat's claw creeper seemed a useful and attractive plant to South African gardeners. But the many flowers develop into long pod-like seed capsules that produce large numbers of winged seeds in summer, and this has contributed to the plant becoming a serious invasive weed. The plant also has an extensive root system, and large tubers, formed along the lateral roots, each produce climbing runners that themselves can form tuber-like roots wherever a node touches the ground. All tubers, whether along laterals or at the nodes of runners, can produce new plants if separated from the parent plant. Mechanical control seems doomed to failure. Chemical control kills only the top-growth and is thus at best a temporary solution, and is, in any case, inappropriate in natural forests.

Cat’s claw creeper has escaped cultivation and invaded natural vegetation, particularly woodland and forest, as well as cultivated orchards, forestry plantations, roadsides and open urban spaces. The full extent of the current distribution and the threat posed by the weed are not yet fully known. It occurs in gardens in many parts of the country, yet awareness of its invasive potential has only developed in the last five years. However, it is has definitely assumed an invasive status in areas of the Northern Province, Mpumalanga and KwaZulu-Natal. In natural forests, the weed forms a thick carpet on forest floors and clambers up tree trunks (using the clawed tendrils to which it owes its common name) to drape itself over the tree canopy, where a combination of weight and shading can kill even the largest canopy trees. In addition, by excluding light from the undergrowth it outcompetes shallow-rooted understorey plants and suppresses seed germination. The largest remaining indigenous forest in South Africa, the Grootvadersbosch, is threatened by a large infestation on its eastern boundary, which has already severely degraded some of the bordering indigenous forest despite costly control attempts.

A biological control programme was initiated in 1996, when possible agents for cat's claw creeper were found during surveys of other weeds in South America. Collections since in Central and South America have yielded nine insect species, of which the leaf-feeding gold spotted tortoise beetle, *Charidotis auroguttata*, was prioritized for introduction and screening. Both larvae and adult beetles feed on the leaves of the creeper, causing them to become skeletonized. At high populations densities, this causes premature leaf abscission and dieback of shoot tips. Following host specificity tests that showed the beetle to be specific to cat's claw creeper, approval for release was given in February 1999, and the first release followed in March close to the edge of the Grootvadersbosch. A mass-rearing project is continuing at this site, although attempts to overwinter beetles hit problems. Beetle numbers have now been boosted, and it is hoped that numbers will build up sufficiently during spring and early summer of 1999/2000 to allow releases to be made into surrounding infestations. Releases are also planned for areas, especially conservation areas, in KwaZulu-Natal during this summer. It is hoped that the severe damage the beetle is expected to inflict will reduce the density of weed canopies and mats, so allowing other plants to compete better. The stress from sustained defoliation may also reduce seeding and slow the rate of further invasion.

Source: *Plant Protection News* No. 54 (Autumn 1999). The newsletter of the Plant Protection Research Institute, a member body of the Agricultural Research Council, South Africa.

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Bug for Bugweed

Another first for South Africa was the release of the lace bug *Gargaphia decoris* against bugweed, *Solanum mauritianum* in May 1999. The release near Sabie was the first release of a biocontrol agent for *S. mauritianum* anywhere in the world. This South American weed is a major environmental problem in the high rainfall regions of South Africa and has been a target for biological control since 1984. Research efforts have been intensified since 1993, and since 1996 research and importation of agents has been funded by the ‘Working for Water’ (WFW) Programme of the Department of Water Affairs and Forestry.

Most potential biocontrol agents were disqualified because of unacceptable broad host ranges, but *G. decoris* proved to be host specific. It was also believed to have considerable potential because of its rapid life cycle and rate of population increase, and the high damage levels it inflicted on *S. mauritianum*. After considerable delay, largely owing to new environmental legislation, it was cleared for release. Cultures of the lace bug are currently being propagated by the insect-rearing facility of the WFW

Programme at Tzaneen in the Northern Province and at the Cedara Weeds Laboratory of ARC-PPRI (Agricultural Research Council – Plant Protection Research Institute) in KwaZulu-Natal, so that extensive releases can be made in the spring of 1999. The goal of these releases is to distribute and establish *G. decoris* in all the major regions of South Africa where *S. mauritianum* is invasive. It is envisaged that future distribution to landowners will be undertaken by the WFW Programme in collaboration with state departments and private companies.

Exploratory releases have already been made to determine whether the insects will survive in the cold winters of high altitude areas (Guateng, KwaZulu-Natal and Mpumalanga) and in coastal areas with milder winters. If cold winters prove a killer to this bug from the subtropics of northeastern Argentina, importations of more cold-adapted 'strains' from higher altitude areas of its range in Brazil may be the solution.

Monitoring the release sites and other bugweed infestations will enable researchers to document the establishment and spread of *G. decoris.* Landowners will be helped to identify the biocontrol agent by the distribution of an illustrated information sheet on the life cycle and effects of *G. decoris*, and there will be a monitoring sheet for recording sightings of the bug and the damage inflicted on *S. mauritianum.* Post-release evaluations will be able to use this information to assess the contribution the bug is making to bugweed management. At the same time, research is continuing as it is expected that a complex of biocontrol agents will be needed to reduce both the reproductive capacity and rapid growth rate of bugweed populations in South Africa. Currently under quarantine testing in KwaZulu-Natal are two promising agents, a flowerbud-feeding weevil (*Anthonomus santacruzi*) and a leaf-mining flea beetle (*Acallepitrix* sp.).

Source: *Plant Protection News* No. 56 (Spring/Summer 1999). The newsletter of the Plant Protection Research Institute, a member body of the Agricultural Research Council, South Africa.

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Whitefly Selection

Whiteflies are a serious global pest threat, and a diversity of initiatives are underway around the world to tackle this. Most of the articles in the following compilation of whitefly news are about two species: *Aleurodicus dispersus* (spiralling whitefly) and *Bemisia tabaci*, particularly the B biotype/ *Bemisia argentifolii* (known variously as silverleaf whitefly, sweetpotato whitefly, etc.). There is a great deal of uncertainty regarding the taxonomy of *Bemisia* whiteflies and whitefly parasitoids in general, and we have not attempted to standardize authors' nomenclature here. We apologise if this is a source of confusion to some readers, and irritation to others, but Andrew Polaszek does round up this whitefly selection with some advice on unravelling the confusion.

Like most world tours, this one is selective and perhaps arbitrary in its coverage. It is merely to give a flavour of what is happening in whitefly biocontrol/IPM research and implementation rather than an overview, and for more extensive information readers are directed to the many contacts and resources given below.

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Whitefly Net

A worldwide open forum for communication among whitefly workers is the e-mail listserv 'WHITEFLY-L'. To subscribe to the list, send an e-mail message to:
listserv@listserv.tamu.edu
Leave the subject box blank, and in the body of the message type:
subscribe whitefly-l yourname
For more information see an article on the Whitefly E-mail Exchange Group in the *Bemisia* Newsletter at:
http://165.95.55.206/biru/bemisia11.htm

The *Bemisia* Newsletter is co-edited by Walker Jones and Dan Gerling. The Homepage contains an archive of past Newsletters, together with links to other whitefly resources and may be found at:
http://165.95.55.206/biru/bemisia.htm

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The 1999 edition of 'Bibliography of *Bemisia tabaci* (Gennadius) and *Bemisia argentifolii* Bellows & Perring' is available for downloading on the USDA-ARS, Western Cotton Research Lab homepage:
http://pwa.ars.usda.gov/wcrl/

The 1999 edition includes the entire database (current through the end of 1998) and the 1998 addendum which includes citations cataloged during 1998. The databases can be downloaded in ProCite (2.11 for DOS and 4.03 for Windows 95), Word 7.0, or ASCII text format. The databases are also available on diskette upon request from:

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European Whitefly Studies Network

The European Whitefly Studies Network (EWSN) had its beginnings when a group of UK and Spanish scientists (with the support of the British Council and the Royal Society) formed a whitefly studies network to collate information on the escalating whitefly problems in southern Europe, and particularly the Iberian Peninsula. As these problems spread into Portugal and to the Atlantic islands, a much larger network of European researchers and industrialists was established and EWSN was born. The Network now has over 50 members from 13 countries with expertise in virology, biological control, resistance management, epidemiology, plant health, systematics and modelling, and is currently funded by a two-year EU–FAIR grant, supplemented by funding from the agrochemical and biological control industries. It provides a forum for gathering information on whiteflies within European agriculture, through meetings, workshops, a newsletter and a website:
http://www.jic.bbsrc.ac.uk/hosting/eu/ewsn

The first workshop was held in May 1999 at Norwich, UK and provided an opportunity for participants to come together and discuss topical issues. An overview of the outcome of these discussions for each discipline area will be posted on the website. The first issue of the Newsletter was published in September 1999 and includes research notes and reports from participating countries.

Coordinated by: Ian Bedford and Michael de Courcy-Williams. For further information contact the Research Facilitator David Oliver at:

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The CGIAR Whitefly IPM Project

In recognition of the crucial importance of IPM to sustainable agricultural development, the Consultative Group on International Agriculture (CGIAR), has established the Systemwide Program for IPM (SP-IPM). One of the projects within the SP-IPM is the Project for Sustainable Integrated Management of Whiteflies as Pests and Vectors of Plant Viruses in the Tropics. The coordinating centre for this project is the International Center for Tropical Agriculture (CIAT) in Cali, Colombia.

To begin organizing the project, a task force meeting was held at CIAT in Cali on 13-15 February 1996, with representatives from CG International Agricultural Research Centres (IARCs), National Agricultural Research Systems (NARS), and Advanced Research Institutions (ARIs). The Whitefly IPM Task Force recommended that work focus on three priority problems for the tropics:

1. Whiteflies as pests in the tropical highlands;
2. *Bemisia tabaci* as a vector of viruses in mixed cropping systems of the tropical lowlands;
3. Whiteflies as vectors of viruses and pests of cassava.

The Task Force also suggested geographical areas in which to begin the work and developed a Work Plan to address these problems.

The CGIAR Whitefly IPM Project consists of a constellation of donor-funded special projects. Work began in 1997 with funding from the Danish International Development Agency (Danida) to cover (Phase 1) work on the formation of a network of professionals working on whiteflies and whitefly-transmitted viruses and in the tropics; and the establishment of a collaborative research agenda for characterization of whitefly problems in Latin America and Africa. Characterization of the whitefly problems is being conducted through extensive survey work in the participating countries. These surveys include the identification of potential biocontrol agents of whiteflies. In 1999, the Australian Centre for International Agricultural Research (ACIAR) granted funding for the characterization work in Southeast Asia.

The USAID Collaborative Research Grants Program approved funding to study the biological control of whitefly pests, by indigenous natural enemies, for major food crops in the Neotropics. The principal objective of this project is to continue exploration of indigenous parasitoids and determine the efficiency of indigenous South American parasitoids against whitefly pests on cassava.

The New Zealand Ministry of Foreign Affairs and Trade (MFAT) granted funding for Sustainable Integrated Management of Whiteflies through Host Plant Resistance. The objective of the MFAT-funded project is to study the mechanism and genetics of cassava lines with whitefly resistance, to map the genes for whitefly resistance in cassava, and to develop molecular markers for subsequent use in the improvement of African, Latin American and Asian cassava germplasm. And, the USAID Office of Foreign Disaster Assistance (OFDA) has approved the Emergency Programme to Combat the Cassava Mosaic Disease Pandemic in East Africa. The objective of this disaster assistance is to boost production of cassava in Uganda, Kenya and Tanzania and enhance both short and longer term food security, through the implementation of an emergency programme to multiply and disseminate mosaic resistant cassava.

The US Department of Agriculture's Agricultural Research Service (USDA-ARS) has recently entered the partnership to link ARS research on whiteflies to the CGIAR whitefly research, and to directly fund research on the epidemiology of whitefly-transmitted geminiviruses.

