General News

Native Flora Emerges a Winner as Mist Flower Clears

A recent paper in *Biological Control*[1] describes the successful biological control of the invasive weed mist flower (*Ageratina riparia*) in New Zealand. It also describes the results of a study conducted in the Waitakere Ranges, native forest-clad ranges to the West of Auckland, which looked at the impact of decreasing weed populations on the native flora. Such flow-on effects are a key concern in environmentally sensitive areas, especially as exotic weeds affecting indigenous biodiversity are increasingly targets of biological and other control methods, yet what happens post-control is seldom as well documented as it is here. There are few quantitative evaluations showing a decline in a weed population following agent release, and even fewer showing benefits in terms of replacement by more desirable species; where such studies have been conducted, they have been largely concerned with situations where weeds invaded economically productive rangeland.

Mist flower is yet another escaped ornamental. Originally from Central America, it naturalized in many parts of the tropics and warm temperate regions, and became a serious invasive weed in places such as Hawaii, South Africa and northern Australia as well as New Zealand. A perennial shrub/subshrub, it thrives in warm moist habitats, producing numerous small white flowers – which in turn produce masses of small seeds that are easily dispersed by wind or water.

In Hawaii, a biological control programme in the mid 1970s saw the introduction of three agents against mist flower (including the two recently introduced to New Zealand; see below). At that time the weed infested 52,000 ha of rangeland and within 10 years this had been returned to productive use. In New Zealand, the weed infested a wider range of habitats, including forest margins and river systems, wetlands, river and stream banks, walking tracks and open areas, as well as poorly managed pasture and roadsides. With its dense mats of semi-woody stems capable of smothering indigenous vegetation and limiting regeneration in natural habitats, the outcome of removing the weed on the flora in such areas was an issue from the outset. In addition, by the time the New Zealand programme started in the late 1990s, the impact of invasive weeds on biodiversity was being acknowledged, and the potential impacts of exotic biocontrol agents on indigenous species were also being recognized.

When the 5-year study began in 1998, surveys conducted before the introduction of the first agent indicated that mist flower, which occurs mostly in the northern part of North Island, was spreading rapidly. Two agents were subsequently released: the smut fungus *Entyloma ageratinae* in 1998 and the gall fly *Procecidochares alani* half-way through the study in 2001.

The fungus established well and spread quickly through all parts of North Island where mist flower was found. Annual 'snapshots' of fungal infection at a range of sites – estimated from the number of infected live leaves per plant – showed how infection levels increased rapidly and levelled off at about 58%. This is probably an underestimate of the real infection rate as it does not include infected dead leaves, which tend to fall off the plants. Associated with the spread of the fungus and mounting infection rates was a massive drop in average levels of mist flower cover between 1998/99 and 2003/04, from over 80% in some locations to less than 2%.

The gall fly also established but is dispersing more slowly and the time span of the study was too short to judge its impact. Nonetheless, in isolated cases high levels of galling were observed and high numbers of galls have been recorded close to sites of initial release. Comparisons of these early results with Hawaii, where the insect is regarded as playing a significant part in suppressing the weed, suggest the gall fly may in time contribute to the control already being exerted by the smut fungus in New Zealand.

The reductions in weed cover observed in the monitoring sites, where no other management was carried out, were reflected more widely in all the fungus release sites. These were spread over a range of habitats over the entire range of the weed in the Auckland and Northland regions. In addition, informal feedback from the two regional councils and the Department of Conservation suggests that there has been no need for other control measures (herbicides, etc.) against mist flower since the biological control programme ended in 2003/04. In some cases, there has been local extinction of mist flower. However, elsewhere it has appeared for the first time, as it continues to disperse. In such cases it is expected to succumb quickly to the fungus, and new infestations are not expected to reach damaging levels.

The authors conclude that at this point there is no need to consider introducing any additional agents against mist flower.

Post-Biocontrol Succession and Native Flora

Quite apart from its dramatic success in reducing mist flower populations to levels at which other interventions are not needed, this biological control programme is noteworthy for the careful documentation of what happened as the mist flower declined. This study, carried out at sites in the Waitakere Ranges, compared plots with high levels of mist flower with nearby apparently similar plots where there was no mist flower present.

Results indicated that as mist flower declined it was replaced by mostly native species; both species richness and percentage cover by native plants increased in plots where mist flower was declining. By the end of the study, the mean native species richness of the mist flower-infested plots had recovered to almost that of the control plots without mist flower, and overall cover was approaching the same levels too (in other words, biocontrol had not left bare ground). The authors note that the strong re-establishment of native species is a reflection of the seed sources in these native-dominated habitats, where propagule pressure from other exotic species is probably low.

There was evidence that African club moss (*Selaginella kraussiana*) is replacing mist flower at some sites, but it is also invading plots that have never been infested by mist flower. This suggests that it may be an emerging threat that needs watching – and it is not alone; the authors note two other species occurring sporadically but showing invasive tendencies in these mountains: greater periwinkle (*Vinca major*) and Mexican daisy (*Erigeron karvinskianus*).

On the other hand, the decline in mist flower has been of direct benefit to two threatened endemic *Hebe* species. The first, *Hebe acutifolia,* had been previously almost eliminated from one of two known sites by mist flower while the other site had also been invaded. Control of the weed has lifted the status of *H. acutifolia* from 'nationally endangered or vulnerable' to 'range restricted'. The second species, *Hebe bishopiana,* is endemic to the Waitakere Ranges where it has been under threat from invasives: mist flower in particular, and to a lesser extent the related species *Ageratina adenophora* and two exotic pampas grass species (*Cortaderia*). At present it remains 'nationally vulnerable' but if mist flower continues to decline – and *Cortaderia* populations are reduced – it may be removed from this list.

The situation in a suburban release site in Mount Eden presented a different picture: other weeds, such as Montpellier broom (*Teline monspessulanus*) and tree privet (*Ligustrum lucidum*) have taken over; but such locations are dominated by exotic species and native plants would not be expected to benefit here without active restoration planting. In any case, as the authors point out, the greatest concern in New Zealand was mist flower's ability to invade pristine native vegetation and suppress regeneration in areas such as the Waitakere Ranges – and biocontrol in this habitat has demonstrably benefited threatened indigenous flora. Threats from other invasive weeds may well come, but they do not appear to have been exacerbated by the mist flower biocontrol programme.

