General News

Who Gains from Water Hyacinth Biocontrol?

A pioneering study* of the socio-economic impact of water hyacinth (*Eichhornia crassipes*) and its biocontrol in Benin found that control had brought about substantial benefits for the local population and thus the nation as a whole. Perhaps as importantly, it developed methodology that may be adapted for assessments of other invasive species.

- Participatory methods, including group discussions and individual discussions, were used in a preliminary, qualitative survey to assess where and how the classical biological control programme had made an impact.
- Based on the results, a socio-economic survey was developed to record perceptions on water hyacinth and quantitative estimates of economic loss from a representative sample of stakeholders living on the infested waterways and deriving livelihoods from farming, fishing and trading.

Classical International Biocontrol Cooperation

Water hyacinth was first observed in West Africa in the late 1970s and within a decade it had become a serious pest. In particular it was a major threat to the highly productive coastal creek and lagoon systems from which many people derive a livelihood, particularly in Côte d'Ivoire, Ghana, Togo, Benin and Nigeria. Although a number of reports and anecdotal evidence suggest that there has been a substantial reduction in water hyacinth, the efficacy of the control and its economic benefits remain controversial.

This study focused on southern Benin, where three natural enemies (*Neochetina eichhorniae, N. bruchi* and *Niphograpta* (= *Sameodes*) *albiguttalis*) had been released between 1991 and 1994. All the agents were obtained from CSIRO (Commonwealth Scientific and Industrial Research Organisation) in Australia, quarantined by CABI *Bioscience* in the UK, and released by IITA (International Institute of Tropical Agriculture) together with the Benin Direction de Pêche (Ministry of Rural Development) assisted by the Project Pêche Lagunaire, which was supported by the German aid agency GTZ (Gesellschaft für Technische Zusammenarbeit).

Monitoring has been conducted since the project began and for many years impact was uncertain. More recently *Neochetina eichhorniae* in particular has begun to reduce water hyacinth cover and formerly abandoned fishing grounds have been reclaimed.

Local Opinion Rates Biocontrol Benefits

Wetland systems are complex and so is their economic valuation because different stakeholders may value them for different reasons and scientists place yet more values on them. This study focused specifically on the utilitarian value of the ecosystem to the communities that rely on it. Based on the results of a preliminary participatory study, a quantitative household survey was developed. The study area was defined as the flood plain between the Sô and Ouémé rivers in southern Benin and, using a two-stage random sampling design, a representative sample of 192 households from 24 villages was selected. In total, 190 men and 171 women (one wife chosen at random from each household) were interviewed concerning their perceptions of the development and importance of the water hyacinth infestation. They were asked what impact it had had on them and to rank these impacts in importance. They were asked to name their major economic activities and indicate whether water hyacinth had had an impact on these. Lastly they were asked to estimate how this translated into income before and at the peak of water hyacinth infestations, and at the time of the survey in 1999.

The study area is a complex of rivers and lagoons, interspersed with banks and elevations, and agriculture, fishing and trading are the most important activities. Its shallow waters are amongst the most productive in the world, and over time the population has developed a system of artificial breeding grounds, or 'acajas', consisting of wooden stakes sunk into the mud in the shallow water. At harvest, these are surrounded by nets and the fish inside them trapped. With few access roads to the villages, water is also the most important means of transport and is thus vital to trading.

The villagers' dependence on waterways was reflected in their perceptions of the effects of water hyacinth. Impacts in order of importance (% respondents) are:

- Transport (70%) including increased travelling time to market (30%).
- Fishing: more difficult to throw nets (48%), fish populations reduced (43%) and acajas destroyed (14%).
- Health (47%) including itching (32%), malaria (11%) and aches and pains (9%).
- Water quality (33%).

Some positive effects were also recorded: the weed is useful as a fertilizer (31%) and helps conserve soil moisture (16%). Its medicinal value was recognized by 6% of respondents.

The division of labour between men and women is quite specific in this area: men do most of the fishing and agriculture, while women are responsible for transport and trade. Agriculture was the most important activity for men (64% put it first and 10% second) followed by fishing (30% and 57%). For women trading is by far the most important activity, with food crops rated most important by 54% and fish by 23%, while 18% give agriculture as their main activity. It is not surprising, given these gender differences, that there were marked discrepancies in how men and women described the economic impact of the weed.

More men than women perceived water hyacinth to have an economic impact. However, although 70% of men said it had an impact on fishing, few reported any impact on trade and agriculture (6% altogether). On the other hand women saw the greatest impact to be on trade, especially of fish (19%) and food crops (9%). For women, the impact of water hyacinth was mostly felt in the extra effort and time that they had to put in to take their little boats to the markets, through the mats of floating water hyacinth. They commented that although their income from trade did not decrease much, it took a lot more time and effort to generate that income, and occasionally they would lose their produce when they could not get through.

Similar gender differences emerged when respondents estimated financial losses, with men mostly affected by fishing, and women by trade. Summarizing the replies, men's annual income from fishing dropped to 31% of pre-infestation levels at the peak of the infestation, but recovered to just under 60% of the pre-infestation level by 1999, largely owing to reduced water hyacinth cover which allowed fishing grounds to be exploited again. Women's income from trading fish and food crops dropped to

26% and 62%, respectively, of pre-infestation levels. By 1999, trade in food crops had largely recovered (to 92% of pre-infestation income) but fish trade was slower to re-establish, remaining at 34% of pre-infestation levels.

One unanticipated feature was a consistent skewed distribution in income from different activities in these communities. Although most people earn very small amounts a few make relatively large incomes. This led to large variation, for example with standard deviation of up to eight times the mean for women's fish trading income. The study implementers note that a larger sample size would have allowed the standard deviation to be reduced: surveying 450 households, for example, would bring standard errors below 15% of the estimated value.

Variation notwithstanding, the reduction in water hyacinth and its benefits to the local inhabitants are clear to them. The reason for the reduction is not so widely known, with only about a fifth of the respondents aware of the biocontrol programme. However, increased publicity about the biocontrol success will bring better public awareness.

Benefits Outweigh Costs

Using the results from the surveys and knowledge of households gained from the survey and a recent census, the combined economic losses from water hyacinth at the peak of infestation were calculated to be US$2151 per household per year, and biocontrol had an annual impact of $783 per household. Extrapolating these figures to the entire region, the regional economic loss was calculated to be $83.9 million/year, and the increase following (and therefore the benefit of) biocontrol $30.5 million. Because of the large variation between households, the sampling error is large and this figure must be treated with caution. However, the 95% confidence interval falls between $17 million and $44 million. Extrapolating the annual benefit over 20 years, with depreciation of 10% annually, a total benefit of $260 million is reached (with a 95% confidence interval of $145-375 million). This is argued to be a good conservative estimate since the full effect of biocontrol may be to come.

The costs of biocontrol are easier to estimate. Rearing the weevils uses little space and simple equipment, thus most of the costs were for labour. Between 1991 and 1998, IITA, GTZ and local organizations' labour costs were some $2.09 million (calculated with depreciation). Comparing this to the estimated benefit of $260 million, the benefit cost ratio is 124:1 (or, taking the 95% confidence interval into account, between 69:1 and 180:1).

The benefit-cost analysis compares the financial benefits to the people of southern Benin with the cost of the international research and implementation programme. The study does not attempt to quantify other benefits such as health and water quality. Furthermore, like many classical biocontrol programmes in Africa, the knowledge and technology generated has been 'exported' along with weevils and adapted for other countries at little additional cost.

This study has implications beyond the boundaries of biocontrol. The economics of invasive species, of which water hyacinth is a well-known example, are poorly understood, but with international agreements such as the Convention on Biodiversity now in place governments are faced with responsibilities for managing them. They need to be able to carry out impact assessments and estimate the effects of various strategies, yet there is very little guidance available on how to do this. This study of the costs of water hyacinth and benefits of biocontrol in southern Benin is the first impact assessment of biocontrol that uses participatory methods and gender-specific data from household surveys. It is therefore significant and timely, providing novel ideas and useful methodology. Thus, in answer to the question in the title to this article, many people in Benin and beyond gained, and will continue to gain, from the biocontrol programme against water hyacinth led by IITA.

*De Groote, H.; Ajuonu, O.; Attignon, S.; Djessou, R.; Neuenschwander, P. (2003) Economic impact of biological control of water hyacinth in southern Benin. *Ecological Economics* **45**, 105-117.

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Putting a Price on Exotic Ornamentals

How important is an exotic (i.e. a non-native) ornamental tree in people's backyards? The answer is "very important if it is a large feature tree in your garden." However, what importance should it be given by governments (state or federal) when making decisions regarding the importation of organisms for biological control of weeds?

This question has arisen in Queensland, Australia, because the lantana treehopper, *Aconophora compressa*, has started attacking fiddlewood trees (*Citharexylum spinosum*) in southeast Queensland and some regional areas of eastern Australia. Fiddlewoods are West Indian trees that were widely planted as shade and screen trees in Brisbane and elsewhere in Australia in the 1970s and 1980s. They are no longer popular because they are untidy and history has shown that the roots damage pipes and underground cables. They have, in fact, been placed on the 'undesirable species' list by the Brisbane City Council and other local councils, as well as by several state authorities. The tree has also become an invasive weed in Hawaii and the environmentally sensitive Galapagos Islands.

Lantana is a major invasive plant from Central and South America. It already affects over 4 million hectares of coastal and sub-coastal Queensland and New South Wales, and is still spreading. It is toxic to stock and displaces useful pasture species. Lantana is spread by birds into native woodland, where its dense thickets smother native vegetation and prevent rainforest regeneration. There has been an active biocontrol programme against lantana in Australia since 1914[1]. *Aconophora compressa* was introduced from Mexico as a biocontrol agent against lantana by the Queensland Government in 1995. Releases of this agent ceased in December 2001.

When this membracid was host-tested in 1993-4, fiddlewood, which is in the same family (Verbenaceae) as lantana, was not included on the official or approved test list. Under the Australian system, the test list was approved by all states and territories as well as by the federal authorities, none of whom suggested the addition of the genus *Citharexylum.* The plant was overlooked possibly because it was no longer being sold by most nurseries, the extent of its ornamental use was not known or documented, and because it did not appear in regional floras as it had not naturalized. Several other genera in the family Verbenaceae were tested, but only *Duranta*, another ornamental genus from Mexico, and which is also often weedy, supported development to adulthood, albeit in very low numbers. The one or two herbaceous species in the family Verbenaceae possibly native to Australia were tested and not fed upon. The bug was therefore approved under the national system as safe to release in 1995[2]. Females lay a batch of eggs, containing between 30 and 50 eggs, but stay with the developing nymphs until maturity before moving off to oviposit again. Nymphs take about 7 weeks to complete development and adults live for up to 6 months.