Geographically, the Whitefly IPM Project is organized into six sub-projects:

1. Whiteflies as pests in the tropical highlands of Latin America;
2. Whiteflies as vectors of viruses in mixed cropping systems in the tropical lowlands of Central America, Mexico and the Caribbean;
3. Whiteflies as vectors of viruses in mixed cropping systems in eastern and southern Africa;
4. Whiteflies as vectors of viruses in mixed cropping systems in Southeast Asia;
5. Whiteflies as vectors of viruses in cassava and sweet potato in sub-Saharan Africa;
6. Whiteflies as pests of cassava in South America.

The network of professionals collaborating on the Whitefly IPM Project include five International Agricultural Research Centres; nine Advanced Research Institutions in Australia, Denmark, Germany, New Zealand, the UK and the USA; and National Agricultural Research System institutions in 30 countries in Latin America, Africa and Asia.

The results of the Danida-funded and USAID-funded characterization projects are currently being analysed and compiled into the first major Project Report. The Report will be available, both in book form and on the World Wide Web, in early 2000.

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Texas Mobilized

The appearance of a new biotype of *Bemisia tabaci* Gennadius (now considered a new species, the silverleaf whitefly, *B. argentifolii* Perring & Bellows) in Texas has had a devastating effect on agriculture in the southern part of the state, particularly in cole crops, cucurbits and cotton. In response to the new pest outbreak, the Agricultural Research Service (ARS), US Department of Agriculture (USDA), directed scientists at the Beneficial Insects Research Unit (BIRU), Kika de la Garza, Subtropical Agricultural Research Center in Weslaco, Texas, to initiate research to determine the feasibility of applying biological control technology as an IPM management tactic. A team was formed composed of specialists in predators, parasitoids and pathogens, with vegetables as the primary target cropping system. Collaborative arrangements were initiated with other ARS facilities, Texas A & M and other universities and USDA-APHIS (Animal and Plant Health Inspection Service), as well as industry partners.

A National Research, Action, and Technology Transfer Plan was established in 1992 to bring together producers, industry, researchers and extension personnel at all levels to meet each year, share progress and prioritize and plan subsequent collaborative research. A report is published annually. The next review conference will be held in San Diego, California, USA in February, 2000. For more information please visit: http://www.slwf.ucr.edu/

In south Texas, BIRU initially began research activities by conducting surveys to determine the seasonal abundance and species composition of natural enemies, primarily parasitoids, with seven species recorded. Two aphelinids were the most important: *Eretmocerus tejanus* and *Encarsia pergandiella*. These parasitoids, as well as several imported species, were evaluated as candidates for mass production and augmentation. Studies on candidate parasitoids included measurements of biological attributes, interspecific interactions, tritrophic interactions, host species and stage preferences, foraging behavior, sampling, insecticide effects, rearing techniques, cold storage, etc. Certain *Eretmocerus* spp. imported and released by USDA-APHIS, Mission, Texas, apparently have become established in the area. Native and exotic species among the genera *Chrysoperla* (Neuroptera), *Serangium* (Coccinellidae), and *Deraeocoris* (Heteroptera) have also been evaluated as potential biological control agents to aid in managing *Bemisia*.

The most immediate success has been with microbial agents. Strains among the genera of fungal pathogens *Achersonia*, *Beauveria, Paecilomyces*, and *Verticillium* were obtained and evaluated in a series of laboratory and field tests. A strain of *Beauveria bassiana* was found to be as virulent as other pathogens and could be produced inexpensively in large quantities. In a partnership with Mycotech, Inc. (Butte, MT, USA), a product, Mycotrol©, has been registered for commercial use. Other pathogens, production systems and application technology continue to be evaluated.

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Geminivirus Group

Another group that meets annually in the USA is the Western Region Coordinating Committee 087 [WCC-087] 'Fundamental Biology and Management of the Bemisia tabaci Species Complex, and Associated Plant Geminivirus Diseases and Disorders'. Its objectives include assembling a multidisciplinary team of scientists addressing whitefly-related and geminivirus-incited disease problems to establish research priorities, promote and coordinate an exchange of ideas and information on whitefly/geminivirus-related problems, and foster cooperative, interdisciplinary research in the context of integrated pest and disease management approaches. It also aims to promote networking, communication and exchange of resources both within and outside the USA, so as to contribute to worldwide management of the problem.

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What's Killing Bemisia in the Field?

Many biotic and abiotic mortality factors impact the population dynamics of *Bemisia tabaci* (Biotype B) in agricultural ecosystems, yet we have a poor understanding of the rates of these mortality factors and how they may be involved in overall population regulation. The effects of various insecticides are generally well known, but the effects of such factors as predation and parasitism are much more difficult to assess. This task is made even harder because of overlapping generations of whiteflies in the field and because pest management activities provide further sources of mortality that may enhance or disrupt natural enemies. We have been using a direct observation technique to construct cohort-based life tables of *B. tabaci* on cotton in central Arizona over the past three years. These studies have identified, quantified, and compared *in situ* sources and rates of mortality of immature whitefly stages in untreated cotton fields and in fields under three different insecticide regimes. Here we summarize our findings from a total of ten life tables completed in untreated cotton during 1997 and 1998.

Combining all immature stages (eggs and all four nymphal instars), predation by sucking predators was a large source of mortality, especially during 1997. Observed rates of predation varied from 36% to 51% in 1997, and 7% to 42% in 1998. A consistently large fraction of immatures was also killed by being dislodged from leaves (29-51% in 1997; 23-43% in 1998). Dislodgment probably resulted from a combination of weather (wind and rain) and chewing predation. Inviability of eggs was a major source of mortality during three generations over the two years (30-68%), but was minor in all other generations examined (2-17%). Parasitism by two genera of native parasitoids (*Eretmocerus* and *Encarsia*) was a very minor source of overall immature mortality (0-4%). Survivorship from egg to adult ranged from 0.8% to 9.5 % in 1997, and 0% to 18.2% in 1998 suggesting a large impact of natural forces on whitefly mortality in the field. Partitioning mortality across the five developmental stages, we found that a large portion of immature mortality occurred in the egg stage (42-76% in 1997; 35-97% in 1998). Of the four nymphal stages the largest proportion of mortality consistently occurred during the 4th stadium (7-28% in 1997; 2-23% in 1998). Stage-specific rates of mortality were highest for eggs and 4th instar nymphs, reflecting, in part, the fact that these are the longest developmental stages in the life cycle. Stage-specific rates of mortality rarely exceeded 30% during any of the first three nymphal stadia, but frequently exceeded 50% for eggs and 60% for 4th stage nymphs. As expected from results of overall immature mortality, predation and dislodgment were consistently the two greatest sources of mortality during each individual developmental stage. The rate of parasitism in the 4th stadium approached 10% in some generations and was consistent with independent evaluations from leaf samples in the same plots. An unusual, but unknown source of mortality affected 4th instar nymphs during the 3rd generation in 1998 and contributed to 0% survivorship in that generation across all treatment plots. The posterior sections of affected nymphs were severely sunken and necrotic areas were sometimes visible at the tips of developing wingbuds. Investigations are still underway to define this mortality agent.

Preliminary estimation of irreplaceable mortality showed that, overall, relatively little mortality from any source is completely irreplaceable. This indicates that the various mortality factors interact and readily replace one another during the five immature developmental stages. Averaged over ten generations, 15.5% of mortality from predation, 10.4% of mortality from dislodgment, 2.2% of mortality from inviability, and <1% of mortality from parasitism were irreplaceable. Four additional generations were observed in 1999 and we now have a robust data set that will be subjected to detailed key-factor and density-dependent analyses.

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Native Parasitoids: Australia's Answer?

Researchers in Australia have over the past three years evaluated the performance, as measured by daily rate of parasitism and total parasitism, of five species of Aphelinidae found in Australia parasitizing *Bemisia tabaci* biotype B. Two *Eretmocerus* spp., *Eret. queenslandensis* and *Eret. mundus* (Australian parthenogenetic form; APF) were the most effective agents in terms of parasitism. Both species appear to be native to Australia, although *Eret. queenslandensis* probably has an Australia-Asian distribution, while *Eret. mundus* (APF) probably represents a distinct population of the normally biparental species which has long been geographically isolated.

In field cage trials using both species, parasitism increased with increasing whitefly density. Further, the increase in parasitism was not due to the presence of more parasitoids as neither the parasitoid-whitefly ratio nor the total number of parasitoids present had a significant effect on parasitism. In the experiment the treatment involving a combination of the two species, gave similar levels of parasitism to that achieved by *Eret. mundus* (APF) alone. Subsequent identification of the emerged parasitoid species indicated that over 50% of the parasitism was due to *Eret. mundus* (APF) suggesting that this species out-competed *Eret. queenslandensis.* Despite this competition there was no reduction in the overall numbers of whitefly killed and so no evidence for disruption to biological control.

Unlike most species of *Eretmocerus* attacking *B. tabaci*, both species are obligate uniparental species. This appears to be induced by *Wolbachia*. This is certainly the case for *Eret. mundus* (APF) where a Group B *Wolbachia* sp. has been shown to be the cause of parthenogenesis. Parthenogenesis is curable by treatment with antibiotics although the subsequent males and females are unable to produce a stable biparental line. Why the species from Australia are parthenogenetic is not clear. An explanation may lie in the low abundance and scattered distribution of the indigenous Australian biotype of *B. tabaci*. Both parasitoid species appear to be specific to *B. tabaci* and so being parthenogenetic may be advantageous when dealing with a low density host.

Interestingly, despite being parthenogenetic, both *Eretmocerus* species successfully parasitized more than ten nymphs per day. This is a higher rate of oviposition than what is normally expected for aphelinids. Being parthenogenetic may impart several benefits upon *Eret. mundus* (APF) in terms of their ability to function as effective biological control agents. It has been suggested that parthenogenetic species (a) will have higher population rates of increase and higher sting rates, (b) are likely to be better colonizers and more easily established at low population densities as there is no need to find a mate, and (c) may be more cost effective to produce in mass rearing as production is not ‘wasted’ on males. These benefits were contingent upon the species not having reduced fertility leading to a reduced number of females produced. The results from this study when compared with studies using closely related sexually reproducing species, indicate there is no evidence for reduced fertility. Further, this study suggests that in terms of oviposition, *Eret. mundus* (APF) is performing as well as several other species, *Eret. hayati* (Multan, Pakistan), *Eret. emiratus* (Arab Emirates) and *Eret. mundus* (Murcia, Spain) released in the USA, indicating that this group of *Eretmocerus* spp. may contain some of the most effective biological control agents of *B. tabaci* biotype B. Further comparisons of several regions of DNA have shown that these species are all closely related and may form a genetic group that is distinct from other species of *Eretmocerus*. Further, when the phylogeny of *B. tabaci* is matched against the origins of these species of *Eretmocerus*, it is apparent that apart from being Old World species, there is little or no association with the centre of origin of the B biotype (Middle Eastern). What appears to be more important is the climate from which both the B biotype and the parasitoids were obtained, i.e. hot dry climates.

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Refuge Crops Enhance Whitefly IPM

The silverleaf whitefly *Bemisia argentifolii* is a key factor affecting tomato production in Puerto Rico. As an important export crop, the problem is made more severe for farmers because high importation standards need to be met. However, an IPM strategy has been developed for whitefly management in tomatoes involving alternative management practices, which in an on-farm trial made an annual saving of up to US$500/acre [approx. $200/ha]. The collaborators in the project were the University of Puerto Rico and the University of Florida, together with a farmer and the US Department of Agriculture (APHIS/PPQ – Animal and Plant Health Inspection Service/Plant Protection and Quarantine).

Field trials

Field trials were established in the Fortuna Agricultural Experiment Station and at Gargiulo Puerto Rico Inc. in Santa Isabel, Puerto Rico to look at possible alternative means of whitefly control. The efficacy of several plant species (*Crotalaria juncea, Hibiscus esculenta, Phaseolus acutifolius, Desmodium ovalifolium, Mucuna deeringiana, Oreganum vulgare* (oregano), *Oscinum basilicum* (sweet basil), *Wedelia trilobata* and *Brassica oleracea* (broccoli)) as refuge crops for whitefly natural enemies or as trap crops was assessed. Whitefly populations and whitefly natural enemies were monitored in both tomato and companion crops. *Bemisia argentifolii* was the only whitefly species collected from commercial tomato areas on the south coast of Puerto Rico. The legume *Crotalaria juncea* hosted the largest whitefly parasitoid population, but only an intermediate whitefly density.