The authors end by noting that the mist flower biological control programme has been the most rapidly successful and most intensively monitored weed biocontrol programme in New Zealand to date, and serves to indicate how control of just one invasive weed in a natural habitat can benefit the indigenous flora.

[1]Barton, J., Fowler, S.V., Gianotti, A., Winks, C.J., de Beurs, M., Arnold, G.C. & Forrester, G. (2007) Successful control of mist flower (*Ageratina riparia*) in New Zealand: agent establishment, impact and benefits to the native flora. *Biological Control* **40**, 370–385.

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Predicting Potential Ecological Impact of Soybean Aphid Biological Control Introductions

The soybean aphid, *Aphis glycines*, was first reported in 2000 from the heart of North America's soybean-producing region; the US Midwest. Very likely, this invasive aphid was accidentally introduced from Asia (i.e. Japan, China or Korea), the region of origin of this species[1]. However, since it was first reported, *A. glycines* has become an unwelcome guest in North America[2]. It has not only established successfully in its novel environment but also expanded its range very quickly – it is currently present in 22 US states and three Canadian provinces and putting >24 million hectares of soybean at risk. The soybean aphid has benefited from the availability of both its winter host (the invasive plant, *Rhamnus cathartica*) and summer host (soybean, *Glycine max*) throughout the soybean cropping region. As a result, this insect pest has become the principal cause of yield loss in soybean in most parts of its introduced range. Since its arrival, *A. glycines* has caused more than US$1 billion in direct crop loss and additional input costs in the USA with, almost on a yearly basis, a large share of the soybean acreage now requiring insecticide treatment. This is striking because prior to the appearance of *A. glycines*, insecticides were rarely used in soybean with insects causing sporadic, local problems once every 10 to 15 years. Additionally, as this aphid successfully vectors various plant viruses, its effects have not been limited to soybean only but have also affected snap bean, seed potato, and melon production in the Midwest.

Finding and Assessing Asian Parasitoids

The *A. glycines* pest problem partly relates to the abundance, seasonal dynamics and efficacy of natural enemies present in soybean fields in its novel environment. In the US Midwest, a variety of indigenous natural enemies has been reported from soybean, with several generalist predators (e.g. coccinellids, anthocorids, syrphids) having a significant impact on soybean aphid (see, e.g., [3,4,5]). In China, *A. glycines* rarely reaches damaging levels on soybean and is found in association with a diverse complex of predators, while aphid parasitoids also appear of key importance[6,7]. In the Midwest, parasitoids are only rarely collected from *A. glycines* in soybean fields, so researchers have been prompted to consider introducing Asian parasitoids of this pest[8]. Beginning in

2002, US researchers have undertaken foreign exploration trips in Asia to study the ecology of *A. glycines* and identify candidate parasitoids for release in North America.

Twenty-six populations of aphelinid and aphidiine parasitoids have been collected in Asia and studied in quarantine facilities at USDA-ARS (US Department of Agriculture – Agricultural Research Service) in Newark (Delaware) and the University of Minnesota in Saint Paul (Minnesota). Aphidiine braconids comprise a few species and strains of *Binodoxys* spp., *Lysephlebia japonica* and *Aphidius* spp. Aphelinids belong to three species complexes: *Aphelinus-asychis*, *Aphelinus-mali*, and *Aphelinus-varipes* complexes, each of which includes several cryptic species which are reproductively incompatible, phylogenetically distinct, and have different host specificities ([9,10]; K.R. Hopper, J.H. Heraty, J.B. Woolley, unpublished data).

A first selection criterion for these candidate parasitoids was host range testing, in which acceptance and parasitism levels are quantified for a range of target and non-target aphid species. For host range testing, a list of 21 aphid species was compiled that included *Aphis glycines*, several common aphid pests and various native aphid species common in natural habitats throughout the Midwest. This list included representatives from a variety of aphid genera. However, many parasitoids were only tested against a restricted set of seven aphid species in five genera and two tribes on four host plant species in four families (K.R. Hopper, G.E. Heimpel, K.A. Hoelmer, W.G. Meikle, R.J. O'Neil, D.G. Voegtlin, unpublished data). These were chosen to provide contrasts of aphid species in the same versus different genera and tribes on the same versus different host plant species. The goal was to explore the phylogenetic and host plant limits on parasitism, as has been recommended for host specificity testing of entomophagous insects[11]. Parasitoids that reproduced well on soybean aphid but had a comparatively narrow host range were selected for further laboratory testing.

Based on these evaluations, all but five populations tested were considered to have host ranges too broad for safe introduction. However, two species of *Binodoxys* (*B. communis* and an as-yet unnamed species), two populations in the *Aphelinus-varipes* complex, and two populations in the *Aphelinus-mali* complex had relatively narrow host ranges and may prove suitable for introduction.

Introduced Aphid Parasitoids and Non-Target Risks

The aphidiine braconid *B. communis* is very promising. A permit for release has been granted for this species and it is expected that field releases will take place during summer 2007. *B. communis* is not a strict specialist on *Aphis glycines* and parasitizes a number of non-target aphid species, some of which are native to North America. The acceptance and successful development of *B. communis* on several non-target aphid species could potentially benefit its establishment in a novel environment, especially during times of low *A. glycines* population levels. However, this finding also points to the potential for undesirable ecological impacts of introducing this parasitoid and has spurred the development of a rigorous pre-release ecological impact assessment.