After release, the bug established slowly on lantana in the Brisbane area, but large and damaging populations began to build up in spring in 2001 and 2002. Unfortunately, hot weather (daily maxima above 37ºC) in both summers killed the bugs, and *A. compressa* was thought to be a failure in the Brisbane region. However, the 2002/03 summer was mild and the populations have steadily increased since on lantana. Whilst this gave encouragement in regard to its value as a biocontrol agent for lantana in the Brisbane area, there was a significant escalation of earlier observations (1999, 2001 and 2002) that fiddlewood trees also appeared to be an attractive host plant. In many areas, much larger and more damaging populations of the bug are occurring in 2003 on fiddlewoods than on lantana. It seems that fiddlewood is less affected by dry conditions, probably because it is a tree, with better sap-flow than lantana.

Fiddlewood trees planted 20 or 30 years earlier are now prized features in some gardens, and the damage to the trees is causing a great deal of community concern and media interest. The large bug populations are causing problems other than the damage to the fiddlewoods: the abundant honeydew is killing lawns, damaging plants beneath the tree and staining laundry (apparently, bugs are attracted to white clothes), and there have been reports that the bugs are even taking sample bites from people if they land on them. They are also leaving the fiddlewood trees as branches die back and are moving onto adjacent garden shrubs, especially *Duranta* varieties. However, this spillover of the bug onto other garden plants should only be temporary. The bugs are not able to maintain populations on these other plants, and should disappear once the nearby dense populations on fiddlewood or lantana have stabilized at lower levels. This kind of spill-over damage happened when the cactoblastis moth (*Cactoblastis cactorum*) was first released back in 1930. Very large numbers of cactoblastis larvae developed in the prickly pear (*Opuntia* spp.) and in several places there was damage to tomatoes, melons and pumpkins. Once the cactoblastis populations fell, there has been no more damage to tomatoes or other crops in the 70 years since.

Since host specificity testing aims to test species closely related to the target weed, if the scientists had realized in 1993 that there were considerable numbers of fiddlewood trees in Brisbane, the tree would have been included in the test list. The host tests would have shown that the bug can develop and breed on fiddlewood, and this might have prevented the release of the agent. But would this have been right? Biocontrol is by far the safest and most cost-effective tool we have to manage serious environmental weeds such as lantana. Biocontrol programmes have led to the control of groundsel bush (*Baccharis halimifolia*), rubber vine (*Cryptostegia grandiflora*), and the serious aquatic weeds water hyacinth (*Eichhornia crassipes*) and salvinia (*Salvinia molesta*) in Queensland, among many other successes in the last 30 years. Any cost-benefit study would probably have concluded that the damage to fiddlewoods, and the cost of treating highly valued trees by stem injection or other methods or replacing the trees by other more desirable shade trees, would be far outweighed by the benefits from improved control of lantana. However, the identification of the fiddlewood tree as a host at that time may have triggered specific research on stem injection or other treatment measures before the release of the agent was made.

In 1995-dollar terms, weeds cost Australia approximately A$3.3 billion per year and biocontrol is by far the most cost-effective weapon. It is also probably the only method for environmental weeds such as lantana, since use of chemical or mechanical control is simply not feasible, economically or environmentally, over the huge areas already invaded. Should damage to an exotic ornamental such as fiddlewood (brought in to the country, sold and widely planted without any controls on the process) be allowed to prevent possible successful control of lantana?

The question is difficult and depends on the perspective. We cannot ignore community concerns – the political backlash has the potential to threaten future use of biocontrol. However, we need to learn from the *Aconophora* incident, and be better prepared to respond to similar issues in the future. When an insect likely to damage ornamentals is approved for release, an appropriate communication plan and recommendations for control should be developed before any release is made.

[1]Julien, M.H.; Griffiths, M.W. (1998) Biological control of weeds. A world catalogue of agents and their target weeds, 4th ed. Wallingford, UK; CABI *Publishing*.

[2]Palmer, W.A.; Willson, B.W.; Pullen, K.R. (1996) The host range of *Aconophora compressa* Walker (Homoptera: Membracidae): a potential biological control agent for *Lantana camara* L. (Verbenaceae). *Proceedings of the Entomological Society of Washington* **98**, 617-624.

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Know your Foe: Closing the Net on a Thorny Invader

European blackberry (*Rubus fruticosus* agg.) occupies nearly 9 million hectares of Australia following multiple introductions since the 1800s. This 'Weed of National Significance' consumes land used for pasture, forestry, recreation and conservation and is difficult to control. The European leaf rust fungus, *Phragmidium violaceum*, was first reported in Australia in 1984 following an unauthorized release of unknown origin. In 1991 and 1992, strain F15 of *P. violaceum*, collected from central France, was released specifically for biological control. The impact of the rust fungus has been spectacular in some locations, but even when the weather is favourable for rust epidemics some blackberry biotypes escape severe disease.

In Europe the *R. fruticosus* aggregate comprises numerous apomictic species (i.e. they reproduce without fertilization) that are closely related. Phenotypic plasticity may be high and morphological variants can arise by hybridization between species. A consensus in the taxonomic treatment of *Rubus* in Europe, let alone in Australia, has not been reached. The increasing availability of DNA tools was a prime reason for a revival of the biocontrol programme of weedy blackberry in 1996 by the Cooperative Research Centre for Australian Weed Management (Weeds CRC). A primary objective was the selection of additional rust strains in Europe to match the range of blackberry biotypes in Australia, a task that depended on adequate characterization of the weed host and rust pathogen.

Weeds CRC researcher Kathy Evans and her colleagues made at least 200 collections of the *R. fruticosus* agg. across Australia and identified 49 DNA phenotypes using an M13 RFLP (restriction fragment length polymorphism) technique. A form of genotyping or DNA fingerprinting, the M13 probe detects length variants in minisatellite DNA sequences when the probe is hybridized to genomic DNA digested with a restriction enzyme. The term DNA phenotype, rather than genotype, is used to reflect that only a proportion of the genome is detected by the DNA probe. Two plants that have different DNA phenotypes are genetically different, but may still belong to the same taxonomic species. However, RFLP analyses revealed that two blackberry plants sharing the same DNA phenotype were very likely to be the same species.

With the help of taxonomist D. E. Symon of the State Herbarium of South Australia, and specialist European *Rubus* taxonomists H. E. Weber of the University of Vechta, Germany and A. Newton of Exmouth in the UK, 33 of the 49 DNA phenotypes identified were correlated positively to 14 taxa or 'species' of the *R. fruticosus* aggregate. The 16 undetermined DNA phenotypes were either new biotypes that have evolved in Australia, biotypes that have not yet been recognized or characterized in Europe, or biotypes that no longer exist in Europe. The outcome of the taxonomic revision, based primarily on morphology but confirmed using DNA technology, is that ten names can now be applied for the first time to exotic *Rubus* material collected in Australia.

A significant outcome of this taxonomic revision of *Rubus* was the determination that the most common and widespread weedy blackberry in Australia was *R. anglocandicans*. The DNA phenotype of five collections of *R. anglocandicans* in England matched exactly the DNA type of 97% of samples ($n = 76$) of *R. anglocandicans* collected across Australia. This weedy taxon in Australia can now be distinguished from *R. armeniacus*, the common weedy European blackberry in the Pacific-Northwestern region of the USA and some parts of New Zealand.

Another important application of the DNA typing tool has been the identification of *Rubus* clones in pathogenicity studies with strains of the rust fungus. The DNA 'fingerprint' of each *Rubus* clone is analogous to bar coding consumer goods in the retail sector. Regardless of their taxonomic status, this technology enabled the identification of plant propagation material with certainty. The M13 DNA typing tool was also applied to strains of *P. violaceum*, to confirm that genetically different rust strains were being assayed and for preliminary studies of the genetic diversity of the rust population in Australia. A major outcome of the research was the development of a differential set of *Rubus* clones for characterizing the virulence phenotype of each strain of *P. violaceum,* thus streamlining the selection process for additional rust strains. An unexpected outcome of population-genetic studies was evidence to suggest that strain F15 is not well established in Australia today.

The next challenge is to monitor the fate of additional strains of *P. violaceum* to be released in Australia soon. This requires that weed managers identify which species of blackberry they are dealing with. DNA identikits for field use are still a dream, so Kathy Evans has teamed up with Bill and Robyn Barker from the State Herbarium of South Australia to develop a computer-driven, user-friendly tool to distinguish between cultivated, native and invasive blackberry species. Funded by the National Heritage Trust, this web-based, interactive tool is expected to be available in 2004, following trials with land managers and community groups across southern Australia.

The battle against blackberry in Australia is far from over, but better understanding of the taxonomy of *Rubus* and the identification of the pathogenic rust strains, underpinned by DNA typing, is helping to close the net on this thorny invader.

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Can the 'Green Tidal Wave' of Asia Be Curtailed?

Mikania micrantha (mikania or mile-a-minute weed) has earned the epithet 'green tidal wave' for the speed with which it can envelop Asian hillsides of tea and forest. An inception workshop in New Delhi in June 2003 signalled the start of the implementation phase of a biological control project against this invasive alien weed in India. The project is developing a biological control component to fit into an IPM strategy being developed against mikania. It is the first time that a plant pathogen has been approved for importation into India as a prospective weed biocontrol agent, and as such the workshop was a landmark event. However, the project has some way to go before an application for field release can be considered.

Mikania is a neotropical invasive weed that has wide-ranging impacts in the tropical moist zones of northeast and southwest India affecting:

- Agricultural productivity and smallholder livelihoods: it invades agroforestry systems, plantations and home gardens. Teak, tea, pineapple and plantain are particularly susceptible. In tea, it has additional impact because it is an alternate host for the tea mosquito (*Helopeltis* sp.), a mirid that causes leaf curl in the crop.
- Trade: massive increase in herbicide use has been detrimental to the marketing of the crop, particularly in Europe, where the European Union has already rejected exports of Assam tea owing to herbicide residues.
- Biodiversity: mikania smothers natural forest and wetland grazing ecosystems.

The weed first emerged as a problem in tea in Assam in the 1940s, but in recent decades its importance has escalated owing to large-scale degradation of natural forests, from which stronghold it can invade tea gardens, which has led to the escalation in herbicide use. More recently, mikania arrived in the Western Ghats range in southwestern India where it poses an immediate threat to natural and agricultural ecosystems, and may spread further.

Current control measures focus on slashing and herbicides but these are expensive, ineffective and unsustainable, and can be environmentally damaging. The initial phase of this DFID (UK Department for International Development) funded collaborative project (1996-2000) involved three institutions in India, Kerala Forest Research Institute (KFRI), Project Directorate of Biological Control, Bangalore (PDBC) and Assam Agricultural University, and CABI *Bioscience*, UK. Their investigation into the potential for an IPM approach to mikania control in the Western Ghats included mapping the distribution and monitoring the spread of the weed, assessing its socio-economic impact on subsistence agriculture, and evaluating fungal pathogens as biological control agents (as mycoherbicides and for classical introductions).