The presence of broccoli affected the incidence of whitefly on the tomato plants: whitefly populations on tomato planted next to broccoli were half of those in control plots, but double those in plots treated with imidacloprid, (the insecticide commercially used for whitefly control). However, broccoli is affected by *Plutella xylostella* (diamondback moth), requiring insecticide applications. Dealing with broccoli pests is troublesome for large, mechanized tomato farmers, but the economic incentive of producing broccoli may be attractive to small farmers, and it is an alternative for small-scale traditional farmers in the mountainous areas of Puerto Rico and possibly other Caribbean islands.

The lowest whitefly density in the three-year study was recorded for the Asteraceae species, *Wedelia trilobata*. This plant has the potential to be used as refuge crop for whitefly natural enemies and also as a repellent plant against whiteflies. The density of whiteflies in tomato associated with *W. trilobata* was similar to that in tomato treated with imidacloprid. The low whitefly population seems to be a combined effect of the high number of whitefly natural enemies on the plant and a low preference for *W. trilobata* by the whitefly or a repellent action of *W. trilobata* against the whitefly.

The presence of *Hibiscus esculenta* and *Oscinum basilicum* also attracted whiteflies natural enemies. However, their use as companion crops in tomato planting needs to be closely monitored as whiteflies migrate to tomato as the companion crops senesce. Both crops provided an economic incentive (as a cash crop) to farmers.

Growth of the cover crop *Mucuna deeringiana* was slow and did not provide appropriate soil coverage. The cover crop did not bloom until late in the season, after most of the tomato crop was harvested. Therefore, no flowers were available for natural enemies during the critical period of tomato fruit set and ripening. In a separate trial, another legume, *Phaseolus acutifolius,* was tested as a cover crop. Whitefly densities were 33% lower on tomato plots with *P. acutifolius* than on plots with no cover crop. Preliminary data suggest that the legume is preferred to tomato by whiteflies. However, the legume should be treated with insecticides to prevent whitefly movement onto tomato plots later in the season. The total number of parasitoids in plots with *P. acutifolius* cover was almost twice that in plots with bare ground. Beans, however, harbour a virus that can affect tomato.

The insecticide mix commonly used by farmers, endosulfan + lamdacyhalothrin + cypermethrin did not provide whitefly control compared with an unsprayed control. On the other hand, the use of imidacloprid provided adequate whitefly control. The combination of imidacloprid with companion or cover crops provided adequate whitefly control and preserved whitefly natural enemies.

On-Farm Trial

An IPM programme was developed and implemented in a commercial setting. An agreement with Gargiulo Puerto Rico Inc., the largest tomato producer on the island, allowed the IPM model to be validated on a 50 acre [approx. 20 ha] field on the south coast of Puerto Rico, over two consecutive seasons. A total of 21,545 linear feet [some 6.5 km] of *C. juncea* was established along the border and head roads. Whitefly natural enemies were liberated on *C. juncea*. Sugarcane was used as wind breaks and as a barrier to prevent whitefly dispersal from adjacent fields.

An economic analysis of the costs of the IPM programme indicated a reduction in production costs of $350 per acre in the first year and $500 per acre in the second year. The logistics and problems associated with the establishment of the companion crop two to three months prior to planting the tomato crop need further research and were not considered in this preliminary economic analysis. However, the economic and ecological incentives motivated this farmer to implement the programme on half of the farm (about 200 acres – 81 ha). Although the IPM programme was tailor made for a large farmer, the methodology used and the results from small plots allow for adaptation to other areas and farmers. Implementation of the IPM programme reduced production costs by reducing the number of insecticide applications, preserved whitefly natural enemies, and provided an economic incentive to farmers using broccoli, sweet basil or oregano as companion crops.

Although whitefly was controlled under the IPM model, the soybean looper caused severe damage to tomato. It is not clear why this secondary pest became a major pest in the south coast of Puerto Rico. This topic requires additional research, but was outside the scope of our research project.

Recommendations

The use is recommended of broccoli, *P. acutifolius*, *W. trilobata* and *C. juncea* as companion or cover crops in the implementation of IPM programmes for whitefly control in tomatoes in Puerto Rico. The selection of the companion crop depends on the intensity of the cropping system. Small traditional farmers will benefit from the use of broccoli, which in addition to providing a refuge for whitefly natural enemies also provides a cash crop. However, large-scale farmers probably will benefit more from using *C. juncea* or *W. trilobata*, avoiding the extra cultural practices associated with the management of broccoli. In order to be effective (to provide a refuge for whitefly natural enemies and allow for an early establishment of whitefly natural enemies), the companion crop needs to be established two to three months before the tomato. The use of companion crops can also be supplemented with the liberation of whitefly natural enemies.

Acknowledgements

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Probes Take the Strain

Silverleaf whitefly currently costs US vegetable, cotton and horticulture farmers some US$500 million annually. Many parasitoid species and strains have been collected from its area of origin in the Old World. These have been, or are in the process of being, evaluated for potential as biocontrol agents, and some have already been released in the USA. There are also a large number of native *Encarsia*. Keeping tabs on which species or strains are successful in establishing and exerting control, and which are not, is quite a problem when closely related and morphologically similar species are involved, and well-nigh impossible for physically indistinguishable strains without time-consuming and costly PCR (polymerase chain reaction) methods. [For an explanation of this technique, see *BNI* **20(2)**, 51N-54N June 1999].

Now USDA-ARS scientists at Fargo, North Dakota have developed a simpler, faster and cheaper DNA 'fingerprinting' technique for identifying the eastern Mediterranean strain of *Encarsia formosa* from Egypt. They found that there was a commonly repeated segment of DNA in this strain, 33 base pairs in length, and from this they developed a DNA probe (a genetic sequence that binds only to a specific base-pair sequence). In practice, the technique involves squashing a wasp on filter paper, immersing the paper in a radioactive DNA probe solution, rinsing the paper, then testing it for any significant residual radioactive activity, which indicates that the probe has 'found' the eastern Mediterranean *E. formosa*-specific base-pair sequence. Potentially, if radioactive probes were replaced by probes with fluorescent dyes attached, the test could be used in the field.

So far, the test is restricted to identifying one strain of *E. formosa*, but the same technique can be used to develop tests for exotic and native *Encarsia* and other parasitoids. Already, probes have been developed that can distinguish strains of *Eretmocerus* from the Old World, Pakistan and the United Arab Emirates.

Source: *Agricultural Research*, April 1999.

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Whiteflies Take Medicinals

In South Carolina, USA, whiteflies (*Bemisia argentifolii*) infested and completed development on five perennial species of medicinal herbal plants: feverfew (*Tanacetum parthenium*), St. John's wort (*Hypericum perforatum*), purple coneflower (*Echinacea pallida* and *E. purpurea*) and common valerian (*Valeriana officinalis*). This is the first report of whiteflies attacking and developing on these plant species. From late November 1998 to January 1999, density of whitefly nymphs was highest on *E. purpurea*.

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Exotic Parasitoids Are Just the Ticket

The cotton whitefly *Bemisia tabaci* is an important pest of economic crops in Egypt and infests 82 host plant species. Three species of predators and four aphelinid species have been found associated with it there, but these are apparently unable to exert effective control. In the last few years the whitefly has become a serious pest as a transmitter of viral diseases to tomato and cotton. Studies were therefore begun to assess the prospects for some exotic agents, which had already been successfully used in control programmes in the USA, Jamaica and Israel.

Three aphelinids and the coccinellid predator *Delphastus pusillus* were obtained from commercial sources in Europe and were released at six localities within 48 h of arrival, directly onto plants heavily infested with *B. tabaci* but free of native parasitoids. First releases were made at the end of March/beginning of April, and follow-up releases were made later in the season. All parasitoid species were released onto tomato, Egyptian cotton (*Gossypium barbadense*) and *Lantana camara*, and *Encarsia formosa* was also released onto aubergine; *D. pusillus* was released onto aubergine only.

Observations made following the releases indicated that parasitism by *E. formosa* increased from 0-7.3% four weeks after the first release to 11.1-29.5% some six weeks later. *Eretmocerus mundus* parasitized 14.7%-35.0% of *B. tabaci* some four weeks after release, and 24.9-68.4% a month after that. *Eretmocerus californicus* also established quickly and is concluded to be the most promising of the agents tested so far. Parasitism rates some five weeks after release were 8.1%-21.7%, and were 25.9%-62.5% after five months; the highest rate was 62.5% on *L. camara*. It was evident that all three parasitoids established easily and spread quickly through the release areas with a dramatic impact on whitefly populations. The coccinellid appeared to have more difficulty in establishing initially, and few *D. pusillus* were found four weeks after release. However, six months later the population had increased ten-fold and all life stages were present.

It is concluded that parasitoids and predators of *B. tabaci* can be successfully established in the field in Egypt by importation of commercial biocontrol agents and direct field release. It is suggested that direct importation and periodic release in the field can be considered as a viable option for the control of *B. tabaci* by exotic natural enemies in Egypt.

Source: Abd-Rabou, S. (1999) Biological control of the cotton whitefly, *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae) in Egypt. *Shashpa* **6(1)**, 53-57.

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Spiralling Whitefly Natural Enemies in India

Spiralling whitefly, *Aleurodicus dispersus*, is a relatively new arrival in India. It was first recorded in the country in Trivandrum in 1994, and was found in Bangalore for the first time in 1995. A study in Bangalore conducted over the next two years recorded it on a total of 45 plant species from 24 families, and eight of these were new host records. Particularly heavy populations were found on *Psidium guajava* (guava), *Michelia champaka*, *Poinsettia pulcherimma* and *Carica papaya* (pawpaw/papaya). Although nine local predators were found attacking the whitefly, and the coccinellid *Cryptolaemus montrouzieri* and the green lacewing *Mallada astur* were commonly associated with it, these were unable to suppress spiralling whitefly populations.

Source: Mani, M; Krishnamoorthy, A. (1999) Natural enemies and host plants of spiralling whitefly *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae) in Bangalore, Karnataka. *Entomon* **24(1)**, 75-80.

In a separate study in Kerala State, spiralling whitefly-infested leaves of brinjal (aubergine/eggplant), chillies and guava were collected from the field and the whiteflies reared through in the laboratory. Parasitized individuals were found developing on all host plants, and these appeared to be an undescribed species of *Encarsia* near *E. meritoria*. They were identified by Dr Mohammed Hayat, Aligarh Muslim University, Uttar Pradesh, who suggested that they may be the Caribbean *Encarsia* species associated elsewhere with spiralling whitefly. This is the first record of a parasitoid of *A. dispersus* from India.

Source: Pathummal Beevi, S.; Lyla, K.R; Vidya, P. (1999) Report of *Encarsia* (Hymenoptera: Aphelinidae) on spiralling whitefly *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae). *Insect Environment* **5(1)**, 44.

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Spiralling Southwards

The Queensland Department of Primary Industries is on the alert for spiralling whitefly following the discovery of an outbreak of *Aleurodicus dispersus* in Townsville. Native to the Caribbean, spiralling whitefly was detected in Papua New Guinea in 1987, and by 1991 had spread to the northern side of the Torres Strait. By 1995 it had crossed the Strait and was found at Bamaga on the northern tip of Cape York. Since then it has moved south, with outbreaks reported on the western side of the Cape near Weipa in 1997 and on the east Coast, and some 600 km further south, at Cairns in 1998. It has not yet been found in commercial horticultural production areas. Surveys in the Townsville area are under way and action taken will depend on how extensive the new infestation is found to be. For the moment, measures aimed at voluntary restriction of plant movement have been publicized. Survey teams are also looking for evidence of *Encarsia* parasitoids, and releases of the whitefly parasitoid in the Townsville area are being planned. So far the only *Encarsia* found parasitizing spiralling whitefly has been *E.* nr. *haitiensis*. This is the same agent that has been very effective on many of the Pacific Island countries. It was released into Torres Strait and has since been redistributed to all known areas of infestation where it has established and begun to spread.