Retrospective analyses of aphid biological control provide some insight into the success and safety of biological control introductions against aphids. Analysis of the BIOCAT database, which includes records of almost all of the insect biocontrol introductions against insect targets that occurred before 1990, reveals that hymenopteran parasitoids have had a much higher success rate against aphids than have predators (18–32% success rate for parasitoids versus only 5% for predators). This is good news because parasitoids also tend to have narrower host ranges than do predators thus reducing the potential for non-target effects. While no studies have explicitly investigated whether aphid parasitoids introduced in biological control programmes have had detrimental effects on non-target aphid species, a survey of aphid–parasitoid associations in Chile by P. Starý and colleagues in the 1980s has provided some useful information[12]. From this survey, which was conducted 10 years after a successful biological control programme against several cereal aphids was undertaken, it is apparent that many of the parasitoid species introduced to Chile attack both target and non-target aphid species. These non-target aphids often belong to different genera and even different tribes from the target aphids. While non-target effects on aphids were of little concern in Chile at the time of the introductions, these effects might have been avoided by selecting parasitoid species with narrower host ranges. Of course, this assertion rests on the assumption that parasitoids with broader host ranges are more likely to attack non-target aphids. This assumption is supported by a positive correlation between the introduced parasitoids' native host range (measured as the number of aphid species they have been reported to attack in their native, palaearctic range) and the number of non-target aphid species they attack in their introduced range. Thus, retrospective analyses of aphid biological control suggest that aphid parasitoids with a comparatively narrow host range, such as *B. communis*, have the potential to be both successful and safe biological control agents.

Lab and Field Research on a Promising Parasitoid – Binodoxys communis

Behavioural assays and parasitism trials showed that various factors interfere with *B. communis* parasitism of different aphid species and shape its host range. These barriers are either behavioural (e.g. aphid defence, parasitoid acceptance) or physiological (e.g. presence of toxic compounds, endosymbionts conferring resistance) (N. Desneux, G.E. Heimpel, unpublished data). Native aphid species that only benefited to limited extents from these barriers are *Aphis monardae*, *Aphis oestlundi* and *Aphis asclepiades*. *A. monardae*, a resident of North America's prairie grasslands, is attacked and successfully parasitized. Considering that prairie habitats in the US Midwest are typically highly fragmented and embedded in a matrix dominated by corn (maize) and soybean fields, *B. communis* could pose a risk to *A. monardae*. Moreover, as *A. monardae* population dynamics in the Midwest are in synchrony with those of *A. glycines*, this risk may be exacerbated. To better quantify the ecological impact of *B. communis* release, we conducted studies on parasitoid host and host plant finding, habitat exploitation, ecological host range in its region of origin and the presence of 'ecological filters' in some of the aphids' natural habitats. A last set of analyses dealt with the phoretic association (whereby the parasitoid could be transported by/in the aphid) of *B. communis* with *A. glycines* and, more specifically, parasitoid potential to follow aphids from summer to winter hosts and back.

Many insect parasitoids rely on info-chemicals which emanate from the host, host plant or host plant complex (HPC). To investigate the extent to which *B. communis* employs volatiles from target (i.e. *A. glycines*) or non-target (e.g. native aphids) HPCs, we conducted a series of olfactometer assays. Parasitoids were exposed to odours from *A. glycines*-infested soybean plants and to those from complexes of certain native aphid species (*A. monardae*, *A. oestlundi*, *A. asclepiades*) on their respective host plants. To understand the level of behavioural plasticity in *B. communis* during host foraging, we compared responses of naïve parasitoids to those of parasitoids with oviposition experience on a certain complex. Volatiles from the soybean aphid HPC and several non-target complexes elicited a response in *B. communis* which was reinforced through oviposition experience. Neither naïve nor experienced wasps, however, showed preferences for odours from target vs. non-target complexes in choice tests[13]. These findings do not provide evidence that *B. communis* odour-mediated foraging could further restrict its ecological host range.

However, field experiments in China indicated that *B. communis'* ecological host range may still be confined to a subset of suitable hosts on certain plant species. Bordering a cotton field with an outbreak of *Aphis gossypii* and associated high *B. communis* population levels, we established 4×4 m^2 plots with a total of 58 different plant species, belonging to 14 plant families. Many of the plants were consequently colonized by a myriad of naturally-occurring aphids. At the time that *B. communis* attained peak population levels in the nearby cotton field, plots were visited and screened for parasitoid mummies. Data showed both parallels and contrasts between *B. communis* laboratory host range and the list of aphids attacked in the field. Certain aphid species (e.g. *A. gossypii*) that proved excellent hosts in laboratory trials were not parasitized by *B. communis* when found on certain plants (e.g. *Salvia splendens*).

Introduced parasitoids may maintain a narrower ecological host range through habitat specialization than expected from laboratory studies. Recent research has shown that natural enemies which do not behave as dietary specialists under laboratory conditions do not necessarily put every suitable and acceptable host at risk, mainly because parasitoids forage in a restricted set of agricultural and/or natural habitats. This hypothesis is currently being tested for *B. communis* in northeastern China. Preliminary studies were conducted during 2006, in which we evaluated parasitoid response to ecotones between soybean fields and various natural/agricultural habitats. Sentinel plants were deployed at different distances from the edge between soybean plots (infested by *A. glycines*) and corn, cotton, peanut (groundnut) and forest habitats. Sentinels were potted soybean plants infested with about 100 *A. glycines*, which were exposed to parasitism for 24 hours in a specific habitat. Within each habitat, we also recorded presence of alternative (aphid) hosts and *B. communis* mummies. Present data indicate that *B. communis* may not forage to equal extent in all habitats, with a fairly pronounced edge-effect at the interface of corn and soybean fields. However, it remains unclear whether this is due to absence of suitable hosts or habitat specialization. For this purpose, the in-field deployment of sentinels during 2007 will be supplemented with parasitoid behavioural observations within the various habitats. We also expect to include a broader range of natural habitats, eventually including grassland (due to its similarity to North American prairies) and mid-successional habitats.

Field Investigations for Native Aphids at Risk

To understand the extent to which native aphids are at risk from attack by *B. communis*, one needs to get a better appreciation of their field ecology. Lack of in-depth knowledge of the dynamics of native insect fauna has historically impeded the development of risk assessment procedures for arthropod biological control. More specifically, we aspired to better understand abundance of three native aphid species (*A. monardae*, *A. oestlundi* and *A. asclepiades*) and gain insights into the community linkages they maintain within the North American prairie ecosystem. Field work in prairie sites in the upper Midwest showed that all three aphid species were tended by a variety of ant species. In certain sites, the ant community was very diverse while in others, cosmopolitan ant species such as *Lasius neoniger* were predominant. Also, one of the aphid species (*A. monardae*) commonly inhabits the flower heads of its host plant, *Monarda fistulosa*. These two ecological facets of aphid populations in their native habitats provided the potential for protecting them from attack by exotic parasitoids such as *B. communis*.