Surveys in India found no indigenous natural enemies with potential as control agents for mikania. However mikania is rarely a weed in its native range in the Americas and natural enemies are seen to exert a significant pressure on the occurrence and abundance of the species, so the weed was considered to be an ideal candidate for classical biological control (CBC) using co-evolved natural enemies from their common area of origin. Characterization of worldwide populations of mikania using AFLP (amplified fragment length polymorphism) analysis indicated that the weed has a relatively narrow genetic base in tropical Asia but is highly variable in its native range. This supports the evidence in the literature of a small number of deliberate introductions of the plant (perhaps four in India) as a cover crop and as airfield camouflage during World War II. As well as confirming the history of its introduction to India, the results suggest that there is a good chance of successful CBC throughout the exotic range, using a single or limited number of natural enemies. Fungal pathotypes are highly specific within species and different pathotypes may be needed to control each genetic type in the introduced range. However, if the invasive population comes from a limited number of introductions it will contain a restricted number of genetic types, which may be controlled by a few pathotypes.

An evaluation of the broad range of fungal pathogens recorded on mikania from its neotropical native range led to the selection of three rust species for further assessment.

Puccinia spegazzinii was identified as the prime candidate for introduction into southern India as a classical biocontrol agent. It is a common and damaging pathogen on mikania in the Neotropics, but is not found in the exotic range of the weed. Eleven isolates of the rust from five countries (Brazil, Costa Rica, Argentina, Trinidad & Tobago and Ecuador) were evaluated. The pathogen demonstrated intra-species specificity, each isolate only infecting a selected number of genotypes of its host. However, one pathotype from Trinidad (W1761) proved to be virulent against a wide range of Indian isolates of the weed, infecting all those tested from the Western Ghats, and hence was selected for intensive screening. This pathotype was shown to be totally specific to *M. micrantha* (55 non-target species have been tested, including many important crop species in India), as well as highly damaging (leaf, petiole and stem infections leading to cankering and whole -plant death). In addition, the rust has a broad environmental tolerance (able to infect after less than 10 h dew at temperatures of 15-25ºC). It is an obligate biotroph, surviving only on living plant material: if infected plant material is dried, the rust is rendered non-viable. However, although the Trinidadian isolate of *P. spegazzinii* infected almost all collections of *M. micrantha* from the Old World, and the ten target populations in the Western Ghats tested were fully susceptible, some collections from Assam proved to be not fully susceptible to this strain. Since then, newly discovered Peruvian and Ecuadorian strains of *P. spegazzinii* have excited interest, as all the northeastern Indian biotypes so far tested are fully susceptible to them, and they are currently being considered as additional agents.

Two *Dietelia* species, *D. portoricensis* from Costa Rica and *Dietelia* sp. nov. from Mexico, are also being maintained in CABI *Bioscience* quarantine as 'reserve' candidates. Preliminary studies found them to be as damaging to their host as *P. spegazzinii*, and they have also only been recorded from *M. micrantha*. Importantly, the *Dietelia* species fully infected some of the mikania strains from northeast India that are only semi-susceptible to the Trinidadian isolate of *P. spegazzinii* and they could thus be considered as alternative agents for mikania in this part of India also.

The first phase of the project culminated in a workshop held at KFRI in November 1999 attended by local and regional scientists involved in the control of invasive weeds [see *BNI* 23(2), 53N (June 2002), Indian invasive forest weeds] which recommended *inter alia* the development of an implementation phase including an application for the introduction of *P. spegazzinii*. A dossier was subsequently produced by CABI *Bioscience*, for the Indian collaborators, containing detailed data on the information summarized above concerning *P. spegazzinii*, as required by the Code of Conduct for the Import and Release of Exotic Biological Control Agents, 1996 (International Standards for Phytosanitary Measures (ISPM) No. 3). This was submitted to the relevant quarantine authorities in India, and permission for PDBC to import the rust into quarantine in India was approved in October 2002, opening the way for the implementation phase to commence.

A quarantine facility at PDBC is under construction, scheduled for completion later this year. In the meantime, PDBC and KFRI will begin studies on the rust at the NBPGR (National Bureau of Plant Genetic Resources) quarantine facilities in New Delhi, by agreement with the Director, using material supplied by CABI *Bioscience*.

The workplan for this phase of the project will begin by ensuring that material is pure and hyperparasite-free and by conducting further host specificity testing to confirm that the rust is safe for India, after which an application for a permit to release can be made. This will include public consultation, in conjunction with the Indian Directorate of Plant Quarantine and Storage (DPQ&S), to ensure that local people are reassured that indigenous plants, e.g. medicinals and tree crops, are not under threat from the pathogen. Methods and facilities for mass producing will be developed, together with a system for transporting the material to Assam and Kerala where further bulking up will be carried out.

Two distinct release strategies may be required:

- An inoculative strategy will be used for the Western Ghats and Assam, adopting a low-tech approach of placing pots of rust-infected plants, with young pustules, at strategic points and at optimum times for infection, within severely weed-infested areas. This approach requires minimum human input and is suitable for initiating epiphytotics within weed infestations of agroforestry and natural ecosystems.
- An inundative strategy is likely to be beneficial in Assam, where mikania is a problem particularly in tea gardens. The inundative approach requires mass-production of inoculum in propagation units during the dry season and mass releases when the rains start. This is considerably more labour intensive and thus expensive than the inoculative approach outlined above, but enables the rust to be quickly established in high value crops such as tea. By diverting into rust production labour that would otherwise be needed for clearing mikania, the agent could feasibly be deployed in sufficient quantities early enough in the season to overcome the natural lag phase so that disease spread becomes exponential in time to stem the 'green tide' before it gets going.

In the long term it may prove unnecessary to continue with the inundative releases since, if the rust is successful, the weed population should substantially decline throughout its exotic range to an extent that it would no longer be considered invasive. A significant bonus in Assam, both economically and environmentally, should be a reduction of herbicide use in tea gardens.

A crucial part of this project will be a farmer and forest department information campaign. As the project to fund the first pathogen to be intentionally released in India against a weed, it is seen as essential to engage with local stakeholders, to ensure they are fully aware of what is happening, and understand the principles and implications of the release of the rust. Socio-economic studies undertaken in Phase I showed that many farmers are aware of biological control and are supportive of the use of fungal pathogens, but the campaign aims to expand on the understanding within farming communities and will promote the release of the rust fungus, analogous to the community-based approach of countries with long experience of weed biocontrol, such as Australia. Wide dissemination is seen as essential to promote the broadest possible uptake of the outputs of this project, and lay the foundations to aid implementation of other biological control programmes in the future.

The project will establish monitoring plots in Kerala and Assam for impact assessment. Biocontrol scientists tend to be reluctant to forecast success for individual introductions; history contains too many disappointments. However, in this case they are optimistic from both field observations within mikania's native range and glasshouse investigations that *P. spe-*

gazzinii could indeed prove to be a rare 'silver bullet'. They predict that, if released in the moist forest region of the Western Ghats, the rust would establish and spread rapidly under the prevailing environmental conditions, and should unilaterally exert a significant effect on the abundance and spread of mikania populations within a few growing seasons. In the long term (5-10 years or more), they predict that the growth and fecundity of mikania would be severely reduced over a significant part of its range. The weed, thus, should no longer pose a threat to the agricultural economy of the infested regions, and the agent would therefore contribute to alleviation of poverty in subsistence farmers, by increasing crop yields and/or reducing time spent on weeding. Equally important, the rust would perform a significant role in the conservation of biodiversity of natural forest ecosystems by reducing the impact of mikania in these habitats.

While work in India has been in progress for some years, alarm about the 'green tide' has also been emerging in other Asian countries. Growing recognition of the threat this invasive weed poses in China led to an initiative between CABI *Bioscience*, Guangdong Agricultural Institute and the Institute of Biological Control, Chinese Academy of Agricultural Sciences. Funding has been secured under the Darwin Initiative of DEFRA (UK Department for Environment, Farming and Rural Affairs), and work will begin in Guangdong Province, China in October this year.

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UK Wakes up to Invasive Weeds

A UK£0.5 million partnership project to investigate the potential for biological control of Japanese knotweed (*Fallopia japonica*) may be a turning point for biological control in the UK, and even Europe. The 4-year initiative, which is being funded by Cornwall County Council, the South West of England Regional Development Agency, the Welsh Development Agency, British Waterways, the Environment Agency, Network Rail and DEFRA (UK Department for Environment, Farming and Rural Affairs), is the first project with the specific aim of developing biological control for an invasive weed in Europe and the first in the world to research the potential for the biological control of Japanese knotweed.

The story behind Japanese knotweed's emergence as an invasive weed will strike chords with weed biocontrol scientists around the world. It was first introduced to Britain in the 19th century as an ornamental plant, and was actually awarded a gold medal at a European flower show as best newcomer. These plaudits were in short supply within a few years once botanists realized exactly what an unwelcome guest it was, and this year the plant won a gold at the UK's premier flower show when used by the Cornwall Knotweed Forum to highlight its dangers.

Japanese knotweed is now a major problem in Cornwall (England's most southwesterly county) and Wales, with sand dunes, forests, riverbanks, canals, waterways, road verges, railway embankments, sites of high heritage value and potential development sites in many areas choked by the weed. Capable of growing from tiny fragments, the plants form large stands, smothering habitats and threatening wildlife. The weed also creates a major problem on 'brown field' (re-development) sites where it can add 10% or more to a developer's cost. Its extensive below-ground root system can cause structural damage, capable of breaking up concrete and tarmac, and soil has to be excavated to a depth of 4.5 m to ensure no fragments remain before building can begin.

The new initiative came about because local authorities had recognized that conventional (chemical and mechanical) control methods for Japanese knotweed were unsustainable and ineffective. It is easy to chop back the plant at the stem, but the weed is equally active beneath the surface. It has an underground rhizome that can spread up to 7 m from the original stem and to a depth of 4.5 m. Even if the land is ploughed up, a new plant can grow from fragments. Pesticides will kill the plant, but this can take years of repeated applications and there are concerns about the toll heavy herbicide use will have on other plants and animals.

- Cornwall currently spends £0.25 million/year controlling the weed.
- The Welsh Development Agency predicts that knotweed will cover some 800 ha of Wales within 8 years, and that the cost of treatment will escalate to more than £76 million by 2010.

A recent DEFRA review of non-native species policy in the UK gave a conservative estimate for knotweed control across the whole of the UK using existing approaches of £1.56 billion, if it were to be attempted.

Alternative technologies were needed. Discussions with scientists from CABI *Bioscience*, which has global experience of biological control spanning 70 years, convinced them that biological control may hold the best long-term prospects for containing the weed.