Source: AQIS Bulletin August 1999, p. 7.

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Marshalling Natural Enemies in the Pacific

Aleurodicus dispersus is known to thrive in prolonged dry weather conditions in the absence of natural enemies, and this has contributed to its increase in the countries of the northern Pacific. In April 1998, an outbreak of spiralling whitefly was reported from the island of Kosrae in the Federated States of Micronesia (FSM). A number of releases of *Encarsia* spp. have been made since then using material field collected in Pohnpei, FSM by the SPC (Secretariat of the Pacific Community) Plant Protection Project, Micronesia. The damage during 1999 has been significantly reduced by the parasitoids.

There have also been serious outbreaks in Kiribati and the island of Nauru, where favourable weather conditions and the absence of natural enemies have meant that spiralling whitefly has become a major problem. SPC scientists found that although *Encarsia* works well in controlling small infestations, *Nephaspis* spp. predators were more efficient at reducing large populations and complement the effects of the parasitoids. The SPC Plant Protection Service Biocontrol Laboratory in Suva (Fiji) screened and reared

Nephaspis dispar, and have released it in both Kiribati and Nauru. They are now rearing *N. dispar* and *Encarsia*, and more releases of these agents are expected soon.

Source: *SPC Agricultural News* (newsletter from the Agricultural Programme of the Secretariat of the Pacific Community) **8(1)**, 10 (June/July 1999).

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Whitefly IPM in South Africa

A preliminary survey of whiteflies revealed that the South African fauna comprises about 20 species. This figure is rather small compared with other African countries, such as Congo and Chad, whose whitefly fauna has been more extensively studied, and more species are expected to occur in South Africa.

The major whitefly pests in South Africa on vegetables and other crops include *Bemisia tabaci* (B-biotype) and *Trialeurodes vaporariorum*. Apart from having caused sporadic problems under greenhouse conditions, these two species have not previously been considered pests in this country. Indeed, collecting records, especially of *Bemisia*, are very scanty. As happened in other countries, it appears that whiteflies have built up resistance towards many insecticides and are becoming an increasing problem. In addition, a tomato yellow leaf curl-like disease that is transmitted by whiteflies has been discovered in South Africa in 1997/1998. The disease is caused by a so far undescribed begomogeminivirus. It is confined to the Onderberg area of Mpumalanga and is considered to be a serious threat to the South African tomato industry.

A project has been initiated to develop control strategies based on IPM with emphasis on biological control, using indigenous natural enemies (parasitoids/predators) as biological control agents for whiteflies. The search for such agents entails: (i) the collection, identification and monitoring of whiteflies and their natural enemies on various agricultural crops and weeds, (ii) the evaluation of natural enemies as potential biological control agents for improvement of natural control and (iii) the development and implementation of integrated pest management strategies. The control of the new virus disease on tomatoes is addressed by the development of an integrated approach, using a combination of different control measures.

The whitefly project is still at an early stage. So far, eight parasitoids of *Bemisia tabaci* and *Trialeurodes vaporariorum*, from the provinces of Gauteng and Mpumalanga, have been identified by A. Polaszek (CABI) and G. Prinsloo (ARC-Plant Protection Research Institute). These include *Encarsia davidi, E. formosa, E. hispida, E. transvena, Encarsia* sp. *lutea*-group, two hitherto undescribed *Encarsia* spp. and *Eretmocerus* spp.

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Encarsia guadeloupae Hits New Whitefly

A first record of *Encarsia guadeloupae* parasitizing *Lecanoideus floccissimus* is reported from the Canary Islands. Since the early 1990s, there has been a sharp increase in numbers of whiteflies on ornamentals and food crops in Tenerife (Canary Islands). These were first thought to be the spiralling whitefly, *Aleurodicus dispersus*. This species was first detected on Tenerife in 1965 (identified by Dr L. M. Russell of the US Department of Agriculture), and it has been a minor problem on six of the seven Canary Islands since then. But more recently, in the rapidly growing tourist developments in the south of Tenerife, infestations on a diversity of ornamental species, such as *Washingtonia* palms, *Ficus* trees and *Strelitzia* spp., have become very serious. In addition, in the north of the island around Puerta de la Cruz, and the capital Santa Cruz, whitefly populations have increased rapidly. Banana, a main crop on the island and important for the export industry, was also heavily infested. The cause of this increase was not clear, but was thought to be due in part to several abnormal dry and warm winters and in part to the exponentially growing areas planted with exotic ornamentals in the tourist resorts.

In 1997 Cabildo of Tenerife, the national agricultural service, agreed to start a mass-culture of the parasitoid *Encarsia* nr. *haitiensis* in cooperation with the Dutch biological control company Nijhof BGB. *Encarsia* nr. *haitiensis* has been successfully introduced many times in biological control programmes for *A. dispersus* in other parts of the world. The *E.* nr. *haitiensis* stock used to start the culture was obtained from cultures in Fiji and Taiwan.

However, during 1997, E. Hernandez-Suarez and A. Carnero of ICIA (Instituto Canario de Investigaciones Agrarias), Tenerife, detected that an undescribed whitefly species (later described as *Lecanoideus floccissimus* by J. H. Martin of the Natural History Museum, UK) was in reality the main cause of the increasing whitefly infestations. *Lecanoideus floccissimus* was subsequently shown to be highly polyphagous. It lives on many plant species together with *A. dispersus*, with pupae and adults of both species side by side on the same leaf. However, no parasitized *L. floccisimus* were found on Tenerife, which explained the fast-growing populations of this whitefly. In comparison, at some times of the year, *A. dispersus* was relatively well-parasitized by the already present parasitoid *Encarsia hispida*.

During the project for mass-rearing *E.* nr. *haitienis* it became evident that, probably due to the rearing environment, no progeny of the parasitoid were produced on either *L. floccissimus* or *A. dispersus*. However, another known parasitoid of *A. dispersus*, *Encarsia guadeloupae*, had been unintentionally co-introduced into the culture, the identification being made by E. Hernandez-Suarez and by A. Polaszek of CABI Bioscience. In contrast to *E.* nr. *haitiensis, E. guadeloupae* flourished and proved to be a very good parasite of *L. floccissimus* in culture, so the goal of the project was changed. The new aims became to set up a mass-culture of *E. guadeloupae*, and to release this parasitoid in the field. The first *E. guadeloupae* release was made in December 1998, and the first *E. guadeloupae*-parasitized pupae of *L. floccissimus* were detected in the field in June 1999. This year culturing and release of *E. guadeloupae* will be continued and its effectiveness for controlling *L. floccissimus* in the field examined.

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Citrus Woolly Whitefly: Acid Test for Biocontrol

The citrus woolly whitefly (*Aleurothrixus floccosus*) which is endemic to Florida (USA) and Central and South America was first accidentally introduced to North Africa in the 1970s. Since then the pest has continued to spread to other citrus growing countries in West, East and southern Africa. In West Africa, *A. floccosus was* reported in São Tomé and Principé in 1984, while on the other side of the continent it was first recorded in the island of La Réunion in 1985. The exact date of its introduction to the East African mainland is debatable but there is evidence to show that it has been in Kenya since 1990. It was reported in northern Tanzania in 1993.

Between April and June 1995, the GTZ (Gesellschaft für Technische Zusammenarbeit, Germany) IPM Horticulture Project in collaboration with the national research programmes of Kenya, Malawi, Tanzania, Uganda and Zambia conducted a survey to determine the spread and incidence of the pest in the region. The survey indicated that *A. floccosus* is widespread in the mainland of East and southern Africa and that it is an economic pest of citrus in the region. It is likely that the pest has spread to far more countries in the region than currently known.

Chemical control of *A. floccosus* has not proved successful in any country where the pest has invaded citrus plantations. Wherever *A. floccosus* has occurred, effective control has mostly been achieved by the use of its natural enemies, the most promising parasitoid being *Cales noacki*. This parasitoid is known to be effective and also capable of spreading quickly in the field. In Sicily, the parasitoid was able to reduce the pest population by 91.2% in the first year of its release, and by the second year a reduction in the pest population of 98.4% resulted in significant savings to the citrus industry. However, although *C. noacki* is known to be effective, and therefore the most favoured parasitoid for the control of the pest, efforts to introduce it into West Africa were fruitless. The parasitoid was therefore considered to be unsuitable for introduction in sub-Saharan Africa, although the failure in West Africa is thought to be partly due to misidentification of the whitefly species involved.

However, the disappointing results obtained in West Africa meant that a pilot project was considered a prerequisite before embarking on a full scale release programme of *C. noacki* in East and southern Africa in an effort to control the spread of *A. floccosus,* and thus save the citrus industry in the region. After the whitefly species occurring in East Africa had been properly identified, an attempt to control the pest using *C. noacki* was made by Uganda in collaboration with the GTZ IPM Horticulture Project. The pilot project was initiated in 1996 by the GTZ IPM Horticulture Project and the Biological Control Unit at Namulonge, Uganda. Between October 1996 and August 1998, *C. noacki* was released in farmers' fields in six districts. Post-release field monitoring done in 1997 and 1998 indicated that the parasitoid was established at all sites and that it was giving effective control of the pest. The parasitoid was also recorded 15 km away from the release foci within the first year, thus confirming its ability to spread freely to new areas.

In Kenya, the parasitoid was released at four sites in April 1998. Post-release surveys have revealed its establishment in all release areas. Preliminary results of its impact on whitefly populations are very promising. In July 1999, *C. noacki* was recorded in two citrus growing districts bordering Uganda, this providing further evidence of the ability of *C. noacki* to spread freely and colonize new areas. Further releases are planned in Malawi and Tanzania in August 1999.

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Identification of Whitefly Parasitoids: Some Advice

The development of control methods for whiteflies, whether classical biological control or components of IPM, is often hampered by the difficulty of identifying their parasitoids. The following is a brief résumé of what information is currently available, what is currently being developed, and some consistent problems in taxonomy of whitefly parasitoids and approaches to their solution.

Family- and Genus-level Identification

It may surprise some people to learn that a total of 30 genera, belonging to five families of Hymenoptera have been recorded (not all published) either as primary or secondary (hyper) parasitoids of Aleyrodidae. Of course, many of the genera represent rare, sporadic or unusual records, but are still noteworthy if one is to develop a perspective of aleyrodid/parasitoid population dynamics. Gerling (1990) keyed out the six most common genera, and Polaszek (1997) covered 23 genera in an unpublished training manual. It is planned to issue a comprehensive and well-illustrated key in 2000 to all 30 currently known genera. This will be available on CD as well as hard copy, and is the result of current collaboration between CABI Bioscience (A. Polaszek) The Natural History Museum, London (J. H. Martin) and the International Institute of Tropical Agriculture (G. Goergen). It will also include illustrated keys to all species of economically important whiteflies.

At the moment, all known whitefly parasitoids belong to just two major groups. The first are the platygastroids (the well-known *Amitus*, the little-known *Aleyroctonus*, and several undescribed, uncommon genera), the remainder are all chalcidoids. A very basic knowledge of Hymenoptera morphology serves to separate these groups or superfamilies, after which any of the regional keys to chalcidoid families and genera will facilitate further identification (e.g. Subba Rao & Hayat, 1985; Gibson *et al*., 1997).

Species-level Identification

Species-level identification is currently a problem in most groups of whitefly parasitoids.

Platygastridae: For *Amitus* there are no keys available, and a global species revision is planned (A. Polaszek, in prep.). *Aleyroctonus* is also somewhat problematic, with one described species, several undescribed, and a number of related, but apparently distinct, genera also undescribed.