To test the hypothesis that *A. monardae* has reduced parasitism from aggregating in flower heads or being tended by ants, we carried out a set of experiments in quarantine. A colony of the ant *L. neoniger* was established in the laboratory and connected to *A. monardae* colonies on cuttings of its host plant. Parasitism rates of *A. monardae* by *B. communis* on flowering stems of *M. fistulosa* were considerably lower than those on vegetative cuttings. Also, attendance of aphids by *L. neoniger* decreased parasitism by *B. communis*, and ants were found to attack and kill foraging wasps and to prey on parasitoid mummies[14]. These physical and ant-mediated refuges, present within the natural environment of native aphids, could act as ecological filters that separate non-target organisms from introduced parasitoids and ultimately make the practice of biological control more safe.

In addition to being protected from parasitism through these physical refuges, native aphid species can also occur in geographical regions where introduced parasitoids are less likely to establish. However, the distributions of *A. monardae*, *A. oestlundi* and *A. asclepiades* were unknown. Using museum records of each of these native aphids, we mapped their distribution in North America. For this purpose, we used DesktopGarp, a software package for biodiversity and ecological research (http://nhm.ku.edu/desktopgarp). Some of these species had distribution patterns that covered most of North America, well beyond the US Midwest soybean growing region. When aphid distribution maps were overlaid with the predicted distribution of *B. communis* in North America (based on climatic similarity – using Climex®, Hearne Scientific Software, Melbourne, Australia), we found various areas that could function as 'geographical refuges' from parasitism by this parasitoid.

Assessing Likelihood of Parasitoid–Aphid Phoresy

While studying interactions between *B. communis* and its target host, researchers became concerned that certain facets of *A. glycines* biology could either compromise parasitoid establishment in its novel environment or increase the likelihood of non-target effects. More specifically, as *A. glycines* is a heteroecious (host-alternating) species that uses at least two host plant species (soybean and the deciduous shrub, *Rhamnus cathartica*) in vastly different environments, this could have major implications for host use amongst its parasitoids. Parasitoids that build up their population levels in soybean fields during the growing season would have to make a dramatic host or habitat shift to cope with the migration of *A. glycines* to its over-wintering host in early fall. Along these same lines, *B. communis* successfully attacking *A. glycines* over-wintering colonies in woody habitats needs either alternative hosts in those habitats during times when the soybean aphid is absent or an intimate coupling with the *A. glycines* life cycle. However, two key findings pointed in the direction of a phoretic association between *B. communis* and *A. glycines*. Parasitism trials showed that *B. communis* readily attacks and successfully develops on alatoid nymphs and winged adults (alates) of *A. glycines*. Also, observations in China indicated large numbers of parasitized aphids at the start of the colonization period on soybean[6], suggesting that *B. communis* could have arrived within *A. glycines* alates. As a result, research was initiated in summer 2006 at the Chinese Academy of Agricultural Sciences in Beijing (China), looking in more detail into the potential for phoresy in *B. communis* and the associated likelihood of this parasitoid migrating within *A. glycines* from soybean to over-wintering habitats and back to soybean. Using a state-of-the-art aphid flightmill, the flight capacity of parasitized and un-parasitized winged aphids is being compared, including spring, fall and summer soybean aphid migrants in the trials. Preliminary results tend to confirm the phoretic association between *B. communis* and *A. glycines*, which could greatly reduce the potential for undesirable ecological impact.

Prospects and Future Work

With *B. communis* scheduled for 2007 release against *A. glycines* throughout the US Midwest, researchers have a wealth of data on the ecology and biology of this parasitoid. Our emphasis on ecological safety is exemplified by the many species/strains of parasitoids rejected because of broad host range, and also by our ecological field studies in both the native and introduced ranges. Our focus on gaining insights into ecological and phenological characteristics of the native insect fauna prior to release of *B. communis* not only allowed an informed ecological risk assessment but also sets the stage for post-release impact assessment. Intensive scouting will be continued in natural habitats at various locations in the soybean growing region, to capture the extent of non-target effects on the native aphid fauna (R.J. O'Neil, personal communication). Post-release monitoring will prove extremely valuable in assessing to what extent some of our predictions (based on laboratory studies or field work in China) actually hold in the field. Despite some level of uncertainty, we need to stress that the successful implementation of biological control introductions against *A. glycines* would provide a sustainable, environmentally-sound solution for a destructive pest that affects one of the key US agricultural commodities. Successful suppression of *A. glycines* then also carries the promise of a considerable reduction in pesticide use in soybean fields and a release from the environmental pressure to which Midwest agro-landscapes have become subject.

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IPM for *Maruca vitrata* on Food Legumes in Asia and Africa

Food legumes such as yard-long bean, mungbean, hyacinth bean, soybean, peas, lentil and cowpea are important food crops grown in Asia and Africa. They are currently grown over an area of 50 million hectares in South and Southeast Asia and sub-Saharan Africa. They are an important source of plant proteins in the human diet throughout these regions. In addition, they also fix atmospheric nitrogen, thereby improving soil fertility. However, tropical food legumes are highly susceptible to pests and diseases which reduce yields and the quality of produce. Among the plethora of insect pests, the legume pod borer (LPB), *Maruca vitrata,* is the most serious. LPB larvae attack flower buds, flowers, and young pods, and up to 80% yield losses have been reported[1].

At present, farmers rely exclusively on the application of chemical insecticides to combat LPB. In order to achieve effective pest control, larvae must be killed within a very brief period, after they hatch from eggs laid on the leaves and before they start boring inside flowers or pods. Once the larvae bore inside plant parts, they are out of reach of most ordinary control measures. This leads farmers to spray their crops very frequently, with five (and sometimes more) different kinds of pesticides. It is quite common for farmers to use pesticides over twenty times on one crop in one season[2]. Intensive use of chemical insecticides results in environmental degradation, decimation of natural enemies, and an increase in pest resistance and resurgence. The resultant increase in the cost of production that makes food legumes more expensive for poor consumers and the occupational hazards to farm workers are additional dimensions of pesticide misuse. Alternative pest management strategies are warranted based on economic as well as social and environmental issues.