Biological control has never been used against a weed in Europe. Historically, the continent has been more a source of invasive weeds than a victim of their effects. It has been a rich source for biological control programmes against weeds exported (albeit inadvertently) to the southern hemisphere and North America, with over 380 releases of biocontrol agents sourced from European Union member states. But although Europe is home to a wide range of biocontrol expertise, efforts to interest European governments in biological control have only recently begun to succeed. Invasive weeds, largely escaped ornamentals, have begun to emerge as an intractable problem in Europe for a variety of reasons [see *BNI* 22(3), 54N-56N (September 2001) Europe acts on invasive alien weeds]. At the same time, the obligations placed on signatories to the CBD (Convention on Biological Diversity) mean that governments must act to control invasive alien species that threaten biodiversity. Taken together these have given invasive weeds an unprecedented high political profile in Europe.

In the UK Japanese knotweed is particularly resilient, which makes it all the harder to control. This resilience can be attributed in part to an absence of its natural enemies, and thus classical biological control is an obvious option to pursue. An added bonus in this context is that Japanese knotweed in the UK is essentially just one female plant as every individual is effectively a cutting of the original import. This is good news for biological control as it means the target population has extremely limited genetic diversity, while the absence of sexual reproduction means that currently it has limited chances of evolving defences against a specific natural enemy.

The results of a preliminary phase of the Japanese knotweed project, jointly funded by the USDA Forest Service and the Welsh Development Agency, were encouraging. Field assessments in Japan to assess the natural enemies in the plant's area of origin indicated that many species of insects and fungi attack it in its native habitat, including various beetles and rust fungi that appear to specialize on knotweed. The next phase will involve more detailed survey work with Japanese collaborators and a full technical research assessment of promising species to ensure that they are specific to knotweed and pose no danger to crops or native biodiversity.

The partnership project is led by Cornwall County Council's Natural Environment Team, part of the Environment and Heritage Service. Cornwall led the way in looking at new methods of controlling the plant through the Cornwall Knotweed Forum, which was set up in 1997 to provide guidance and information on policy and control methods, now an internationally recognized example of Best Practice in the control of invasive, non-native species. Project partners do not expect biological control to be a silver bullet, but are hoping that it will stop its spread and allow native species to compete more effectively.

If the Japanese knotweed project is successful there may be calls for more. The mild southwest of the UK that has borne the brunt of the Japanese knotweed invasions is under attack from others. For example, Cornwall's land managers, farmers and gardeners are also battling giant hogweed (*Heracleum mantegazzianum*) and Himalayan balsam (*Impatiens glandulifera*) while native vegetation in its picturesque hedgerows is being smothered by winter heliotrope (*Petasites fragrans*) and yellow archangel (*Lamium galeobdolon* ssp. *montanum*).

Under the terms of the Code of Conduct for the Import and Release of Biological Control Agents (International Standards for Phytosanitary Measures (ISPM) No. 3), the government of a country implementing classical biological control "should designate the competent authority empowered (normally the National Plant Protection Organization) to regulate or otherwise control and, where appropriate, issue permits for the importation and release of biological control agents. The authority may exercise its powers by using an internationally accepted standard (such as this Code) for guidance or by applying national legislation (which should be aligned with this Code. Importations of biological control agents should only be carried out with the consent of the authority."

Thus the final decision on whether biological control agents of Japanese knotweed can be released in the UK will lie with DEFRA. Looking at the furore surrounding attempts to introduced 'GM' crops to the UK, the process of informing the public about biological control needs to be taken as seriously as the search for an effective biocontrol agent. In this context, countries such as Australia, New Zealand, South Africa, Canada and the USA, with a successful history of community involvement in biocontrol, may provide some useful models.

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New Whitefly Killers

Two prospective agents for whitefly control have shown early promise.

The platygasterid parasitoid *Amitus fuscipennis* has been evaluated as a biocontrol agent of *Trialeurodes vaporariorum* on bean crops in Colombia in a PhD project by Maria Manzano (supervized by Joop van Lenteren, Wageningen University, Netherlands and co-directed by Cesar Cardona, CIAT (International Centre for Tropical Agriculture), Colombia). The parasitoid has proved easy to mass rear with a sex ratio strongly biased towards females. Populations of the parasitoid grew faster than those of the whitefly in tropical high and mid altitude zones. In addition, it exhibits area-restricted searching, which is an appropriate searching strategy for a whitefly host such as *T. vaporariorum* which tends to have a clumped distribution. Field releases are planned to find out whether these promising attributes translate into field efficacy.

Coenosia attenuata 'tiger flies' are from the same family as, and are similar in appearance to the house fly *Musca domestica*, but females have three black horizontal stripes on their abdomens. Adult flies kill not only adult whiteflies but also adult leafminers, while its larvae prey on soil-dwelling pests such as fungus gnat larvae. These flies, which have been recorded in Spain, Italy and Germany and thrive in the glasshouse crop environment, are generating great interest as prospective biocontrol agents in protected crops. Studies in all three countries have shown them to be able to reduce whitefly, leafminer and fungus gnat populations, and artificial breeding methods are under development.

Source: European Whitefly Studies Network Newsletter, No 16 (May 2003), pp. 2-3.

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Thomas R. Odhiambo: Founding Father of ICIPE

This article is based, with kind permission, on tributes given at Professor Odhiambo's funeral by Professor David Wasawo and Dr Hans Herren. The Editors also gratefully acknowledge the help of BNI *Editorial Advisory Board member Dr Brigitte Nyambo.*

Professor Thomas Risley Odhiambo, the founding director of the International Centre for Insect Physiology and Ecology (ICIPE) in Kenya, who died on 27 May 2003, was described by ICIPE's Governing Council and staff as "a great scientist and visionary who founded an institution of which all Africans could be proud." In an appreciation of his life, Professor David Wasawo (Chairman, University of Nairobi Council) described him as "a distinguished son of this nation of Kenya; and an incomparable and valued member of the world's scientific community." Hans Herren (ICIPE's current Director General) praised Odhiambo's "dedication to educate and train young developing country scientists."

Herren outlined how a lifelong interest in insects led a small boy who conducted experiments on wasps and their nests to become, via the prestigious Makerere University College in Uganda, Cambridge University in the UK, the University of Nairobi and then ICIPE, Africa's leading biological scientist of his generation. Wasawo described how this began 50 years ago when "the late professor Leonard Beadle who was then the professor of Zoology at Makerere recognised the academic promise of Tom. After his BSc qualification, Professor Beadle arranged for his placement at the Tea Research Institute for East Africa at Kericho as a Research Assistant; and later found him a job as a curator at the Insect Collections at Kawanda Research Station in Uganda. Tom's love for insect science thus started early in his life. In those days every effort was being made at Makerere, to identify brilliant students and enable them to be trained abroad so that on qualification they could return to Makerere as members of staff." Professor Beadle arranged for Odhiambo to be admitted to his own *alma mater*, Cambridge University, from where he emerged with an excellent PhD.

At Cambridge, where he studied under the legendary Professor Sir Vincent B. Wigglesworth, he is remembered as an organized student already capable of excellent research when he arrived. Peter Lawrence (MRC Laboratory of Molecular Biology, Cambridge), who shared a room in the Department of Zoology with him, says, "Tom was very well organised… the central table was divided up between us with a precise boundary in the middle, Tom's pens and pencils lined up like soldiers on his side, a mess on my side. He was always indulgent, putting up with my chaotic attempts to discover how to do research, something he knew all about from the beginning. He used to give me advice… He was so patient with me, and always even tempered and kind. He had a wonderful laugh, and we had a good deal of fun together." Simon Maddrell, still in the Department, describes him as, "a quiet, well organized student who did some excellent electron microscopy under the supervision of Sir Vincent Wigglesworth." Later, in the mid 1980s, when Maddrell was sent by the Royal Society to attend a presentation of science carried out at ICIPE, he found Odhiambo "by then also an excellent politician and manager as he must have been to have been so important in the setting up and maintenance of the centre as a dynamic place with such uncertain lines of financial support."

Professor Wasawo described how Odhiambo's dual talents as scientist and teacher have created their own legacy: "It has often been remarked that good science practice depends upon the quality of questions one poses but a good scientist only comes about as a result of the breadth of knowledge one has acquired in the relevant subject area, and the God-given ability to ferret out the interrelatedness of those bits of knowledge. Tom had all these qualities in abundance, to the extent that he was already publishing refereed scientific papers even before his PhD was out. What is more, he had the uncanny ability as a university teacher to rub off some of these qualities of his onto his own students. It was thus not surprising to see him rise rapidly from being a lecturer in University of Nairobi's Department of Zoology to a full Foundation Professorship in the newly created Department of Entomology in the Faculty of Agriculture in a matter of 6 years. A few months later, he became the first Dean of the Faculty. I have been privileged to meet some of his academic children and grandchildren. They all speak very highly of their mentor. Tom had the satisfaction of interacting with these, his children and grandchildren. One academic child is now the Dean of that very faculty of which he was the first Dean."

Odhiambo combined the qualities of outstanding scientist and teacher with those of a visionary. Herren described how: "His love and fascination for insects was only equalled by his love and dedication to the next generation of scientists and their successful undertakings to see Africa and other developing countries move forward in *science-led* sustainable development. This was his vision long before these words became common language." Odhiambo himself said of his university years, "One of the key issues we were always thinking about was excellence. How does one build that into African endeavours?" His answer was ICIPE.

Wasawo recalled the disquiet felt after World War II by "some of the greatest scientists and philosophers of the day, at the disastrous effects of the atomic bomb and the directions scientific research were taking. This led to Albert Einstein, the great philosopher Lord Bertrand Russell, the Nobel Prize winner Joseph Rotblat and others, to found the Pugwash Conferences on Science and World Affairs. In 1965 they decided to hold one of their meetings in Africa at the headquarters of the Organization of Africa Unity. They were anxious to address themselves to the increasing poverty on the African continent, which could be a threat to world peace. One of the ideas that was mooted at that conference was the need to set up first-rate scientific research institutions that would address the needs of the African continent. This took another 4 years before it could happen."

Herren described the history of ICIPE's founding as "somewhat of a legend." While still a young staff member at the then University College, Nairobi of the University of East Africa, in Odhiambo's own words, "a 'serendipitous opportunity' presented itself in 1967 when I took the challenge from the Editor of… *Science* to write a major review of the status of science in Africa. In it, I made a strong plea for establishing a few large centres of excellence... I gave, as an example, the pivotal areas of the management of insect populations in a sustainable, ecologically-friendly way, [using technologies] that would be within the means of the resource-poor rural communities. Strong encouragement to actually launch such a centre cascaded from an over-arching positive response…"

Herren summed up: "This article proved to be a rallying call for attention to be paid to Africa and its development issues. The centre would provide a mechanism and focal point for linking the world's leading scientists with the problems facing the small-scale farmers of the developing world." Wasawo pointed out that Odhiambo's proposal "…because of his international track record in research, could be seriously listened to and looked at [thus] Tom was able to win backers like Professors Carl Djerassi and Eugene Rabinovitch of Pugwash. He obtained support from the various scientific organisations, from foundations, from governments and from multilateral agencies. The International Centre for Insect Physiology and Ecology was born... with Tom as its first Director." In 1977, ICIPE was granted full international status by the Government of Kenya and in 1986 it was converted into an intergovernmental organization by the signing of a charter in a ceremony chaired by the UN Development Program.