Chalcidoidea: Pteromalidae, Encyrtidae, Signiphoridae: There are very few published records from these families, so in some ways species-level identification will always be problematic. LaSalle *et al.* (1997) described *Idioporus affinis*, an eunotine pteromalid parasitoid of *Aleurodicus dugesii* in Central America and the southern USA. *Signiphora* species are commonly reared from whiteflies in the Americas, mostly as hypers. There are a few unpublished records of *Chartocerus* (Signiphoridae), also as hypers, from the Old World. Several *Metaphycus* species (Encyrtidae) appear to be specialized whitefly primary parasitoids in Central and South America, but none of these is yet described (J. S. Noyes & A. Polaszek, in prep.).

Chalcidoidea: Eulophidae: Euderomphalini: The euderomphalines constitute a very interesting group of specialist whitefly parasitoids which are particularly abundant and diverse in Central and South America, but also occur elsewhere. The most widespread genus *Euderomphale* is in need of revision. LaSalle & Schauff (1994) treated Euderomphalini at generic level but many species known to these authors are still undescribed.

Chalcidoidea: Aphelinidae: This is the most problematic group taxonomically, with a few exceptions. The well-known *Cales noacki* (placed in Aphelinidae only for convenience) is generally not a problem to identify. Apart from a few isolated records of *Myiocnema* and *Ablerus* (probably both as hypers), the remaining problems are in *Dirphys*, *Encarsiella*, *Encarsia* and *Eretmocerus*. The former two genera were treated together by Polaszek & Hayat (1992), but since then many new species have been recognised, and a new revision is in preparation by this author. *Encarsia* and *Eretmocerus* are bigger problems!

***Encarsia*: Geographical:** The Oriental region is well served at species level with illustrated keys to Indian species by Hayat (1989, 1998) and to Chinese species by Huang & Polaszek (1998). Europe is served by Viggiani's (1987) key to Italian species, which works well for most European species, apart from a few recent introductions. North American species were treated by Schauff *et al*. (1996). Africa and South America are the main remaining problem areas.

Systematic: Revisions have either been undertaken, or are in preparation, for the following species-groups within *Encarsia*: *strenua*-group: Heraty & Polaszek (submitted: *strenua*, *protransvena* and related species) and Heraty & Polaszek (in prep.: *strenua*-group, world revision); *cubensis*-group: Evans & Polaszek (1998); *luteola*-group: Evans & Polaszek (in prep.); *lutea*-group: Pedata & Polaszek (in prep.); and *citrella*-group: Evans & Polaszek (1997).

Economic: Polaszek *et al*. (1992) treated the species known at that time to attack *B. tabaci*/*argentifolii*, and this was updated by Evans & Polaszek (1997). Consistent problems in *Encarsia* include the identity of the widespread species used for biological control of spiralling whitefly, *Aleurodicus dispersus*. This species has been variously referred to as "*Encarsia* sp. near *haitiensis*" or just "*E. haitiensis*" or, more correctly, "*Encarsia* sp. near *meritoria*" (see other contributions in this issue). Evans & Polaszek (in prep.) are attempting to solve the taxonomic problems in the *meritoria*-subgroup of the *luteola*-group using morphological methods, supported by DNA sequence data obtained by Paul DeBarro's and John Heraty's labs in Canberra and Riverside, respectively.

***Eretmocerus*:** It would be true to say that almost nothing useful is currently available for identification of *Eretmocerus* species, except for Hayat's (1998) treatment of the Indian species. Two recent publications by Rose & Zolnerowich (1997, 1998), although rather difficult to use, have alleviated the situation slightly, but there are still a great many obstacles to the successful identification of *Eretmocerus* species. In short, a usable world revision is called for, although it is difficult to say when such a project will be completed.

Training in Identification of Whitefly Parasitoids

CABI Bioscience, in association with the Natural History Museum, London, runs a four-day training course on whiteflies of economic importance and their natural enemies. This course, which is largely taxonomic but includes rearing and mounting methods, as well as economic aspects, has been held on several occasions at their former London base, and also in the Philippines (University of Los Baños) and Australia (CSIRO). The next course is provisionally scheduled for Autumn 2000. For further details please contact Stephanie Groundwater at:
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Further individual or group training can be tailored according to user needs for variable periods. Please contact Andrew Polaszek at the address below.

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Indian Hive of Biocontrol Activity

In the last issue, it was announced that the Project Directorate of Biological Control in Bangalore had been given the 'Best Institution Award' for 1998 by the Indian Council of Agricultural Research (ICAR), New Delhi for furthering the cause of ecologically sound pest management. Here we give a short history of the Directorate and an outline of its many and varied activities.

The Directorate was established by ICAR during 1993 by upgrading the existing All-India Coordinated Research Project on Biological Control of Crop Pests and Weeds. Since then it has scaled new heights by virtue of concerted and systematic research efforts, effective team work, a liberal work culture and disciplined financial and administrative support. The Directorate has a network of 16 crop-orientated field centres in different state agricultural universities and ICAR institutes. The Directorate has made rapid strides in basic research on different aspects of biological control, and this has formed the basis for technologies in Biointensive Integrated Pest Management. Within this field, achievements have been realized in: mapping the biodiversity of natural enemies; the introduction of potential natural enemies for managing exotic pests; standardization and development of improved breeding and mass production technologies for natural enemies, and developing low temperature storage technologies for them; understanding the tritrophic relationship between host plants, pest insects and natural enemies; the development of superior strains of natural enemies for different crop ecosystems and tolerance to pesticides; and the development of biocontrol based technologies for pest management in crops including sugarcane, cotton, maize, tobacco, vegetables and fruit crops. A number of these technologies have been transferred to private enterprise for commercial exploitation, including the recently developed endosulfan-tolerant strain of the egg parasitoid *Trichogramma chilonis* [see *BNI* **19(3)**, 74N-75N]

The Directorate is organized into laboratories in Biosystematics, Introduction and Quarantine, Mass Production, Pathology, Entomophagous Insect Behaviour, and Biotechnology, in addition to a Co-ordination, Documentation and Training Cell. The Directorate is well equipped and has excellent facilities for research, training, education and consultancy on all aspects of biological control. Mysore University, Bangalore University and the University of Agricultural Sciences, Dharwad, Karnataka have recognized the Directorate as a centre for post-graduate studies. The Directorate is also recognized as a nodal agency for the import/export of biocontrol agents into/from the country. The Agricultural Research Information Service network and an excellently stocked library, which contains CD databases, a reprint collection, books and bibiliographies on different aspects of biological control, have enabled the Directorate to remain at the forefront of information technology in biological control.

Under a 'National Repository of Natural Enemies' project, the Directorate is maintaining live cultures of beneficial insects, viruses, bacteria, fungi and nematodes. Nucleus cultures of superior strains are supplied to centres/agencies for trials. The Directorate conducts large-scale demonstrations in a number of crop ecosystems.

Collaboration with different organizations including CABI Bioscience, UK are in operation at the Directorate, and the Directorate has been recognized as a Team of Excellence for Training in biological control in the country under a World Bank-funded NATP (National Agricultural Technology Project). The Documentation Unit produces a newsletter for biocontrol workers, and *Journal of Biological Control* is published by the Society for Biocontrol Advancement.

Current research priorities include the development of biocontrol for export-oriented crops, crops under protected cultivation, organic farming, and standardization of techniques for natural enemy conservation. Technologies under development include effective strains of entomophilic nematodes for management of soil pests, fungal agents for nematode pests and weeds, fungal antagonists for managing root rot and wilt diseases, and effective baculoviruses for pest management. The Directorate is striving to develop a 'green alternative to chemical pest control' so that dependence on chemical pesticides can be reduced.

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Training News

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

Vegetable IPM Gains Ground in Ghana

Good planning and prior validation of methods are key elements in the success of a Farmer Field School (FFS) training scheme for vegetable IPM in Ghana. The Ghanaian Government's enthusiasm for FFSs has its origins in a successful pilot project on FFSs in rice IPM in 1996, which became the starting point for an expansion of FFS/IPM training into other crops within the framework of the National IPM Programme. A consultative workshop in May 1997 made recommendations and an action plan for this expansion, which included a national programme and a sub-programme tailor-made for five districts selected for UNDP assistance. One of these sub-programmes was for vegetable IPM/FFS training.

The sub-programme began with a national survey of crop practices in vegetables, followed in January 1998 by a workshop to design a workplan for a six-month vegetable IPM trial validation period. At the workshop, vegetable farmers' problems were prioritized, and these were linked with field trials and exercises to be validated by the future vegetable IPM master trainers. Validation of the trials and exercises was conducted during a 'pre-TOT' (Training of

Trainers) period at Ashiaman in February-August 1998. Participants were local scientists and IPM trainers who had undergone the previous IPM TOT in 1995-96, and had conducted subsequent rice IPM FFSs. The output of the workshop was a detailed work plan for the pre-TOT period, including six field trials each for tomato and cabbage, dealing with the effects on crop health and production of variety and nursery practices, land preparation, transplanting method, fertilizer, intercropping, weed management, pest and disease management, water management and harvesting procedures. Potential IPM exercises to be validated throughout this period were also designed, together with methods for agro-ecosystem analysis (AESA). A study tour by three of the future vegetable IPM master trainers to the Cambodia IPM programme was made in February 1998.

The results of the validation trials were used as the basis for a workshop held in August 1998 to develop a curriculum for a season-long vegetable IPM TOT. The workshop was in two parts: during the first week, participants included a mixture of university and research institution scientists, representatives from the Ministry of Food and Agriculture (MOFA), the Vegetable Producers and Exporters Association of Ghana, Ghana Irrigation Development Authority, FAO (the Food and Agricultural Organization of the UN), GTZ (Gesellschaft für Technische Zusammenarbeit, Germany) and the Post-Harvest Division of MOFA, together with coordinators of vegetable projects, IPM/FFS master trainers, vegetable farmers and an IPM/FFS consultant from CABI Bioscience. The second week was more informal, with master trainers and the CABI Bioscience consultant discussing and preparing a detailed curriculum for the vegetable TOT in Weija.

The season-long IPM TOT began at the Weija Irrigation Project on 24 August 1998, and ran until 18 December of the same year, following the curriculum devised at the workshop, and incorporating trials on cabbage and tomato. Five FFSs with 25-30 farmers took place simultaneously for the TOT trainees to learn and practise FFS skills. There were some 30 TOT trainees, who came from Ghana and Malawi, and from both government ministries and institutions and NGOs. After the TOT, graduate trainers returned to their various bases in Ghana and Malawi and initiated vegetable FFSs in their respective areas.

By the end of 1999, 240 farmers at Weija had been trained through the TOT in 1998 and follow-up FFFs in 1999. Many farmers at Weija had abandoned cabbage growing over recent years because pest damage was so high and they were ill-equipped, in terms of both knowledge and resources, to manage it. However, the results from the cabbage trials conducted during the season-long IPM TOT, which compared farmers' traditional practices with IPM practices, suggest that FFSs can lead to radical improvements for cabbage growers. The IPM practices included improved nursery and planting practices, the use of manure and mulches, and weekly AESA to decide whether crop protection measures (biopesticides – *Bacillus thuringiensis*, and botanicals – neem and garlic) were needed. Cabbage yields and net returns recorded in three farmers fields indicated that where farmers used their conventional practices, they achieved yields of 1.8-14.4 t/ha and consistently made losses (of Cedi 0.67-1.6 million), but where they adopted IPM practices, they achieved yields of 18.3-27.5 t/ha, and consistently showed profits (of Cedi 1.7-3.9 million). [US$1 ≈ Cedi 2500]

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Tomato Training at the Fayoum Oasis

The Fayoum Oasis is a natural depression 80 km west of Cairo in Egypt, of which the deepest part (Lake Qarun) is some 40 m below sea level. The climate is dry (10 mm annual rainfall) with hot summers and mild winters, and the entire area is dependent on irrigation water from the River Nile, which enters via a single conduit from the south-east, the Bahr Yousof Canal. Yet the Fayoum has always been one of Egypt's major crop-producing areas. Irrigation water is available year-round, but the supply is limited in the hottest months. About 87% of the area is cultivated with field crops (wheat, berseem, sorghum, maize, cotton) and 9% with vegetables (notably tomato and cucurbits). The cropping pattern is based on three seasons: winter, summer and *nili.* Although some 20% of Egypt's total tomato production is still located in the Fayoum, it has declined to its present level of some 13,500 feddan from some 70,000 feddan in 1989 [1 feddan = 0.42 ha]. In recent years a geminivirus, tomato yellow leaf curl virus (TYLCV) transmitted by whiteflies (*Bemisia tabaci*), has been a serious constraint to tomato cultivation, and this has been related to the development of insecticide resistance in the vector. TYLCV is a widespread and devastating disease of tomato in the eastern Mediterranean. It was first described in Israel in 1966, and from Egypt in 1969. A severe outbreak in Fayoum in 1988-89 resulted in the failure of the major tomato crop.