Biological Control

LPB is a serious production constraint on the food legumes which occupy almost 29 million hectares in South and Southeast Asia. AVRDC – The World Vegetable Center, based in Taiwan, has recently started developing an integrated pest management (IPM) strategy to manage this insect on yard-long bean to reduce pesticide abuse as well as to increase yields. A similar approach has been followed for more than a decade by the International Institute of Tropical Agriculture (IITA), based in Nigeria, to combat this insect pest on cowpea, which is an important component of the African diet[3]. The sustained research efforts from these International Agricultural Research Centers (IARCs) have revealed the presence of potential natural enemies and entomopathogens for LPB upon which an IPM strategy could be built.

Natural Enemies

Several parasitoid species have previously been reported to attack LPB larvae in different parts of the world. However, they have not been exploited successfully in biological control programmes due to the low level of parasitism observed with most of them. LPB has been found damaging *Sesbania cannabina*, a leguminous green manure crop grown all over Taiwan during the summer season. Although a few other related species like *S. pachycarpa* have been reported to be widespread host plants of LPB in Benin, *S. cannabina* has not been recorded as a host plant outside Taiwan. This green manure crop is rarely sprayed with insecticides in Taiwan, and at AVRDC we have investigated the large numbers of natural enemies, especially parasitoids, attacking LPB larvae on *S. cannabina* in Taiwan with a view to exploiting them in the biological control of LPB. Huang *et al.*[4] recorded three braconid wasps (*Apanteles taragamae*, *Bassus asper* and *Dolichogenidea* sp), three ichneumonids (*Trichomma* sp., *Triclistus* sp. and *Plectochorus* sp.) and two unidentified tachinid flies. In subsequent years, another ichneumonid wasp, *Trathala* sp. has also been observed on LPB larvae. However, we suspect an error in the original identification of two species of tachinid flies, which probably occurred because of the difference in sizes between the sexes. We have identified only one species, *Nemorilla maculosa*, a larval–pupal parasitoid.

Within this parasitoid diversity, *A. taragamae* and *N. maculosa* were concluded to be the most promising candidates to be exploited for the biological control of LPB. This is because *A. taragamae* was observed to exert as high as 63% parasitism and *N. maculosa* is quite active during both summer and winter seasons achieving about 40% parasitism in both. Although these parasitoids have been recorded on a few other pyralid moths, their parasitism is considerably higher on LPB larvae in the pest's natural habitats.

IITA imported *A. taragamae* from Taiwan in 2005 and conducted a series of preliminary, pre-release studies, particularly with regard to host range, ability to locate LPB on the different host plants on which it feeds, and basic reproductive biology with a view to optimizing mass rearing. Based on the outcome of these studies, experimental releases were carried out, in collaboration with national programme scientists and plant quarantine officers in Benin and Ghana, on patches of natural vegetation comprising major host plants for LPB such as *Pterocarpus santalinoides*, *Lonchocarpus sericeus* and *Pueraria phaseoloides*. Monitoring surveys to assess establishment have already been initiated in both countries, but LPB population levels have been too low throughout the last few months to be able to observe signs of parasitism by the released *A. taragamae*.

In addition to this, IITA has been actively working on a few indigenous African parasitoids of LPB[4], including two braconid species: *Phanerotoma leucobasis* is one of the prominent parasitoids on LPB larvae in Africa; *Braunsia kriegeri* is another potential candidate, although its parasitic efficiency is highly influenced by the nature of the host plant on which the LPB larvae feed. The third larval parasitoid worth mentioning is *Pristomerus* sp., an ichneumonid wasp, but its parasitic efficiency is low compared with the above braconids and it has not been identified to the species level. In addition to these larval parasitoids, *Trichogrammatoidea eldanae*, an egg parasitoid, has also been recorded but it may not be able to exert a high level of parasitism because of its polyphagous nature.

Entomopathogens

- *Fungi:* Three species of entomopathogenic fungi, viz., *Fusarium* sp., *Paecilomyces* sp., and *Beauveria bassiana,* have been recovered from several cadavers of LPB in Taiwan by Huang *et al.*[5]. Similarly Ekesi *et al.*[6] observed the ovicidal effect of a few isolates of *B. bassiana* and *Metarhizium anisopliae* in Nigeria. However, their ability to control LPB on tropical food legumes has not yet been practically exploited.

- *Bacteria:* Because of its widespread activity against lepidopteran insect pests, *Bacillus thuringiensis* (*Bt*) is being used in the management of several insect pests including LPB. Among the different *Bt* formulations tested at AVRDC, Dipel (*Bt* subsp. *kurstaki*) and Florbac (*Bt* subsp. *aizawai*) were found to be highly effective against LPB.

- *Viruses:* About 10 years ago, IITA identified a cytoplasmic polyhedrosis virus (CPV) infecting LPB larvae in Benin. Although this CPV has some limitations for managing borers like LPB because it causes chronic rather than lethal disease, it can still be exploited in pest management as the infected adults may be dysfunctional or have reduced viability/fecundity. In addition, it could be vertically transmitted from one generation to the next. Besides CPV, a granulosis virus (GV) has been reported from Benin, Kenya and China. A new entomopathogenic virus which was distinct from CPV and GV was found to infect LPB larvae in Taiwan during 2004. Subsequent characterization of this virus at AVRDC, in collaboration with the Southern Taiwan University of Technology, led to the discovery of a nuclear polyhedrosis virus (NPV) specifically infecting LPB larvae[7,8]. This is the first record of an NPV infecting LPB and it was named MaviMNPV. A few NPV formulations have already been produced using MaviMNPV and they are currently under field evaluation at AVRDC. IITA also imported MaviMNPV in 2006 and it is currently being studied in controlled experiments at IITA-Benin. Preliminary observations indicate the high potential of this virus as a biopesticide for the control of LPB.

Sex Pheromones

A synthetic sex pheromone for LPB consisting of (E,E)-10,12-hexadecadienal, (E,E)-10,12-hexadecadienol, and (E)-10-hexadecenal[9,10] was developed by the Natural Resources Institute (NRI), UK and has been used to attract male moths in Benin and Ghana, while (E,E)-10,12-hexadecadienal alone has been shown to be most effective in Burkina Faso[11], when they were evaluated under field conditions in collaboration with IITA. Neither pheromone is effective in Southeast Asia, while a variant blend is effective in South India. Intervention thresholds based on pheromone trapping could be used to time applications of MaviMNPV in order to maximize its impact in the field. This approach has already been used with *Helicoverpa* NPV (HNPV) on chickpea and pigeonpea in India[12]. The geographical variation in the appropriate blend of LPB sex pheromones is currently acting as an obstacle to the implementation of similar trap-based monitoring of the pest in some regions of the world where subsistence legume crops are extremely important.