From its humble in a small garage, ICIPE moved to purpose-built premises on the University of Nairobi, Chiromo Campus before relocating in 1990 to its present-day headquarters, Duduville, at Kasarani north of Nairobi. A major field station at Mbita Point in Western Kenya was inaugurated in 1986, and other field sites were established in Kenya and neighbouring countries. ICIPE developed and still possesses some of the best facilities for scientific research and development (R&D) on the continent.

Herren noted that ICIPE's three basic missions, as expressed by Odhiambo, still hold good today:

- To create a body of basic knowledge of key tropical pests and disease vectors that attack the people of Africa, their crops and livestock.
- To transform these discoveries and innovations into strategies for managing these pests.
- To ensure that a motivated, highly talented human capital in insect science is built up, so "as to enable Africa to sustain herself and to lead the entire pan-tropical world in this area of endeavour" (his words).

Herren described how the R&D programmes Odhiambo established on important pests of field crops such as stemborers, termites and the desert locust; on disease vectors (yellow fever and malaria mosquitoes and sandflies) and on livestock pests (tsetse and ticks), together with the development of technologies such as NGU tsetse traps and biological control of stemborers, provided a firm foundation on which ICIPE can still build. Wasawo recognized the importance of Odhiambo's clear thinking and leadership, saying, "...it is one thing to found an institution and have a vision for it, but quite another to develop it along the right pathways in order to achieve its goals. Here, Tom's knack for asking the right kind of scientific questions based on his immense knowledge of the subject of entomology came in handy. He formulated research programmes that correctly addressed the problems of pests in their relation to agricultural productivity in Africa. In this he had the instinctive support of his Governing Council, because of the respect he had earned." Herren described how Odhiambo had been strongly influenced by Rachel Carson's book, *The Silent Spring*, which sounded the alarm about pesticide misuse and its implications for ecosystems, declaring how he "understood very early on the problems that the use of synthetic pesticides were (and still are) creating, both for the environment and the farmers, as he recognised that pesticides soon lead into a treadmill from which farmers would eventually beg to be taken off. He therefore based the research programmes at ICIPE on the biological and integrated control track. This was far ahead of many scientists in the developed world at the time. He has been proven right many times over, and today ICIPE is continuing with this philosophy, for the benefit of the farmers and the environment." Wasawo pointed out that, "The research results emanating from ICIPE have helped not only in solving some of the problems addressed; but have also formed the basis for further research, carried out not only at ICIPE but also at universities and research institutions in Africa and elsewhere. ICIPE has thus helped in stimulating the quality of university education in this continent of ours as well as elsewhere in the developing world."

However, both Wasawo and Herren highlighted human and institutional capacity building as perhaps the most enduring of Odhiambo's many achievements. Herren outlined how a highly successful programme for training PhD scientists was launched by ICIPE in 1983. Called the African Regional Postgraduate Programme in Insect Science (or ARPPIS), some 230 students have been enrolled and over a hundred have received degrees. Herren points out that in this way Odhiambo's "legacy in building the human capital to solve Africa's problems lives on, and the ARPPIS and other graduates are now filling prominent positions in universities, government departments and R&D institutions, private companies, and international organisations throughout the continent." Wasawo said, "Professor Odhiambo conceived of and executed the postgraduate as well as postdoctoral programmes in collaboration with universities and research institutions in Africa and elsewhere. He thus made a tangible contribution in the development of high-level manpower and brainpower for various institutions on our continent." Herren noted that ICIPE is proud that most have not succumbed to the temptation to join part of the 'brain drain', and are still working in Africa.

Odhiambo believed that scientific publication and access to literature, and for African scientists to be heard and exchange information with colleagues abroad was an integral part of scientific research, and capacity building. From his years at ICIPE, two important outputs emerged: The first was the international journal co-hosted by ICIPE and the African Association of Insect Scientists, *Insect Science and its Application*, which he served as the first Editor and is now in its 23rd year. In 1987, Odhiambo spearheaded the establishment of a new imprint, ICIPE Science Press, and publication of the journal was moved from the UK to Nairobi. ISP continues to be an active, scientific scholarly publisher. Wasawo noted: "The role of academies in stimulating academic excellence has been well appreciated since the days of Plato and Aristotle; through the foundation of the Royal Society in England up to the present day. Professor Odhiambo acutely felt the need for such academies for the Third World and for Africa. With the Nobel Laureate Professor Abdul Salaam they founded the Third World Academy of Sciences, of which Tom became the first Vice-president. Tom was also the Founding President of the Africa Academy of Science. Who else but Professor Odhiambo could have the capacity and the professional clout to persuade our African presidents of the need for science-based development in Africa; and then set up a forum for them to deliberate on such matters? Thus the Research and Development Forum for Science-led Development in Africa (RANDFORUM) came into being with Tom as its first director." And, always mindful of the importance of the next generation, Odhiambo has also been chairman for the Foundation for the Promotion of Children Science Publications in Africa.

In terms of his own scholarly output, Odhiambo was the author of over 160 peer-reviewed publications and he was awarded numerous international prizes: the Albert Einstein Gold Medal (1991), the Gold Mercury International Award (1982), the Gold Medal Award from the International Congress of Plant Protection (1983), the African Prize for Leadership for the Sustainable End of Hunger (shared with President Albert Diouf of Senegal in 1987), the ISCTRC Silver Jubilee Award of the African Union (2000), and others. He was also awarded honorary doctorate degrees from some of the world's leading institutions. Under his tenure, ICIPE itself was awarded as an organization the St Francis Prize for the Environment (1992), awarded by the Franciscan Centre of Environmental Studies in Assisi, and the Alan Shawn Feinstein World Hunger Award of Brown University (1986).

Herren referred to the "many and varied initiatives of Professor Thomas Odhiambo" and Wasawo described how Odhiambo's broad interests had continued to provide fresh ideas: "Recently he has been developing ideas on community-based university institutions as well as the role of faith and spirituality in human society."

Herren declared that "[Odhiambo's] vision when he created ICIPE with a few friends and colleagues way back in the late 1960s became reality, thanks to his perseverance and dedication. He created an absolutely unique institution, that has become known around the globe for scientific excellence in biological and integrated pest and vector management." Herren said that ICIPE is meeting the challenge of how to pay a long-lasting tribute to Odhiambo by helping "spearhead the formation of a trust in his honour that will help sponsor promising young African academics in their research, among other activities. This will help his legacy live on through the next generations of scientists and leaders."

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IPM Systems

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

Sulawesi Setting for Cocoa IPM Initiatives

Cocoa, like many plantation crops, has a long tradition of over-dependence on chemical pesticides. But it also has the distinction of being a birthplace of IPM. In the 1960s, Gordon Conway, now President of the Rockefeller Foundation, identified use of chemical insecticides as the cause of outbreaks of bagworms and nettle caterpillars on cocoa and worked out the process since dubbed the 'pesticide treadmill'. IPM became the underlying principle of cocoa pest and disease management in plantation systems, but over the last 30 years cocoa has increasingly become a smallholder cash crop. An estimated 80% of the world's cocoa is now produced by smallholders. Often these farmers do not have the knowledge to enable them to implement IPM, and traditional top-down extension has proved to be an inappropriate vehicle for providing IPM training in many crops. In cocoa, which has the capacity to be an important engine of sustainable development, the situation is exacerbated by low farm-gate prices, which mean farmers cannot afford inputs necessary for good soil and crop health. This contributes to the impact of pests and diseases in terms of both increased aggressiveness and an increased range of the organisms involved. Farmers are seeing yields decline, but are trapped in a downward spiral.

Indonesia was one of the world's smaller cocoa producers until coinciding events in Brazil and Indonesia changed this. In the mid 1970s, indigenous smallholders in Sulawesi, using private and public finance, began planting in new areas. The area planted to cocoa increased to more than 0.5 million hectares in 20 years. As the cocoa sector was growing in Indonesia, witches' broom (*Crinipellis perniciosa*) was decimating Brazil's production following the arrival of the disease in the key production areas of Bahia State in 1989. This created a gap in the market which Indonesia could fill, and it is now the world's third-largest cocoa producing and exporting country. There are close to 400,000 smallholder cocoa growers in Sulawesi alone, producing 350,000 tonnes of cocoa annually. The average size of holding is small at 1-2 ha for each farm family.

This rapid explosion of cocoa growing, with 70% of Indonesia's cocoa produced by smallholders, has created its own set of problems. Firstly, the rapid expansion in Sulawesi has not been matched by the development of support institutions, infrastructure or expertise, and this has been compounded by the rapid pace of political reform and decentralization in Indonesia. Secondly, the expansion sometimes threatens the integrity of rainforest adjacent to the cocoa-growing regions, including the Lore Lindu National Park, a vast area of virgin rainforest in Central Sulawesi containing many rare mammals and birds.

Over the last 2 years, smallholders in Sulawesi have experienced a dramatic decline in saleable cocoa with losses now averaging 40%, largely attributable to three major pest and disease problems:

- Cocoa pod borer, *Conopomorpha cramerella* (CPB), a moth that infests over half the cocoa plantings in Sulawesi, causes an estimated 25-40% yield loss; in 2002 these losses were estimated to be 150,000 tonnes, worth US$200 million.
- *Phytophthora* (or black) pod rot and canker, caused by the oomycete *P. palmivora,* typically cause losses of 15%.
- Vascular-streak dieback (VSD), caused by the fungus *Oncobasidium theobromae*, is common but appears not to be destructive on established trees.

Additional losses, estimated at US$25 million, are caused by poor quality of dry beans, mostly due to lack of fermentation.

Lack of farmer know-how in managing pests and diseases is illustrated by an analysis of how Sulawesi's farmers currently deal with CPB. Peter van Grinsven, speaking at a recent workshop (see PRIMA Cocoa project, below), said that very many of Sulawesi's smallholder cocoa farmers use chemical control measures to try and control CPB, but these are probably not used in an effective or efficient way, and there is room for improvement with regard to safety of application.

The constraints faced by the smallholder cocoa sector in Sulawesi are similar to those of many countries, but Sulawesi is also home to some innovative projects that aim to bridge the technology and knowledge gaps and facilitate an improvement in cocoa productivity and quality.

First Success

The SUCCESS (Sustainable Cocoa Extension Services for Smallholders) project uses Farmer Field Schools (FFSs) to demonstrate IPM practices in cocoa to farmers and to show that the extra effort is financially worthwhile. The project has been funded by the US Department of Agriculture (USDA) in partnership with the American Cocoa Research Institute (ACRI) (later merged with and renamed World Cocoa Foundation (WCF)) and the Biscuit, Cake, Chocolate and Confectionery Alliance (BCCCA) in the UK, and implemented by ACDI/VOCA (an international non-profit organization working toward agricultural and smallholder development) in collaboration with the local governments of three provinces in Sulawesi. WCF is a US-based organization, launched in 2000 by the Chocolate Manufacturers Association, ACRI and the Cocoa Merchants Association of America.