For the last 15 years, farmers in the Fayoum have benefitted from support by the Dutch-funded Horticultural Development Project (HDP) The project has investigated and developed measures to alleviate TYLCV, including land preparation, reduction of insecticide use, post-harvest sanitation, introduction of virus-resistant/tolerant hybrids, elimination of a known alternative host (*Datura stramonium*) in the vicinity and identification of other over-summering hosts, interrupting continuous tomato cropping, intercropping with aubergine, and trapping whiteflies in open nurseries. According to a survey on current practices conducted in 1996, farmers intercrop tomatoes with cucurbits so the latter can act as a trap crop for the whiteflies and reduce TYLCV incidence in the tomatoes. (The Fayoum produces some 21% of Egypt's cucurbits.) The most common tomato variety in the Fayoum, Castle Rock, is very susceptible to TYLCV and has no heat tolerance. Hybrid varieties have been introduced by the HDP, notably Jackal which is TYLCV-tolerant. Raising hybrid seedlings in unprotected seedbeds is profitable but also very risky with a high chance of failure, so most hybrid seedlings are raised in protected shade houses and sold on. However, only 5-10% of farmers grow hybrid tomatoes because they view the cost of investment in expensive hybrid plants as still too high while the shortage of irrigation water continues. Seeds, fertilizers and pesticides have been identified as the major cost items in tomato cultivation in the Fayoum. Results of surveys found that most farmers interviewed applied fertilizers at least once a season. They also indicated that 45% of farmers used six or more fertilizer applications a season and, in addition, some 80% used insecticides, 30% acaricides and 40% fungicides; most farmers spray insecticides less than four times and fungicides once each season, but some spray five or six times. A host of minor pests have been recorded on tomatoes in the Fayoum but two other major problems are blossom rot and root-knot nematodes (nematodes are found in about 50% of fields).

The HDP ended in August 1999 but it has been succeeded by another Dutch-funded project, the Fayoum Integrated Pest Management Project, which has been conceived as a follow up to increase adoption of the HDP results by farmers. The first 15-month planning phase is to prepare for an implementation programme that will have a Farmer Field School (FFS) focus on IPM in tomato and also cotton and possibly other crops. An important goal is to convince stakeholders of the effectiveness and feasibility of an IPM approach through FFS in the Fayoum. A pilot study is being conducted to demonstrate this and to identify, develop and/or adapt suitable technology for local conditions. Pilot learning activities for tomato are expected to include investigations into the effects on TYLCV of protected *vs* open nurseries, hybrid *vs* common varieties, mixed cropping with coriander *vs* monocropping, and the use of botanicals/biopesticides. A training programme is being developed to train trainers in the FFS style and to familiarize extension staff and farmers with the 'learning-by-doing' principles. The project will develop a process to train extension staff as FFS Facilitators initially, and later on as Trainers of Facilitators who will be able to help introduce and implement IPM on a larger scale elsewhere in the Fayoum. Participants are proving very enthusiastic about the new participatory approach to training and there is very good support on the ground.

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Training with an Holistic Module Approach in East Africa

The GTZ (Gesellschaft für Technische Zusammenarbeit, Germany) IPM Horticulture Project for Eastern and Southern Africa, in collaboration with ICIPE, organized a four-week hands-on IPM training course from 31 May to 25 June 1999. The participants, with BSc or MSc degree or equivalent qualifications, included entomologists, plant pathologists, agricultural extension managers and agronomists from national agricultural research and extension systems in Kenya, Tanzania, Zanzibar, Uganda, Malawi, Mozambique, Zambia, Zimbabwe, Namibia, Ethiopia, Ghana and Sudan.

The course integrated field and laboratory sessions with group assignments on individual crops, plenary sessions and informal lectures to cover complete crop cycles of selected vegetable crops. Emphasis was on integrated pest (insect pests, diseases, weeds, nematodes etc.) and crop management, development of appropriate farmer participatory vegetable IPM research programmes, participatory extension methods and suitable field and laboratory diagnosis methods of insect pests and diseases of selected vegetable crops.

Although offered and co-ordinated by ICIPE scientists, the course benefitted greatly from input by invited specialists within eastern Africa. This was indeed the first course of its kind in the region as it involved a multi-disciplinary and inter-disciplinary training approach which was received with a lot of enthusiasm by the participants as well as resource personnel. Owing to the success of this first course, ICIPE is planning to organize similar courses in the near future.

The course was organized with grant support from the Netherlands through the DSO project 'Human Resource Development for Science & Technological Capacity in Arthropod Science in Africa' No.KE/91/955.

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A Parable from Nepal

Just how well communities worked together proved to be the crucial variable in the success or failure of a project for potato wilt (*Ralstonia solanacearum*) integrated management in the high hill country of Nepal.

Potato is the most important vegetable crop in Nepal, and ranks fourth as a food crop after rice, maize and wheat. It is grown throughout the country, but it is of particular significance in the higher regions, and it is the staple crop above 2000 m. The high hill pockets are also traditional areas of high-quality seed potato production for the rest of the country (supplying some 80% of its total needs), and this represents an important income source for farmers. However, with an average yield of only 13.54 t/ha, Nepal has a far lower productivity for this crop than many of its South Asian neighbours. Losses owing to pests and diseases are a major cause of low yields, with late blight (*Phytophthora infestans*), bacterial wilt and red ants (*Dorylus orientalis*) the three most important pests. Bacterial wilt was first identified in Nepal in the Kathmandu valley in 1966 from where it spread, at least partly through distribution of diseased planting material, until it now occurs over a large part of the eastern, central and western hills.

The Lumle Agricultural Research Centre (LARC) at Pokhara in Kaski has been studying the disease since 1987, and since 1990 has been developing IPM methods for its management. The prevalent race of bacterial blight in this area has been identified as bio-var II or race 3, a variant identified as particularly virulent by the International Potato Centre (CIP). A one-year village-based project for its management was implemented in two villages in Kaski in 1990, with striking success in one that followed the project through to the end. This led to a five-year collaborative project, which began in 1993, between LARC and Landusers' Perspective With Agricultural Research and Development (UPWARD) in the Philippines to try similar methods in two further villages.

Disease management tours that had been conducted since 1987 meant that farmers were educated to some degree in understanding bacterial wilt. In the new project, researchers now tried to mobilize farming communities. In visits to villages, they held discussions with farmers and village leaders, provided guidance for a village-based technician in bacterial wilt, and other activities were designed to help farmers diagnose bacterial wilt and to understand its economic importance and how it might be controlled.

The essential components of the control strategy were:

- Elimination of infected planting material. The use of farmers' own seed potatoes was prohibited. All stored [ware] potatoes were removed from the village and stores/storage materials disinfected.
- A three-year moratorium period with cereal crops grown in infected traditional growing areas. No other solanaceous crop was permitted during this period, but many new crops were explored.
- A clean-seed potato multiplication programme.
- Roguing plants from self-sown potatoes.
- Farmer education in causes, symptoms, disease cycle, and management methods of bacterial wilt.

The restriction on growing potatoes for three years was undoubtedly a real challenge to these high hill farmers, for whom potatoes are not only their staple but also a major source of income. Yet the nature of the disease and the objectives set out for the project were such that 100% participation was judged to be necessary for it to succeed. The project addressed the difficulty of imposing the draconian control measures by seeking mass consensus to begin and by unifying the farming community of each village through a Cropping System Improvement Committee (CSIC), which was formed to represent the different strata of political and social mores, wealth status and ethnicity. A mass meeting was held in each village at which the project implementation was endorsed, and the CSIC was empowered with both responsibilities and authority for enforcing rules and regulations in the project. Subsequent training, national-level workshops and in-country tours gave the CSIC members more experience of research and development activities related to potato in Nepal.

There was full endorsement of the project in both villages in the first year and, with what must have been a great deal of faith, farmers did not plant their staple food. What happened next proved to be very different in the two villages, with complete breakdown of the project occurring in one of them. Whilst this must have been a bitter disappointment to those who strove hard to make the project work, ironically, the very contrasting fortunes of the two villages may serve as a parable for future projects. The results are also a reminder of the importance of the human factor in agricultural research and development.

In Ulleri, differences, mostly inter-personal, grew and the necessary level of participation could not be sustained. The CSIC split into two groups and became less functional. Eventually it became incapable of enforcing the regulations, the moratorium on potato planting was broken and the project was abandoned. In 1997, wilting of potatoes was observed in many farmers' fields and incidence levels of up to 50% were recorded. Wilt incidence was even higher, however, at a non-participating village.

At Jhilibrang, the community remained united. A handful of households tried to break the moratorium on potato planting but this was resolved. In 1997, potatoes were grown again in accordance with the project design, and bacterial wilt symptoms were recorded only twice: in two small plots of land wilting was recorded in a local variety and NPI/T0012, possibly from imported, diseased seed. The same varieties in adjoining plots were unaffected. Potatoes from the affected land were all consumed, and the ground drenched with 5% formalin and covered with a plastic sheet for 72 h. The subsequent crop was free of bacterial wilt.

Other positive outcomes at Jhilibrang included the successful cultivation of two varieties of cold tolerant rice and fresh vegetables. Initially there were severe weed problems in rice crops. Manual weeding and butachlor were tried, but the efficacy of the herbicide was found to be very dependent on soil moisture. However, training in manual weeding and harrowing by experts from an upland rice cultivation area helped to reduce weeding costs. Rice cultivation has since become popular among the Jhilibrang villagers, who now produce their own minimum rice needs rather than bartering potatoes for it.

Management of disease free seed remained a concern. Potato seed stock needs to be replaced every one to five years, with three/four years the average time span in Jhilibrang, and the replacement stock needs to be free of disease. To circumvent the problem, the project was extended for an extra year until June 1998 so that farmers could be trained in technologies associated with disease-free seed production using mainly pre-basic seed and true potato seed as source seed material.

The LARC/UPWARD joint experience during this project, mirroring the experience of the previous one-year project, was that the overriding difficulty was in managing the communities. In view of the problems encountered, it is perhaps commendable that both projects sustained what proved to be the highly effective participation of one out of their two villages. LARC comment that future projects need to take account of the level of commitment required of the participants, and the need for support programmes to make participation both more attractive and more participatory.

Source: Ghimire, S.R.; Dhital, B.K. (1998) Community approach to the management of bacterial wilt of potato in the hills of Nepal: a project terminal report.
LARC Occasional Paper No. 98/1, 22 pp.
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Internet Round-up

By: Tony Little, Technical Support Group to the Global IPM Facility, CABI Bioscience.

This issue, we look at web resources for pesticide side-effects on non-target organisms, and there are two very useful databases available:

SELCTV at:

http://www.ent3.orst.edu/Phosure/database/selctv/selctv.htm

is a database of pesticide impacts on non-target arthropod natural enemies, and includes a bibliographic database from which the data was sourced. Its development began in 1986/87 in the Department of Entomology at Oregon State University, Corvallis (Oregon, USA.). The database represents a relatively comprehensive compilation of the worldwide published literature, from approximately 12,500 data records describing pesticide effects on non-target arthropods from 1921 to 1994, although almost all originate from the pre-1986 literature. Each record in the principal table represents one screening of a pesticide on one natural enemy taxon under conditions described in the source publication.