Neem

Variable results have been obtained with the application of neem-based pesticides against LPB. Aqueous extracts of neem seed at 10% were reported to be effective against LPB on cowpea in Nigeria[13] and Ghana[14], although neem seed extract was not as effective as the synthetic insecticides for the LPB on pigeonpea in Kenya[15]. However, neem oil formulations have exhibited a high degree of insecticidal activity against LPB larvae[16]. Hence, neem-based pesticides could be evaluated in combination with other biopesticides such as MaviMNPV and *Bt* to develop an effective IPM for LPB on major food legumes in tropical regions.

Future Direction

LPB is thought to have evolved in Southeast Asia and possibly spread across Asia and into Africa. Success in controlling it would be higher if we could explore the parasitoid complex in its region of origin to identify the most efficient parasitoid(s) specifically infesting LPB. A grant proposal has been developed to fund such exploration with a view to introducing the most effective parasitoid(s) discovered, together with MaviMNPV, *Bt* and neem, to other parts of Asia as well as sub-Saharan Africa for classical biological control of LPB.

Differential responses to the pheromone blends in different geographical regions in Asia and Africa currently restrict the use of this pheromone for predicting LPB outbreaks. Understanding population differences will assist in improving the predictive capability of pheromone traps, thus enabling timely interventions in important legume-growing regions. The geographically separate populations of LPB have their own preferential host plants. Cowpea and several leguminous trees such as *Lonchocarpus sericeus* are preferred in sub-Saharan Africa; pigeonpea and hyacinth bean in South Asia; *Sesbania cannabina* and *S. grandiflorum* in Taiwan; yard-long bean in Indonesia, Cambodia, Philippines and Thailand; and soybean in Vietnam. This may have led to the development of genetically distinct populations (sympatric host-plant races) and thus different pheromones. This has apparently occurred in some other pyralid pest species like *Ostrinia nubilalis*. Another project proposal being considered would aim to test the hypothesis that observed differences in responses to sex pheromones among distinct populations can be explained by genetic separation. The ultimate aim is to refine the performance of sex pheromone trapping so that it could be integrated into an IPM programme.

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New Zealand Releases Roller against Boneseed

In New Zealand, boneseed (*Chrysanthemoides monilifera* subsp. *monilifera*) is a threat to low coastal vegetation, which it can rapidly take over and replace. It shades out seedling trees like pohutukawa or New Zealand Christmas Tree (*Metsiderosis excelsa),* which, although a tough and adaptable coastal tree, needs a lot of light for seedlings to grow. Ironically, pohutukawa is itself emerging as a weed problem in South Africa where there are now restrictions on its propagation and sale.

Boneseed has invaded coastal cliffs, sand dunes, grassland and roadsides in North and South Islands of New Zealand, even crowding out gorse on coastal sites, and its thick growth cuts off access to beaches, especially when it takes hold in sand dunes. Offshore islands are particularly vulnerable. The scale of the problem and its growth on often inaccessible terrain means controlling the weed with herbicide is not feasible. It is difficult to control because of the large numbers of seeds it produces – up to 50,000 per plant per year – which can remain dormant in soil for up to 10 years. Its spread is aided by birds and possums which eat the fleshy fruit and spread undigested seeds. Seed germination is stimulated by fire.

In February 2005 the Environmental Risk Management Authority (ERMA) approved the release of the boneseed leafroller moth (*Tortrix* s.l. sp. *chrysanthemoides*) in New Zealand. It has previously been released in Australia and is regarded as the most damaging natural enemy in boneseed's home range in South Africa. First releases in New Zealand were made at the end of March 2007 on Waiheke Island, in the Hauraki Gulf off Auckland's Pacific coast.

While scientists in New Zealand continue to release the leafroller in other locations and wait to see how the agent performs, in South Africa scientists are testing a promising rust species, *Endophyllum osteospermi* on native New Zealand species.

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Can Everybody Become an Expert Weevil Taxonomist? A New Lucid Key

Delays in the implementation of biological control programmes against salvinia, cassava mealybug and others underlie the important role of taxonomy in this field. However, at a time when more taxonomists are needed to support biological control and other biodiversity conservation efforts, the discipline continues to decline – the so called taxonomic impediment. New invasive species continue to emerge at alarming rates and the importance of taxonomy has become even more apparent in the context of trade. Given the growing shortage of taxonomists, the need for development of new tools to facilitate identifications has become clear.

For more than two centuries, dichotomous keys have been the primary tools for taxonomic identification. Now a revolution in computer diagnostics is underway that may result in the replacement of traditional keys by matrix-based computer interactive keys. Such computer based decision support tools offer a unique solution by capturing knowledge resident in the diminishing number of taxonomists or in complex print-based dichotomous keys in a simple and easy to use macromedia format. These tools utilize high definition images and can include extensive background information available in the literature. The tools can also be deployed on the Internet allowing access across the globe. Interest in this new direction has been spurred in part through development of user friendly macromedia matrix -based interactive keys, especially Lucid™ which was developed by the University of Queensland, Australia (www.lucidcentral.com). Already a range of such tools, mainly for pest taxa, have been developed. The Center for Biological Control in the College of Engineering Sciences, Technology and Agriculture at Florida A&M University in Tallahassee, Florida (USA) has also recently launched a Lucid-based key for the identification of weevils used in the biological control of terrestrial and aquatic weeds in North America[1].

This tool was developed by Drs. Muhammad Haseeb, Charles O'Brien, Wills Flowers and Moses Kairo and is freely available on the Internet (www.famu.org/weeviltool). It is aimed at general biological control practitioners or those involved in faunistic surveys. It also has tremendous value as an educational tool. Specifically, the system facilitates easy identification of weevil biological control agents, even by non-taxonomists. Currently, it includes 38 beneficial weevil species in 28 genera. Among these species, 36 are exotic and two are endemic in the USA and Canada. For each species the system provides detailed textual information, images of diagnostic characters and dorsal and lateral habitus using recent auto-montage imaging technology. The system uses 32 species characters, 145 sub-characters and 144 images.