Building on the work of the SUCCESS Project which ends in September 2003, a new 3-year project initiative called SUCCESS Alliance has already begun in Sulawesi and West Papua. The project is funded by the US Agency for International Development (USAID) and implemented by ACDI/VOCA, in alliance with WCF and Masterfoods/USA. SUCCESS Alliance aims to improve the quantity and quality of smallholder-grown cocoa in Indonesia and carry on training farmers, through FFSs, farmer-led research and participatory means, to adopt good crop husbandry methods and effective IPM practices which will sustain a regular source of income for them. The new project also seeks to strengthen the partnership between the local governments, universities and farmer groups and the US private sector to better utilize resources to support the sustainable development of the cocoa industry in Indonesia. The project also has regional outreach where it works in the Philippines, assisting local institutions on cocoa production and setting up tree nurseries for cocoa.

Both SUCCESS and SUCCESS Alliance work to improve the income of cocoa smallholders in Sulawesi by reducing crop losses from the CPB through good crop husbandry practices: frequent harvesting, better pruning, sanitation of pod husks and improving fertilizer use, both chemical and organic. These methods are widely know in Indonesian as PsPSP (Panen Sering, Pemangkasan, Sanatasi and Pemupukan) and were recommended as a result of previous research in Indonesia by Dr John Mumford of Imperial College London, UK, with support from BCCCA, ACRI and ASKINDO (the Indonesian cocoa association).

Participatory training has been gaining in acceptance since the 1980s as an effective way of increasing farmer uptake of sustainable production methods. The FFS approach was developed in rice in Southeast Asia and has been adapted for a number of other annual crops. However, adapting it for a perennial tree crop such as cocoa presented new challenges.

The SUCCESS Project has trained over 35,000 to date in 2.5 years, well above the targeted 20,000 farmers. The project successor, the SUCCESS Alliance, will train an additional 30,000 farmers in good crop husbandry practices through FFS. The SUCCESS extension message was built on 2 years of extensive field research conducted in Sulawesi by ACRI, BCCCA and ASKINDO, alongside provincial agricultural department, or *Dinas Pekerbunan*, staff. The combined approach by government and the producing and manufacturing industries ensured a solid foundation to establish a unified extension programme. Involving local extension staff in project development meant the project was designed to fit local constraints and build capacity within the local extension services to address CPB.

In each training village, a demonstration plot is set up where FFS training teaches PsPSP methods to control CPB infestation, good crop husbandry practices are taught and farmers learn about the pest's life cycle by observation. Armed with this knowledge, they then learn how to manage the pest through complete and frequent harvesting, pruning, sanitation and the safe and prudent use of fertilizer, and how to identify the right time for each intervention. Rather than being a passive learning process, the farmers conduct research for themselves to confirm the value of each practice.

Just one year into the SUCCESS programme, cocoa losses from CPB amongst the trainees were down from an average of 40% to 15%, and quality had also improved. By following the practices they learnt at the FFSs, farmers not only saw reduced losses from CPB, but also saw pod sizes improve through better crop management, and benefited from decreased pressure from *Phytophthora* pod disease and rodent problems.

The sustainability and further dissemination of the project message (key issues for farmer participatory training) were also promising. In some areas, trained farmers were hired by untrained farmers to share their skills, which is both an indication of the confidence of trained farmers and a sign of growing business acumen that puts the spread of this technology on an entrepreneurial and more sustainable course.

Building from Local Diversity

An Australian-Indonesian collaborative venture to improve cocoa quality and insect and disease resistance by selecting from local cocoa plantings is being funded by ACIAR (the Australian Centre for International Agricultural Research). The project team, from The University of Melbourne and Latrobe University in Australia, Masterfoods Australia/New Zealand, Ballarat (part of Mars Inc.), the Agricultural Technology Assessment Institute (BPTP) in Kendari, Southeast Sulawesi, and the Indonesian Coffee and Cocoa Research Institute in Jember, East Java, began work in 2000.

From the outset, the project engaged with local stakeholders. The first workshop, at Kendari in June 2001, was attended by agricultural extension staff from 10 cocoa-growing provinces of Indonesia, and cocoa researchers from Java, Papua New Guinea (PNG) and Australia. Participants summarized the current status of the cocoa industry and planned the development of straightforward methods for identifying and screening improved individual trees, especially trees with resistance to CPB, *Phytophthora* pod rot and VSD, from existing cocoa plantings. The purpose was to ensure that selections are adapted to the local environment, and that cocoa growers, extension workers and local scientists manage and control the selection process. Promising genotypes were identified and collections established. Trials to screen the field selections in the face of natural epidemics of the pests/diseases and trials investigating improved farm management practices were also established. A second workshop held at Kendari in June 2002 focused on technical aspects of disease diagnosis and treatment. The newly constructed facilities at BPTP, Kendari were equipped for research in applied plant protection. Thus the project enhances the infrastructure and capability within Indonesia using locally available resources, especially the great genetic diversity of the cocoa already being grown in the country.

So far over 40 collections of promising genotypes, including some international genotypes, have been established at two sites. Cuttings of promising genotypes are prospected with the help of farmers and extension staff, collected from the field and transported and grafted onto existing cocoa trees for evaluation under local conditions. In this way the mother trees are not damaged, and the grafts begin producing pods within 18 months. Yield, pest and disease resistance and cocoa quality attributes can then be assessed under trial conditions. The trials also represent a locally available collection of potentially useful genotypes that can be readily propagated for distribution to farmers. It is planned that elite selections will be distributed widely for propagation, use in other cocoa projects in Sulawesi, and eventual release to farmers. The majority of grafts are now flowering and setting fruit, and assessments of their resistance to VSD, *Phytophthora* pod rot and CPB, and cocoa quality attributes have begun.

While it is expected that some useful selections of high quality pest and disease resistant planting material will be made available to growers as a result of this, and other, projects, an important aim of the project is to demonstrate the usefulness of local selection of improved planting material using straightforward methods based on locally available genetic diversity within the crop. It has been previously shown in PNG that it is possible to select cocoa genotypes with durable resistance to VSD from among a great diversity of planting material exposed to a natural epidemic of the disease. This amounts to natural selection – very susceptible genotypes are killed by VSD and are no longer available for propagation; the failure of the commonly occurring VSD to kill trees in Sulawesi (as occurred dramatically in PNG in the 1960s) suggests that the cocoa there has gone through this selection process over the last 30 years. The aim of the ACIAR project is to repeat this process with *Phytophthora* pod rot and CPB. (There is already evidence of resistance to CPB, as shown by the studies of a scientist at Tadulako University in Palu, Central Sulawesi). This approach is important in a country like Indonesia with its great genetic diversity of a wide range of tropical crops. So far the project has taught some valuable lessons in how to proceed with research and development based on local resources. The method being used in the trials of sidegrafting of improved budwood onto existing trees also demonstrates a method of upgrading existing cocoa plantings with minimal loss of yield during the process, methods already being adopted by some farmers following their observations of the trials. The SUCCESS project is keen to incorporate this method of local selection and sidegrafting, and also any useful cocoa clones that emerge from the project, into their FFS programme.

Reducing cocoa losses due to pests and diseases will also reduce the pressure to expand cocoa plantings into virgin rainforest. Previous studies have shown that integrating cocoa growing with traditional mixed farming minimizes pesticide use and retains up to 70% of the original biodiversity. In a further illustration of good collaboration between universities and industry, PT Effem (a part of Mars Inc.) is assisting with the logistics of establishing the field trials and cocoa quality assessments of pest and disease-resistant selections.

IPM Linked to a Chain Approach

Pest problems in cocoa that lead to poor yields and low quality beans affect not just farmers but cascade along the cocoa chain to where the beans are processed. For this reason, PRIMA Cocoa (Pest Reduction and Integrated Management for Cocoa), a 2-year project that began in January 2003, is piloting both integrated management of pests and a chain approach to cocoa production in Sulawesi.

Despite the achievements of the projects above, the pest and disease status of Sulawesi's cocoa is still sufficiently serious that PT Effem Indonesia in Makassar had to close down its cocoa processing plant temporarily in 2002 as there were simply not enough quality beans available. The situation faced by PT Effem was not unique, as evidenced by the temporary shutdown of a number of cocoa processing factories in Indonesia, and complaints of high waste in Sulawesi beans by regional and international cocoa grinders. The situation in Sulawesi is thus of great concern to all in the cocoa industry.

Masterfoods and the worldwide cocoa industry are committed to promoting sustainable cocoa production systems. With this in mind, PT Effem together with its European sister unit Masterfoods Europe, Veghel and Senter International (part of the Netherlands government international development agency) are funding a project which will introduce, on a pilot scale, an integrated management system to control CPB and also raise bean quality and production by improved agricultural practices and post-harvest treatment. Promising biocontrol methods are being identified, then tested and validated in cooperation with the University of Hassanuddin, Makassar and a local entrepreneur to establish whether they have wide-scale application.

The total pipeline approach also includes cocoa collectors in the pilot area, who will be trained in techniques for proper drying and grading of beans which are then purchased by PT Effem for processing. The improvements should increase the income of smallholders and benefit the environment through the promotion of sustainable cultural and biological control methods. Given the importance of the cocoa sector, its relevance to development on Sulawesi is potentially huge and it is intended that all stakeholders (smallholders, cocoa collectors and cocoa processors) will benefit.

One of the project's first activities was a Technical Brainstorming Meeting on Biocontrol Technologies for IPM in Cocoa in Makassar in June 2003. There has been a good deal of scientific and field-based research on ways of enhancing cocoa production through controlling CPB by mechanical, cultural and biocontrol methods. The majority of this knowledge is spread around different research and academic institutions and private farms in Indonesia and Malaysia. The meeting brought together people with knowledge of CPB control by these various methods to discuss and define the most promising farmer-friendly and practical options for a use in an IPM strategy to control CPB and improve cocoa production in Sulawesi. The most promising CPB control systems will be implemented as part of the PRIMA Cocoa programme.

Topics discussed included genetic improvement, use of ants as predators, entomopathogenic nematodes and fungi, and more efficient sleeving methods. The challenges to designing IPM for the combination of pests and diseases that attack cocoa were highlighted in some of the discussions:

- It seems that where ants are present the incidence of CPB infestation is reduced. However, it is unclear what is needed for successful establishment, what effect a history of pesticide use might have, and what impact introducing ants would have on existing predator populations. In addition some species may carry pathogens such as *Phytophthora.*
- Sleeving has been practised in the past but is a time-consuming process and thus farmers tend to abandon it. A simple pipe and stick technique, which enables >600 pods/hour to be sleeved, has one big drawback: plastic bags are used, which are both expensive and a source of environmental pollution (for 1 ha potentially 6000 bags could be used). Again, there may be a danger of encouraging *Phytophthora* pod rot.