Koppert's database can be found at

http://www.koppert.nl/english/service/index.html

and you need to go through a simple registration process the first time you use it. This database contains information about the side effects of pesticides on natural enemies and bumblebees. The information should be regarded as a guideline for the use of pesticides in combination with natural enemies and bumblebees under field conditions. The information is based on results from the IOBC Working Group 'Pesticides and Beneficial Organisms' and various research institutes. More than one hundred scientific publications were included in the comparative literature study. Much of the data was also derived from Koppert's own research and the experiences.

In terms of the implications of pesticide side-effects for registration, the US EPA (Environmental Protection Agency) post their data requirements at

http://www.epa.gov/pesticides/fifra6a2.htm

which while not exactly a riveting read is a useful resource.

Over the past few years OECD have been harmonizing the regulations for their member countries and the fruits of their efforts can be seen at

http://www.oecd.org/ehs/pest_tg.htm

The International Organization for Biological Control (IOBC) has a Working Group on pesticides and beneficial organisms. Considering the crucial contribution it has made to the study of pesticide side effects, and the fact that they developed the test procedures now adopted by several governments across the globe, their website, at:

http://iobc.ethz.ch/

is surprisingly modest, but does give you contact details for further information.

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.

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Arthropod Pathogen Germplasm Centre at ICIPE

The International Centre of Insect Physiology and Ecology (ICIPE) based in Nairobi, Kenya, conducts mission-oriented research on sustainable strategies for the management of arthropod plant pests and disease vectors. As part of its on-going research activities, ICIPE has recently established a Germplasm Centre to act as a repository of arthropod pathogens (fungi, bacteria and protozoa) for use against a wide range of target pests, including locusts and grasshoppers. These pathogens will be made available upon request to investigators in other institutions. The activities of the Centre include isolation, culture, identification, and preservation. Samples from Africa and elsewhere are welcome for inclusion in the collection.

Depositors will be asked to supply the following information:

- Scientific name of the microorganism (if known)
- Host source of isolation: order, family, genus, species (if known)
- Date of collection and date of isolation
- Collection location (town/province/state/country/climate)
- Depositor's reference number (if available)
- Name of isolator
- Address, telephone number and address of collector, isolator, or depositor

The project is funded by USAID's Africa Bureau and is managed and implemented by Virginia Polytechnic Institute and State University (USA) with seven other consortium partners in Africa (Desert Locust Control Organization for Eastern Africa (DLCO-EA), Direction de la Protection des Végétaux (DPV/Senegal), Locustox (Senegal), International Centre of Insect Physiology and Ecology (ICIPE, Kenya)), the USA (ACDI/VOCA), and Europe (European Biological Control Laboratory (USDA/EBCL, France) and the Institut National de la Recherche Agronomique (INRA, France)).

More information is available at:
http://www.icipe.org/germplasm/htm
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COSAVE Sets Out Priorities

The Southern Cone Plant Protection Committee (Comité de Sanidad Vegetal del Cono Sur – COSAVE) is a Regional Plant Protection Organization (RPPO) established in 1989 within the framework of the International Plant Protection Convention (IPPC), through an agreement among the governments of its member countries (Argentina, Brazil, Chile, Paraguay and Uruguay). One of the goals of COSAVE is to coordinate biological control activities within the region. In accordance with this, the Biological Control Permanent Working Group of COSAVE has determined priorities for pests to be targeted in order to speed the development of biocontrol technologies and has established a list of biological control agents used within countries of the region.

The Working Group first established the main pests for each COSAVE country and the biological control technologies currently available for them. A technical report has now been produced, which is organized as a series of tables, each of which deals with a crop important to three or more countries (23 crops in all). A preliminary list of the main pests for each crop has been drawn up; countries in which the pest is considered important are listed, together with the status of biological control for the pest in that country and biocontrol agents that either have been used or are under study. The list will be updated periodically.

More about COSAVE can now be accessed on their website at:
http://www.cosave.org.py/baseing.htm
This site includes a wide range of information about the structure and activities of the organization. Products available include standards and other documents for public consultation, lists of quarantine pests for countries of the region, pest data sheets, methods for risk analysis and pest diagnosis/identification, and technical publications. A Phytosanitary Forum gives participants an opportunity to discuss phytosanitary matters. There are also extensive links to organizations and institutions within and beyond the region involved in plant protection and risk analysis, and to other relevant web-based resources.

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IOBC Biocontrol Agent Rearing Website

The IOBC Global Working Group on Arthropod Mass Rearing and Quality Control (WGAMRQC) has now established a website (http://www.amrqc.org) to facilitate and advance cost-effective rearing of high-quality insects and other arthropods in support of biological control and integrated pest management.

The site includes a history of the Working Group, with summaries of its many workshops and assessments of its achievements over the years. There is a reference database for access to literature on insect rearing and quality control, plus quality control tests and standards, and quality control guidelines for more than 20 natural enemies.

On-line access to the IOBC WGAMRQC workshop proceedings is under construction. *FRASS*, the Insect Rearing Newsletter will also be available on-line in the near future. It contains a useful and eclectic mix of serious articles and lighthearted entertainment. There is also a listing of links to related websites.

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Conference Reports

East Africa Invasives Workshop

A regional workshop on 'Invasive Species in East Africa' was held on 5-6 July 1999 at ICIPE in Nairobi to raise awareness on the status of invasive species in the region. The workshop focused on Ethiopia, Kenya, Tanzania and Uganda, was attended by 70 people from 41 national and governmental bodies, institutions, organizations and businesses involved in conservation, land management, biodiversity, GIS, research, agriculture and education. A full account of the workshop can be found at: http://www.icipe.org/invasive/default.cfm

On the first day of the workshop, Hans Herren, Director General of ICIPE, welcomed the participants. Scott Miller in his introductory remarks considered the relevance of international treaties and conventions to the control of invasive species. Jeff Waage (Head of Biological Pest Management for CAB International Bioscience, UK and on the Executive Committee of the Global Invasive Species Programme, GISP) described the global nature of the invasive species problem, the challenges presented by invasive species to national, regional and global ecosystems and political/economic systems, and the possible role of GISP. He later described the two toolkits and associated case studies under preparation by GISP members. One toolkit will provide strategies and a database as part of an early warning system, while the other will provide strategies for developing national policies in the area of invasive species.

Moving on to national programmes and case studies, Wilson Songa (Kenya Plant Health Inspectorate Service) described legal and policy aspects of invasive species from the perspective of the Kenyan quarantine system, and Okaasai Opolot (Ugandan Phytosanitary and Quarantine Services) commented on the Ugandan experience. Christo Marais described how South Africa had started the Working for Water Programme having determined the high cost of water-consuming invasive plants in the dry Cape regions. This programme not only reduces the damage done by invasive species, but also, because it employs people from impoverished communities, helps to alleviate poverty and empower communities. Victor Kasulo (York University, UK & Malawi) described some of the economic and social costs of invasive species, incentives for changing individual and institutional behavior, and possible roles for donors in establishing sustainable invasive species programmes. Vishnu Tezoo (& Yousoof Mungroo) (Mauritius National Parks and Conservation Service) described a variety of approaches taken in Mauritius, an island with long experience of invasive species, including the active removal and continued exclusion of invasive species from a set of small reserves on the island. Timothy Twongo (Fisheries Research Institute of Uganda) described the impact and control options for plant and animal invaders in aquatic habitats. Geoffrey Mungai (National Museums of Kenya; NMK) described how herbarium records can be used to track both recent and historical movement of invasive plant species. Waweru Gitonga (Kenya Agricultural Research Institute; KARI) described efforts to control invasive aquatic weeds, including preemptive efforts, obtaining biological control agents for aquatic weeds that not yet in Kenya but have been invasive problems elsewhere. Josephine Songa (& William Overholt, ICIPE) described the ecology and dispersal of an agricultural invasive pest, the stem borer, *Chilo patellus*, providing insight into how non-agricultural alien insect pests might invade an area.

Richard Bagine moderated a session in which country-based working groups discussed the status of invasive species within protected areas and which ecosystems were most vulnerable to invasive species. Presentations of the outcomes showed striking similarities among the countries in pointing out that, both in protected areas and elsewhere, there was a need for more information and research on invasive species, for more capacity building at several levels, for better national and regional policy and associated enforcement, and underlying all of the other needs, a need for more funding and government commitment to controlling invasive species.

During the final session, attention was focused on shaping future efforts to control invasive species in East Africa. Four working groups were assembled and a brief report was presented for each: The Role of EAFRINET in the Fight Against Invasive Species; Strengthening Research and Research Links on Invasive Species; Coordinating Regional Efforts to Control Invasive Species; and Capacity Building and Implementation in Invasive Species Programmes.

ICIPE and its workshop co-sponsors (the National Museums of Kenya, the World Conservation Union (IUCN), CAB International, the Kenya Wildlife Service, EAFRINET, and Makerere University of Uganda) acknowledge financial support from the United Nations Environment Programme (UNEP) and the International Development Research Centre (IDRC) for funding the workshop. Support was also received from CAB International, the National Museums of Kenya, Kenya Airways, South Africa Airways and Air Mauritius.

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Plant Protection in Jerusalem

The XIVth International Plant Protection Conference (IPPC) was held in Jerusalem, Israel on the 25-29 July 1999 under the motto: 'Plant protection towards the third millennium – where chemistry meets ecology'. More than 1000 scientists, plant protection professionals and administrators attended six plenary lectures and participated in 25 symposia, 28 workshops and 13 poster discussion sessions covering a wide array of topics in diverse field such as biological control of arthropods, weeds and diseases, theory and application of integrated pest management, utilization of biotechnology in pest control, pest resistance, crop resistance, genetic engineering, novel approaches in pesticides and pesticide technology, the sterile insect technique, precision farming and regulatory issues in plant protection.

Biological control was dealt with in the broadest sense. Several symposia discussed the more theoretical contributions to biological control. Topics dealt with included the concept of greenhouses as islands, insect behavior and communication as a source for pest and natural enemy manipulation and improvement, and the utilization of plant characteristics for improved biological control. Posters and lectures were presented concerning practical topics such as mass rearing and release of beneficials, implementation and evaluation of biological control in practice, the integration of biocontrol into protected agriculture and the conservation of natural enemies. The integration of chemical and biological control was also dealt with, and included probes into the use of new or less harmful insecticides, novel and better application methods, and the preservation of natural enemies.

The congress honoured the memory of the late Professor D. Rosen, a leading figure in the science of biological control, who was instrumental in electing Jerusalem as the site of the current congress and passed away while chairing the organizing committee. The opening plenary lecture entitled 'The David Rosen Memorial Lecture, Biological Control of Citrus' was given by Marjorie Hoy from the University of Florida, USA on Sunday 25 July.

The 'International Association of Plant Protection Sciences' (IAPPS) was inaugurated during the Congress. IAPPS will become a permanent multi-disciplinary association under which future IPPCs will convene. Beijing, People's Republic of China, has been elected as site for the XVth IPPC in 2003.

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Methodology Workshop on Biocontrol of Plant Diseases

This workshop took place in CATIE (Centro Agronómico Tropical de Investigación y Educación), Costa Rica from 28 June to 4 July 1999. It was jointly organized and sponsored by CABI Bioscience, CATIE and the US Department of Agriculture. Thirty-three participants and facilitators from ten countries attended: Brazil, Cameroon, Colombia, Costa Rica, Ghana, Panama, Peru, Trinidad & Tobago, UK and USA. The objective of this workshop was to provide, discuss and develop sound research methodologies for biocontrol of plant diseases and to encourage increased coordination and communication between different research groups involved in biocontrol. The main target groups were junior researchers and technical staff involved in the practical aspects of biocontrol and integrated disease management in cocoa. The emphasis was on biocontrol of fungal diseases, principally frosty pod (*Moniliophthora roreri*), black pod (*Phytophthora palmivora* and *P. megakarya*) and witches' broom (*Crinipellis perniciosa*).