Support for the development of this Lucid-based key was provided in part by the US Department of Agriculture – Animal and Plant Health Inspection Service (USDA-APHIS).

A growing number of agencies is presently focusing on the possibility of expanding the use of Lucid-based identification and diagnostic tools, including USDA-APHIS, USDA-ARS (Agricultural Research Service), California Department of Food and Agriculture, the University of California, Florida A&M University, the Marine Biological Laboratory (Massachusetts), the National Museum of Natural History (Washington DC) and the Smithsonian Institution (Washington DC).

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Plant Pathogens and Host Ranges

A study by US scientists on tropical rain forest species in Panama[1] has raised the possibility that plant pathogens may have much larger host ranges than previously thought. If this is the case, it has significant implications for risk analysis in biological control, as well as for regulating international movement of plants and pathogens.

Experimental inoculations with fungal leaf pathogens have shown that most are polyphagous, but that most plant species within a local community are resistant to any given pathogen. The accepted explanation is that co-existence has allowed local evolution of resistance/susceptibility traits in plants and pathogens. The authors extended this work to a reforestation nursery, which formed an artificial assemblage of species that would not normally be found together, and a semi-deciduous lowland moist tropical forest, where species had been co-existing as a local community. They looked at whether or not leaf pathogens infected the plants.

Currently accepted theory says that the likelihood a pathogen can infect two plant species decreases with phylogenetic distance (i.e. the estimated time of independent evolution). This has been shown for rain forest herbivorous insects – and is the theoretical basis for the centrifugal phylogenetic method of host testing, which underpins risk assessment for potential weed biocontrol agents. The reasoning is that closely related species are more likely to share traits (morphological, physiological, biochemical, etc.) that affect susceptibility/resistance. However, plant pathogens have been less studied; plant host – pathogen records tend to be for economically important plants, and are frequently more based on observation than derived from experimental studies. This also means that susceptible plants have been recorded but resistant ones far more rarely.

In their study, Gilbert & Webb found that most pathogen species had a moderate number of potential hosts (median: 27.7% of 53 plants tested), while only two were restricted to a single host, and few appeared to be very broad generalists. Somewhat surprisingly, the results from the nursery and forest experiments were similar; there was no suggestion that local evolutionary changes had affected resistance/susceptibility.

In both nursery and forest situations, the proportion of plant species that became infected declined with phylogenetic distance, but the steepest decline occurred in the least-distantly related species. The gradual tail-off meant that although, as anticipated, plant species in the same genus tended to be vulnerable to the same pathogens, distantly related plants often showed similar susceptibilities. The authors concluded that, as far as pathogen host range and plant susceptibility/resistance were concerned, the phylogenetic signal (the tendency for related species to resemble each other) extends beyond genus and family to include unrelated angiosperms that diverged early in their evolutionary histories.

The authors note that this work provides the first quantitative assessment of the phylogenetic signal in host range of plant pathogens. As such it provides a benchmark for evaluating the robustness of existing tools, and could be used to develop novel predictive tools, with applications for epidemiology, ecology, biodiversity, agronomy and quarantine. For example, they discuss how it could be used to inform cropping system designs by predicting the likelihood of different crop combinations sharing common pathogens.

They sound a note of caution about current methods of risk assessment for biological control agents, biological invaders and quarantine decisions. They express concern that arbitrary cut-offs at genus or family level – which are widely accepted in risk assessment – underestimate host ranges of plant pathogens and therefore risk. They suggest that analysis of likely hosts based on a continuous logistic function of estimated phylogenetic distance could give more realistic evaluation.

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Prosopis juliflora in India: from Royal Tree to Pariah

A recent publication on *Prosopis* from FAO[1] includes a paper from India which highlights the divergent opinions about introduced *Prosopis* species – and *P. juliflora* in particular. Such conflicts of interest occur in other countries. In India they reflect some wider issues the Government is facing in tackling the problems of its rural poor.

The differing views were summarized in a policy brief written for the Government of India[2]: "Invasion of grasslands, protected forests and nature reserves has alarmed ecologists. Invasion of irrigation channels and arable land has affected the agricultural community, and landowners and large, commercial farmers have seen their income threatened. These groups have put pressure on state governments, which have responded by asking forestry departments to stop further planting of *P. juliflora* and begin eradication programmes, notably in Gujarat, Rajasthan, Haryana and Tamil Nadu. However, *Prosopis* is also playing a vital role in sustaining the livelihoods of the rural poor, including the landless, small farmers and artisans – the least vocal groups of society. These groups want a means to increase the value of this tree, not eradication. In rural areas, *P. juliflora* is often the only source of fuel, small roundwood and dry season fodder, and provides the *only* income for many families."

Many species of *Prosopis* have been considered for growing in dry areas of the world because of the usefulness of their wood for fuel and timber, and the value of their seeds for human and animal food (although the latter is sometimes questioned). However, some species, or species crosses – the provenances of introductions have not always been well documented, are invasive, and form extensive dense thorny thickets that hinder human and animal access. Even so, control – and in particular sustainable control using classical biocontrol agents – is regarded apprehensively by those who believe management through utilization is the solution, especially for poor people living in marginal areas.

This article on *Prosopis* in India continues an occasional series in *BNI* on *Prosopis* [see *BNI* 27(1) and 27(2), March and June 2006]. Readers' attention is also drawn to papers in the recent FAO publication which review *Prosopis* in some other countries[1].

In India a native *Prosopis* species, *P. cineraria* (khejri), has long been a predominant climax member of the flora of the arid zones of the country, notably the Thar Desert in northwestern India, one of the driest and most desolate regions of India and characterized by dry tropical thorn forest. *P. cineraria* provides browse and forage for animals, and the pods are used for animal and human food – they have a particularly important role during famines. Arable crops have been grown in association with the tree for centuries. As a leguminous species, it fixes nitrogen and improves soil fertility, but its deep root system, a survival strategy in this xerophytic species, does not compete with crops for water.