Participants agreed on future research directions, and a basket of measures for immediate incorporation into the PRIMA Cocoa project:

- Harvesting: weekly and complete
- Height management: trees should be <4m; side grafting to rehabilitate old trees
- Sanitation: removing damaged and diseased pods and covering spent husks with plastic for 2+ weeks
- Off-season sleeving, but try to move away from using plastic bags
- Rational pesticide use
- Conserving ants
- Introducing black ant (*Dolichoderus thoracicus*) where confident of success

Websites:

ACDI/VOCA: www.acdivoca.org/

ACIAR: www.aciar.gov.au

Mars, Inc.: www.mars.com/

SUCCESS Alliance:
www.successalliance.org

WCF: www.chocolateandcocoa.org/WCF/wcfindex.htm

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This article has been developed from a series of articles that appeared in the newsletter GRO-Cocoa *(Nos 1 & 3). See:*

www.cabi-commodities.org/

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Announcements

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

Whitefly Symposium

The European Whitefly Studies Network (EWSN) announce that the 2nd European Whitefly Symposium will be held on 5-9 October 2004 at Cavtat in Croatia, hosted by the Institute of Adriatic Crops and Karst Reclamation, Split. Five keynote areas will be covered, giving ample coverage to biocontrol:

- Faunistics, systematics and ecology
- Whitefly transmitted viruses and epidemiology
- Whitefly natural enemies
- Chemical and physical controls
- IPM and biological control

The symposium also aims to address recent advances in European crop protection towards satisfying current legislation and effectively controlling problems.

Further information/pre-registration:
www.whitefly.org/EWSII-info.htm

Or contact the EWSN Events Organizer:
ewsn.organiser@whitefly.org

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IPPC Postponed

The Organizing Committee of the 15th International Plant Protection Congress (IPPC), considering the health and the safety of all participants and in view of uncertainty of the Severe Acute Respiratory Syndrome (SARS) in China at the time a decision had to be made, postponed the congress due to be held in Beijing on 6-11 July 2003.

To prevent the conflict with dates of other international congresses in plant protection to be held next year, the Organizing Committee checked the scientific calendar of 2004 and discussed an appropriate date with the International Association for the

Plant Protection Sciences (IAPPS). The new dates for the Congress will be 11-16 May 2004, at the previously planned venue, the Beijing International Convention Center.

For more information see:

www.ipmchina.net/ippc/ippc-4.htm

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Biocontrol Books from CABI

Two new books from CABI *Publishing* may be of interest to many readers.

Biocontrol and IPM in Africa

This book* synthesizes information on the past successes and on-going challenges for biocontrol, both as a stand-alone approach and as a component of IPM in Africa. The 24 chapters cover largely arthropods (field crop, perennial, agroforestry and forestry pests) and weeds (terrestrial and aquatic species), but diseases (including nematodes) are also covered. The opening chapter gives an historical overview. This is followed by chapters focusing on key pest (cassava and mango mealybug, cassava green mite, mango fruit flies, banana weevil, potato tuber moth, diamondback moth, whiteflies, cereal stemborers, larger grain borer, cotton boll worm and termites) and weed (chromolaena and striga) species, interspersed with others taking a crop-based approach (conifers, commercial forestry, cowpea and coffee). Other chapters cover alien plant invaders, aquatic weeds, plant nematode management and endophytic diversity, microbial control of plant diseases and nontarget testing of the Green Muscle biopesticide. The book closes with a chapter on the role of biocontrol in development and environmental protection in Africa.

Quality Control and Production of Agents

Implementation of biocontrol has been increasing worldwide, and there are numerous companies now mass-producing natural enemies for this purpose, and species for other beneficial purposes such as pollination. This book** provides both background theory and practical guidance in key areas. The opening chapter discusses why quality control is needed. Practical topics covered in subsequent chapters are: mass production including rearing, storage and release of natural enemies; pathogens of mass produced natural enemies and pollinators; quality control of insect and microbial agents, including US and European experience of merging customer and producer needs; risk assessment in relation to regulations for imports and releases; and basic statistical methods. More theoretical topics include natural enemy foraging behaviour, and population ecology and genetics in relation to managing small artificially reared populations. There are also chapters concerning guidelines for quality control of commercially produced natural enemies, and their commercial availability.

*Neuenschwander, P.; Borgemeister, C.; Langewald, J. (*eds*) (2003) Biological control in IPM systems in Africa. Wallingford, UK; CABI *Publishing*, 448 pp. Hbk. UK£75.00/US$140.00. ISBN: 0 85199 639 6

**van Lenteren, J.C. (*ed*) (2003) Quality control and production of biological control agents. Wallingford, UK; CABI *Publishing*, 352 pp. Hbk. UK£65.00/ US$120.00. ISBN: 085199 688 4

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Web: www.cabi-publishing.org/bookshop

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Conference Reports

Have you held or attended a meeting that you want other biocontrol workers to know about? Send us a report and we will include it in BNI.

Weed Biocontrol Symposium

The XI International Symposium on the Biological Control of Weeds, hosted by CSIRO Entomology, was held at the Australian National University in Canberra, Australia from 27 April to 2 May 2003. This 4-yearly symposium series provides one of the most important forums for scientists working in this field of research dealing with the ecology of invasive weeds and the use of arthropods and pathogens to control their spread, as well as with the ethics and risks associated with the overall concept of biological control. The Canberra meeting was attended by about 220 delegates from around the world. Australia, New Zealand, South Africa and the United States were strongly represented but there were also a number of absences due to the recent Iraq war and SARS. The overall emphasis of the conference lay on the importance of ecology as the underlying discipline for biological control. The conference was divided into five main themes: biocontrol theory and new approaches, target and agent selection, risk analysis, integration and management, and evaluation. Fifty-eight talks and 122 posters were presented.

The keynote speech by Donald Strong (University of California, USA), opening the theme ‘theory and new approaches’, gave a general insight into how future biological control needs to diversify as a discipline encompassing not only life but also social sciences. The other topics addressed during this session were the new encounter concept as a potential strategy for weed biocontrol using plant pathogens (Harry Evans, CABI *Bioscience*, UK); the necessity to test climate compatibility of biological control agents in order to predict their establishment and performance in the area of introduction (Marcus Byrne, University of the Witwatersrand, South Africa) and the potential influence of interactions between insect and fungal agents on various aspects of biological control of weeds e.g. agent selection and effectiveness (Richard Hill, New Zealand).

The theme ‘target and agent selection’ was introduced by Peter McEvoy (Oregon State University, USA) stressing the importance of looking at critical attributes of enemies, weeds and environment as well as identifying crucial stages in the weed’s life cycle in order to avoid introduction of non-effective control agents. The majority of talks presented in this session were entomologically orientated, although a pathology paper presented by Carol Ellison (CABI *Bioscience*, UK) looked at the significance of intraspecies pathogenicity in the selection of a pathotype of the rust *Puccinia spegazzinii* for classical biological control of mile-a-minute weed (*Mikania micrantha*) in Southeast Asia (see ‘Can the ‘Green Tidal Wave’ of Asia Be Curtailed?’, General News, this issue).

The theme ‘risk analysis’ was divided into three sessions. Criticism of weed biocontrol usually focuses on the danger of biocontrol agents attacking species other than the target weed. Hence, the talks presented generally dealt with how to minimize such risks, e.g. through rigorous refined specificity testing procedures, or how to assess and weigh the risk associated with the use of biocontrol agents. An example of how to assess and manage the risk of using the non host-specific pathogen *Sclerotinia scleroti-*

orum was presented from New Zealand (Graeme Bourdôt) where the extent of safety zones around biocontrol sites were estimated based on models of escape and aerial dispersion of its spores. Lars Baker (Wyoming Counties, USA) gave an interesting talk on the impact of leafy spurge biological control agents on non-target spurges. Although the introduced leaf beetles fed on the indigenous spurge, which occurred in the same habitat, they preferred the target weed, which they controlled, and the net effect was for the indigenous spurge to become more common. This was picked up by Tony Willis who pointed out very clearly that in evaluating the risk that biological control agents present to indigenous plants, the fact that a biological control agent may feed on an indigenous species is not critical, but it is the impact on that indigenous plant which needs to be evaluated. Jim Cullen picked up in this in his concluding presentation (see below) and it is a message that needs to reach biocontrol's customers and the public.

Many talks presented within the theme 'integration and management' gave overviews of individual biological control programmes and extension work as the socioeconomic dimension. Overall release strategies of agents were also frequently addressed as for example in the paper given by Alana Den Breeÿen (Plant Protection Research Institute (PPRI), South Africa). The speaker documented the release strategies adopted for *Mycovellosiella lantanae* var. *lantanae* against *Lantana camara* in South Africa using a combination of isolates to target a wide range of *L. camara* biotypes in the field as well as releasing them over a range of environmental conditions.

The last main theme addressed different aspects of evaluating weed biological control. Cheryl Lennox (PPRI, South Africa) presented the success story of the Australian gall rust *Uromycladium tepperianum* released into South Africa in 1987 against the invasive shrub *Acacia saligna* which is now considered to be under complete biological control. Jane Barton (New Zealand) reported that in plot experiments in New Zealand control of the Central American weed *Ageratina riparia* using the introduced white smut *Entyloma ageratinae* benefited the native vegetation rather than, as often feared, other weedy exotics, while the last speaker of the symposium, Andrew McConnachie (University of the Witwatersrand, South Africa), put some hard figures on the successful biological control of *Azolla filiculoides* in South Africa with a calculated benefit-cost ratio of 2.5:1 for 2000 and a forecasted ratio 15:1 by 2010.

Several workshops were organized by individual delegates including:

'Assessment of biological risk factors associated with the use of exotic organisms in containment facilities' (Glynn Maynard, Office of the Chief Plant Protection Officer, Department of Agriculture, Forestry & Fisheries – Australia (OCPPO/AFFA), Australia). This workshop was organized in order to obtain scientific input from biocontrol practitioners into the policy document currently being drawn up by the OCPPO.

'Where biocontrol is heading in the 21st century' (Rachel McFadyen, Cooperative Research Centre (CRC) for Australian Weed Management). Discussions during this workshop raised a number of issues, which need to be addressed within the context of biological control in the future e.g. the need to select and breed better agents; the issues of genetically modified agents; acceptance of test results from other countries; studies of interactions between agents, weed and native biodiversity; increased legislative problems; intercountry movement; more emphasis on economic issues; future job prospects for researchers. Suggested actions that need to be taken included targeting stakeholders, promoting integrated weed management, promoting internationally agreed testing protocols for insect and pathogens acceptable to regulators and raising the awareness about success stories in weed biocontrol.