The programme included lectures and practicals on: (1) Overview of cocoa diseases and methods for identification (H. Purdy); (2) Production of zoospores of *Phytophthora* and field inoculation methods for fungal pathogens (J. Castillo, M. Gonzáles, W. Phillips & S. Bharath); (3) Mechanisms of actions of biocontrol agents (R. D. Lumsden); (4) Biocontrol of cocoa diseases in Latin America – status of field trials (K. P. Hebbar, S. Lambert, U. Krauss & W. Soberanis); (5) Classical biological control (H. Evans); (6) Isolation of native fungal and bacterial antagonists against plant diseases (U. Krauss & E. Bustamante); (7) Fungal endophytes of tropical trees: methods and potential for biological control of fungal pathogens of cocoa (B. Arnold); (8) A preliminary study of cocoa-associated microorganisms (K. P. Hebbar); (9) Pre-screening of biocontrol agents with emphasis on bioassays (U. Krauss); (10) Fermentation and formulation of biocontrol agents (K. P. Hebbar); (11) Spray application of biopesticides to perennial crops (R. Bateman); (12) Diversity of *Phytophthora* species causing black pod disease of cocoa and implications for effective biocontrol (A. Appiah, J. Flood, P. Bridge & S. Archer); (13) The use of antagonist mixtures in biocontrol (U. Krauss); (14) Statistical considerations in scientific experimentation (C. Kleinn); and (15) Technology transfer and rural development (R. Mack & L. Rodríguez). Group discussions dealt with: (1) Practical notes on work with *Phytophthora* species (S. Bharath, W. Phillips, A. Appiah, H. Evans & U. Krauss); (2) Diversity of *Crinipellis* and *Moniliophthora* species (H. Evans & W. Phillips); and (3) Safety issues and regulations for initiating a biocontrol project. Requirements for setting-up a biocontrol facility (R. D. Lumsden, U. Krauss, K. P. Hebbar, H. Evans, & B. Arnold).

A two-day field trip included visits to (1) La Lola Experimental Station to see two biocontrol trials in cocoa against *Phytophthora palmivora* and *Moniliophthora roreri*, (2) an on-farm cocoa biocontrol trial in Talamanca, (3) the Asociación de Pequeños Productrores de Talamanca (APPTA) and their post-harvest facilities for organic cocoa, (4) Plantanera Río Sixaola environmentally friendly and fair-trade banana plantation with a stop at a port to appreciate the necessity of infrastructure, and (5) a rural biocontrol fermentation of entomopathogenic fungi.

The workshop came to the following conclusions and recommendation:

- In general, the experiences gained from field trials support the conclusions that there is a high potential for biocontrol agents to assist management of certain fungal diseases of cocoa that are presently unmanageable using available control methodologies. Gradual scaling-up of research effort and developing suitable strategies might offer the route to effective uses of biocontrol agents.
- Existing literature should be re-read carefully and critically. Co-ordinate with others in your field. Negative results of thoroughly conducted experiments are a valuable source of information and should be reported.
- The diversity of pathogen species must be considered when developing biocontrol agents. *Phytophthora* spp. are known to be highly diverse but for other pathogens this phenomenon is still under-investigated and often overlooked.
- Mixtures of pathogen strains should be employed to develop mixtures of antagonist strains. This should increase the chance that they are active against pathogen populations under a range of environmental conditions. Thus they may function better than a single-strain biocontrol inoculum.
- There is an urgent need to investigate the epidemiology of antagonist–pathogen–host interactions taking environmental factors into account.
- Promising biocontrol candidates have been obtained using the 'classical biocontrol' approach, which searches for co-evolved antagonists in the centre of origin, by baiting for indigenous epiphytes and mycoparasites and by isolating endophytes which may be particularly useful against pathogens with an obligate parasitic phase.
- Evaluate biocontrol candidates for their activities using target species in bioassays, rather than using *in vitro* screens. Confronting the pathogen simultaneously with relatively low (similar) concentrations of the antagonist under non-sterile conditions may provide the strictest and best selection procedure. It should be preferred to lenient pre-screens.
- Pilot fermentation and formulation facilities should be set up as soon as possible because they are often limiting factors for field trials. Quality control is absolutely essential.
- Within the holistic concept of 'delivery systems', application technology must be considered simultaneously. More attention should be paid to oil-based formulations.
- First field trials should be initiated as early as possible and then expanded if results are favourable. Researcher-managed trials on experimental stations, and participatory and grower-managed trials on-farm serve different purposes and should be used accordingly.
- Trial results can only be as good as their experimental design, data collection, statistically correct analysis and inter-

pretation. Randomization and the replication of treatments must be considered in relation to the variability of cocoa production within a field and over time. It is often more realistic to include border trees in trial plots because a large proportion of a smallholder's cocoa is encountered in border rows.

- Implementation and adoption of biocontrol by farmers and industry is best achieved by involving growers' organizations, extensionists and industry at an early stage to initiate a participatory development. Gradual improvement through R&D and continuous technology transfer lead to improved communication amongst all participants.

- Biocontrol is not automatically safe and similar precautions as with chemicals should be taken. FAO guidelines and national laws determine how to move biocontrol candidates within political entities and across international borders. For biopesticides longer trial duration than for chemicals are necessary to assess the impact of the living organism on the environment, as well as people.

The proceedings of the workshop were published as a course manual:
Krauss, U.; Hebbar, K (1999) Research methodology in biocontrol of plant diseases with special reference to fungal diseases of cocoa. CABI Bioscience, CATIE & USDA, Turrialba. 159 pp.
The manual can be consulted in the following libraries: CABI Bioscience: UK Centres in Ascot and Egham, the Caribbean Regional Centre, Curepe, Trinidad & Tobago and the African Regional Centre in Nairobi, Kenya; CATIE, Turrialba, Costa Rica and CATIE-MIP, Nicaragua; CIRAD, Montpellier, France; Cocoa Research Institute of Ghana, Tafo, Ghana; Cocoa Research Unit, Trinidad & Tobago; Darwin Library, Edinburgh University, UK; Instituto de Investigación Agropecuaria de Panamá, Panama City; Scottish Agricultural College, Auchincruve and Edinburgh, UK; Smithsonian Tropical Research Institute, Barro Colorado Island, Republic of Panama; Universidad de Panamá, Panama City, Panama; Universidad Nacional Agraria de la Selva, Tingo María, Peru; Universidad Nacional La Molina, Biblioteca de la Especialidad de Fitopatología, Lima, Peru; University of the West Indies, St. Augustine, Trinidad and Tobago; and USDA National Agricultural Library, Beltsville, USA. A few copies are still available upon request, for public libraries only. Developing countries will be given preference.

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Pesticide Reduction Workshop

The PAN Europe workshop, Pesticide Reduction – *Time for Action* was held in Hamburg, Germany on 30 September - 2 October 1999. Pesticides Action Network (PAN) Europe is coordinated by an Executive Committee from PAN Germany, PAN Belgium, Pesticides Trust (UK), the European Public Health Alliance and the Dutch NGO Stichting Natuur en Milieu, all of which work on PAN issues in their respective countries. Europe-wide coordination was revived in 1998 with the appointment of a PAN Europe Coordinator, based with PAN Germany. This workshop was to cement coordination, particularly on EU (European Union) lobbying, and to discuss a draft position paper for lobbying, covering issues of pesticide reduction policies, water and food residues, EU CAP (Common Agricultural Policy) reform, human health, genetically modified crops, organic and ecological agriculture, pesticide disposal *inter alia*.

The workshop started by group discussion on the role of NGOs in European pesticide policy. Over 40 people attended from NGOs and governmental organizations, mainly from northern European countries, but there were also delegations from the Ukraine and Poland. Elizabeth Salter from WWF-UK summarized current issues concerning endocrine-disrupting compounds (EDCs) and their undermining of basic ecosystem functioning, compounded by their persistence and bioaccumulation. In addition to the well-known pesticide EDCs such as DDT and aldrin, which are also among the Persistent Organic Pollutants (POPs), she highlighted the need to focus on others such as the herbicide atrazine and several synthetic pyrethroids, which can disrupt fresh water ecosystems. Gerd Winter from the University of Bremen outlined pathways for NGOs to influence European Commission legislation on pesticides via relevant directives on market harmonization, environmental protection and agriculture.

Government officers from Denmark, Sweden and Finland reviewed their national pesticide reduction programmes. The Danish programme achieved the target 50% reduction in usage by 1997, however shifts towards lower dose products meant that there was little change in application frequency, an aspect of impact common to many national programmes. Most pesticide use in Sweden is destined for timber production and preservation, given the country's important forestry sector. Their national risk reduction programme has reduced usage by 75% since 1987 through a switch to safer active ingredients, safer handling and mandatory user training and certification, along with decreased use. For example, all Swedish farmers must now measure temperature, wind speed and direction before spraying, in order to protect buffer zones. The Finnish programme includes thresholds and forecasting, testing of spray equipment, safe use training, protective cultivation measures and impact monitoring. At EU level, CAP Agenda 2000 reform which could help reduce pesticide use and promote non-chemical alternatives includes integration of environmental measures, promotion of organic farming and agri-environment activities. Forthcoming changes in policy and legislation will also provide instruments at member state and European level for pesticide reduction, for example, measures to fast-track European registration of biopesticides could promote the use of biological control. The working group on sustainable agriculture discussed organic farming experiences in Germany, CAP reform and EU agricultural policy, IPM issues, and Good Agricultural Practice (GAP) initiatives with supermarkets.

The workshop adopted a 13 point position paper and efforts will be made to increase PAN Europe profile in Brussels, although support for eastern European countries' activities is also necessary. Current Europe-wide pesticide campaigning will focus on lindane and dichlorvos bans, the EU Water Framework Directive and pesticide reduction.

Copies of the workshop presentations, briefings and position paper can be obtained from:
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Weeds at Bozeman

The Xth International Symposium on Biological Control of Weeds was held at Montana State University, Bozeman, Montana, USA, 4-9 July 1999. The meeting was co-sponsored by the United States Department of Agriculture – Agricultural Research Service (USDA-ARS) and Montana State University, Bozeman, and the co-chairs, Bob Nowierski & Neal Spencer led

a professional team who put together and ran the symposium. Most of this was done through the symposium website which was used for the discussion, planning and administration of the development of the conference programme, registration, submission of abstracts and papers, etc. The meeting programme, list of participants (including the facility to send e-mails to the participants), etc., will remain available on the Symposium website:
http://www.symposium.ars.usda.gov/
so check it out if you want the details.

The meeting had over 280 registered participants, and stretched the capacity of the meeting venue. A large number of high quality posters were presented in sessions held over the extended lunch breaks, but being placed in a rather cramped adjacent building, they may not have got the attention they deserved. Just over half the registered participants were from the USA, but Australia, CABI (UK and Switzerland), Canada, New Zealand and South Africa all had strong groups, with a sprinkling of participants from other countries around the World.

The Sessions (and Session Leaders) were as follows:
Success in Biological Control of Weeds (Rachel McFadyen)
Biological Control of Weeds-Failures (Judy Myers)
Role of Molecular Biology in Biological Control (David Kazmer)
Weeds of Aquatic Systems and Wetlands (Ted Center)
Safety of Biological Control: What More Can We Do? (Ernest (Del) Delfosse)
Ecological Principles of Biological Control Introduction: (Rob Bourchier)
Host Selection & Specificity (Roy Van Driesche)
Post Release & Impact Studies (Eric Coombs)
Plant Pathogen/Microbe/ Insect Interaction (Tony Caesar)
Negative Economic and Ecological Impact of Invasive Weeds (Robert Pemberton)
Complications in the Implementation of Weed Biocontrol (John Hoffmann)

The symposium featured three honorees: Lloyd Andres, Peter Harris and Dieter Schroeder. A colleague gave a short entertaining presentation on the career of each, followed by a few words by each honoree, and a presentation.

Almost inevitably, at times the North American interests dominated the agenda and discussion. Similarly entomological expertise tended to dominate, and the use of fungi, at least as classical biological control agents, was under-represented. This was particularly true in the session on host-specificity; hopefully this will be redressed at the next Symposium which will be hosted by CSIRO and held in Canberra in April 2003.

All in all, the organizers are to be congratulated on an efficiently run meeting and as always it provided a great opportunity for the still relatively small world of weed biological control to meet, discuss and get to know each other better.

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