'Centres of origin' (Alec McClay, Alberta Research Council, Canada) provided a forum for emphasizing the difficulties in identifying centres of origin.

Jim Cullen (CSIRO, Canberra) closed the symposium on Friday afternoon giving an overall synthesis of the meeting. He pointed out the complexity of the systems biological control of weeds has to deal with, the significant progress which has been made in many areas, but also the attention which is needed with respect to the socioeconomic context, economic evaluations and the predictability of control measures.

This report is adapted from a report written by Marion Seier (CABI Bioscience*) for* BSPP News*, the newsletter of the British Society for Plant Pathology, which funded her attendance at the symposium.*

www.bspp.org.uk/

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Bioherbicide Workshop

The VI International Bioherbicide Workshop, 'Bioherbicides: The Next Generation' was held on 27 April 2003, immediately before the XI International Symposium on the Biological Control of Weeds, at the Australian National University in Canberra, Australia. The workshop, which constitutes the forum of the International Bioherbicide Group, was organized by Maurizio Vurro, Bari, Italy and was attended by some 35 scientists working in the field of mycoherbicides who gave 17 oral and 3 poster presentations.

The workshop explored the possibilities and constraints of using plant pathogens in an inundative approach to control weeds, particularly with a view towards the future of bioherbicides. Four invited speakers, Raghavan Charudattan (University of Florida, USA), Alan Watson (McGill University, Canada), Ken-ichi Yamaguchi (Minami-Kyushu University, Japan) and David Sands (Montana State University, USA) set the scene discussing what traits would be desirable for future bioherbicides, how their efficacy could be enhanced, why overall bioherbicides had only limited success and which factors influence the biopesticide market in Japan. Following on from this several papers presented case studies looking at certain aspects regarding the control of specific weeds with individual biocontrol agents, as well as new research into formulation and application of plant pathogens aiming to overcome environmental constraints. Particularly interesting was a paper by Charudattan and co-workers, reporting on the discovery of tobacco mild green mosaic tobamovirus (TMGMV) causing a systemic, hypersensitive response in and, thus, killing tropical soda apple (*Solanum viarum*), a highly invasive weed in the southeastern United States. Should current attempts to develop and register TMGMV be successful this would constitute the first virus-based bioherbicide. [See also *BNI* 24(2), 31N-32N (June 2003), Tropical soda apple biocontrol bears first fruit.]

The general discussion at the end explored new concepts for bioherbicides, for example formulating cocktails of different plant pathogens effective against several weeds or using strains of plant pathogens capable of producing phytotoxic amino acids. Options for applying plant pathogens, highly virulent but exhibiting less host specificity, were also discussed. Finally, the necessity of choosing the right organisms and the right market niche in order to develop a successful bioherbicide was stressed.

This report was written by Marion Seier (CABI Bioscience*) for* BSPP News*, the newsletter of the British Society for Plant Pathology, which funded her attendance at the symposium.*

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Chromolaena Workshop

The 6th International Workshop on Biological Control and Management of *Chromolaena odorata* was organized by the Chromolaena Working Group, hosted by Dr. R.N. Muniappan (University of Guam), under the auspices of the International Organization for Biological Control of Noxious Animals and Plants (IOBC), with sponsorship from IOBC Asia & Pacific Regional Section and the Australian Centre for International Agricultural Research (ACIAR). It was attended by some_30 scientists from Australia, East Timor, Fiji, Guam, Indonesia, Micronesia, Papua New Guinea (PNG), South Africa and the UK.

This Workshop is held every 3-4 years to discuss current research on the biological control and management of the invasive alien weed *Chromolaena odorata.* Indonesia was originally chosen as the venue but for security and logistical reasons, this was moved to Cairns.

Rachel McFadyen, recently appointed as Chief Executive Officer for Australian Weed Management (CRC), opened the workshop with a history of the research on biological control of chromolaena weed which started with her work on insect natural enemies at CIBC (Commonwealth Institute of Biological Control, now part of CABI *Bioscience*) in Trinidad in the mid-1960s, with funding from the Nigerian Oil Palm Research Institute. Since then, this neotropical plant has become an extremely problematic invasive weed not only in West Africa but also in Southern Africa and throughout tropical Asia and the Pacific Islands. At the last Workshop, held in Durban (South Africa) in October 2000, it was recommended that chromolaena weed should now be adopted to replace the outdated and misleading old name Siam weed.

Since this pioneering research by CIBC, most of the research efforts have continued to be directed at arthropod natural enemies, with some work on fungal pathogens being undertaken by South Africa supplemented by unfunded inputs from CABI *Bioscience*. This was reflected in the presentations most of which concentrated on projects or programmes funded by the US Department of Agriculture and ACIAR (Australian Centre for International Agricultural Research) to introduce and establish two insect agents from Trinidad, the arctiid moth *Pareuchaetes pseudoinsulata* and a tephritid gall fly *Cecidochares connexa* in the Asian and Pacific Regions. Successful control of the weed was first achieved in Guam with the moth but control elsewhere has largely been ineffective and the evaluation of other arthropod agents has continued in both Asia and South Africa, the former funded by ACIAR because of concerns about its continued spread through Southeast Asia and the Pacific islands and the threat posed to Australia.

Successful control seems also to have been achieved in Indonesia and parts of PNG with a combination of the moth and gallfly. However, the search for additional natural enemies is continuing in the Americas, mainly involving South African scientists, for those areas where the gallfly is ineffective, either through parasitism or climatic unsuitability. An excellent study by Costas Zachariades and co-workers (Plant Protection Research Institute, South Africa) detailed the search for the origins of the distinctive South African biotypes; using biogeographical, morphological and molecular evidence, which strongly suggests that it was introduced from the northern Caribbean region. This explains why both insect and fungal natural enemies from South and Central America have proven to be ineffective against the South African biotype and why recent collections from Cuba and Jamaica are showing promise.

A CABI *Bioscience* paper, delivered by Harry Evans was the only one out of the 20 presented which dealt with fungal biocontrol agents. The main emphasis of the paper was on the related weed *Mikania micrantha,* and considerable interest was expressed in the CABI biocontrol project in India since this weed is becoming a serious invader in many countries of the Australasian-Pacific region and has recently been recorded in northern Australia. Amongst the recommendations made at the closing session was that the scope of the Workshop should be broadened to include all invasive Eupatorieae (*Ageratina, Ageratum, Austroeupatorium,* as well as *Chromolaena* and *Mikania*), and that new research initiatives to assess additional natural enemies, including fungi, should be encouraged in countries having problems with invasive Eupatorieae. Barbara Waterhouse (Australian Quarantine and Inspection Service, AQIS) gave a comprehensive overview of the Australian efforts under the Northern Australian Quarantine Strategy (NAQS) to prevent invasive weeds from reaching tropical Australia, and the costly efforts by the Australian peacekeeping forces in Southeast Asia to de-contaminate military equipment.

Owen Zeimer (Centre for Wet Tropics Agriculture, Queensland) presented a detailed report on the nationally-funded campaign to eradicate *C. odorata* and *M. micrantha*, which were first detected in northern Queensland in the early 1990s. *Chromolaena odorata* has proven to be the more widespread, and hence more problematic weed, and an intensive programme involving cultural practices, herbicide application and controlled burning has been on-going for the past 5-6 years. A field visit to these sites followed to appreciate at first-hand the difficulties of topography and logistics which are involved in any eradication campaign.

The concluding papers described potential new biocontrol agents of *C. odorata* and new weed problems involving species of Eupatorieae. Of interest and no little concern, is that a defoliating butterfly (*Actinote)* is being considered for release in China, despite the fact that the host range is relatively wide, including both *Chromolaena* and *Mikania.* Broadening of the Workshop terms of reference, to include all invasive Eupatorieae, appears, therefore, to be propitious, especially since a new invasive weed, *Praxelis* (*Eupatorium*) *clematidea*, closely related to *C. odorata*, has recently been identified in northern Australia and is also invading southern China and Taiwan.

By: Harry Evans, CABI *Bioscience*

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Proceedings

Chromolaena Workshop Proceedings

The proceedings have been published of the 5th International Workshop on Biological Control and management of *Chromolaena odorata**. The workshop was held in Durban, South Africa in October 2000 under the auspices of IOBC (International Organization for Biological and Integrated Control of Noxious Animals and Plants).

As is usual and useful in the outputs of such workshops, country and regional reports (from Congo-Brazzaville, Ghana, Indonesia, Malaysia, Micronesia, Papua New Guinea, the Philippines and South Africa) form a major part of the proceedings. These review the distribution, mechanisms of dispersal, spread and impact of chromolaena, together with status of efforts at containment and/or management in the various countries. The importance of raising awareness of (a) the threat from the weed and (b) the need for resources to combat it are highlighted in presentations from South Africa. A Malaysia report describes how chromolaena is causing coconut plantations to be abandoned. Classical biocontrol is a popular (but not universal) choice, with herbicides, manual control and burning also used. The need for rehabilitation of infested land is discussed in a South African paper, and countries where it is perceived as a useful resource note the need to replace chromolaena with alternative species. Countries are at various stages in control programmes, and reports of successful establishment, spread and impact of natural enemies (for example *Cecidochares connexa* in Indonesia) make encouraging reading, and in particular the successful control achieved with *Pareuchaetes pseudoinsulata* in Ghana. Progress with assessing new prospective agents is summarized in another South African contribution (and there is more on biocontrol in later papers). A different perspective is given by Australian contributions, where chromolaena is not yet established, and they focus on prevention, early detection and hopes of eradication.

Papers on the taxonomy of the tribe Eupatorieae and chromolaena from morphological and DNA-based studies and contributions on the effects of environmental factors on seedling growth, species invasion and regeneration potential – together with one on the impact of the weed on crocodiles – provide useful baseline information for future integrated management strategies.

Contributions that consider impacts and management of chromolaena in both natural and agricultural systems strategies indicate how the impact of the weed may be lessened. From discussions of, variously, lessons learnt from control efforts, how fire may be used to regenerate chromolaena-free land, the Farmer Field School approach in training farmers in biocontrol, and how best to substitute for chromolaena in a cropping system, "judicious guidance" emerges as the key term.

A series of papers on current biological control projects for chromolaena, in conjunction with the country reports, provides a useful accumulation of knowledge on which agents have been released where, and how they are performing. There are also contributions, for various natural enemy species, on host specificity testing, mass rearing, biology, and impact on flowering and foliage, and land management practices, following release. Significant issues include the potential for pathogens, and why *Pareuchaetes* spp. moths have failed to establish in some instances.

A report on the 6th International Workshop on Biological Control and Management of Chromolaena is in the 'Conference Reports' section of this issue.

*Zachariades, C.; Muniappan, R.; Strathie, L.W. (*eds*) (2002) Proceedings of the 5th International Workshop on Biological Control and Management of *Chromolaena odorata*, Durban, South Africa, October 2000. Pretoria, South Africa; ARC-Plant Protection Research Institute, 186 pp.

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