The importance of *P. cineraria* to the people of the Thar Desert is encapsulated in a legend that has spread beyond India's borders, cited by environmentalist groups as an early evocation of environmental awareness and commitment. In 1730 more than 350 members of the Bishnoi, a Hindu sect devoted to living in harmony with the environment, died in Khejrali Village near Jodhpur in Rajasthan trying to protect *P. cineraria* trees from the soldiers of a Maharajah of Jodhpur who had sent them to cut wood for a new palace. The Government of India commemorates the incident through the Ministry of Environment and Forests' Amrita Devi Bishnoi Wildlife Protection Award[3].

But *P. cineraria* grows very slowly, especially during the early stages – and this lay behind the introduction of the New World species, *P. juliflora*. First introduced under British rule in 1857, its potential in terms of adaptability and growth in these new environmental conditions was quickly recognized. Widespread planting followed as it was deployed to check encroaching desert sands and as a 'regreening' tool. In the late 1870s seeds were imported to Madras (now Chennai) following a request from the Conservator of Forests of the Northern Circle (Madras) and planted in arid areas of Andhra Pradesh. Around the same time the tree was also planted in arid tracts of northern India – Gujarat and Rajasthan. *P. juliflora* remained popular for the next century; for example, aerial seeding was carried out over large areas at Marwar in Rajasthan in the 1930s, and during the

1940s it was declared a 'royal tree' and people were instructed to plant and protect it.

Other New World *Prosopis* species have been assessed and introduced since the 1960s, including *P. pallida, P. chilensis, P. alba, P. pubescens* and *P. tamarugo*, but it is *P. juliflora* that fuels the control–utilization debate in India and is the subject of the rest of this article.

In India, *P. juliflora* is now distributed from the state of Punjab in North to Tamil Nadu in South and from Gujarat in the west to Orissa in the East. It grows predominantly in Gujarat, Rajasthan, Haryana, parts of Punjab, Delhi, the plains of Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Maharastra, Andhra Pradesh, north Karnataka and Tamil Nadu. Infestations are seen up to altitudes of 1200 m above mean sea level. Because of its rapid colonizing ability, it has spread over large tracts of arid and semi-arid land; these are its preferred habitat but its ecological adaptability means it has also spread to other zones with more moderate climates. Although comprehensive and reliable surveys on the area infested by *P.juliflora* are not available, the species has established in areas characterized by gullies and ravines, land affected by salinity, degraded pastures, sandy desert areas, degraded forests, and industrial wastelands, in total covering approximately 5.55 million hectares. In its entire range of distribution, the species occur as thickets, woodland or sparse bushes, in a variety of habitats. The rate of expansion of the species is alarming. It is reported that an area under *P. juliflora* in the state of Gujarat has increased from the original planted area of 31,550 ha to 200,000 ha – a six-fold increase within a couple of decades. Remote sensing data has predicted the expansion of the species in the Banni area of Gujarat at a rate of about 25 km^2 per year. Reports predict that by the year 2020, more than 56% of the area in Banni with its rich biodiversity and grassland ecosystem would be under *Prosopis*.

Rural Promise

Although *P. juliflora* was introduced to India for soil conservation and restoration purposes, it also became important to rural economies. It is now the main source of fuel in some areas, meeting some 70–75% of the firewood requirements of people in the tropical arid and semi-arid parts of the country. It gives 40–139 kg high-calorific wood per trees 4–10 years old, even in areas like Rajasthan with less than 400 mm rain annually. The economic and energy value of the wood is increased by making charcoal, which is also lighter to move. *P. juliflora* timber is used for fencing, building and furniture, and is also manufactured into building materials and cardboard. Foliage is used green, in the absence of other browse, and dry, as animal forage, and seed pods are used as a livestock feed, either raw or processed (although some argue that the hardness of the raw pods causes dental breakage and decay). Leaves are also used for mulching and compost, and the tree is used for living fences. There is some pod processing for human consumption, and the pods have been lauded as a famine food, because the tree continues to produce when other food crops and sources fail. The gum has found uses in adhesive and food stabilizer/gelling agent manufacture, and the flowers produce good honey. *P. juliflora* also has reported medicinal uses.

Training in *Prosopis* utilization did not emerge until after the founding of a *Prosopis* Society in 1993 in Jodphur, Rajasthan. In 1998, an international workshop at the Central Arid Zone Research Institute (CAZRI)[4] brought together experts in *Prosopis* utilization from Central/South America as well as India, with samples of their products. Further training courses held in Gujarat, Rajasthan and Tamil Nadu in 2001 included NGOs, foresters, farmers and commercial representatives among participants. In 2000, with funding from the UK Department for International Development (DFID) CAZRI and the UK's HDRA (Henry Doubleday Research Association) published a technical manual on managing *P. juliflora*[5].

Some of the collaborative work undertaken in the late 1990s by HDRA and CAZRI, funded through DFID's Forestry Research Programme, was aimed at collating information on the most common *Prosopis* species in India. Its main conclusions were that: (1) *P. juliflora* can be a very valuable resource for the drylands; (2) efforts to completely eradicate it are overly expensive and likely to be ineffective; and (3) when managed, it can be a very valuable source of commercial products and livelihoods in the drylands.

According to the ICRAF website[6], *Prosopis* has been shown to be an important source of fuelwood and income for low-income earners in Tamil Nadu. The Indian Forestry Department produces and markets *Prosopis* charcoal through special development corporations. Its value for woodfuel, charcoal, timber, furniture construction, animal feed, human food, and medicinal products have been documented and increasingly exploited. Its value for reclaiming degraded saline soils has also been widely acknowledged. The Planning Commission of India's Action Plan for Greening India identifies *P. juliflora* as one of the most promising agroforestry options for problematic and saline soils. Its edaphic adaptability is striking, growing in all type of soils, from sandy to saline-alkaline soils, and it is useful for afforesting shifting sand dunes, coastal dunes, river beds, saline-alkaline lands, eroded hill slopes, mine-spoiled areas and other wastelands.

Rural Threat

P. juliflora's wide climate and soil tolerances mean it has expanded beyond the arid and semi-arid areas where it was introduced. Its invasion of pastureland, protected forests, arable land and even water catchment reservoirs has alarmed agriculturalists and ecologists. Initially, it was observed to occur in areas with 150–750 mm mean annual rainfall. But invasions have been recorded in large rice growing stretches of the Cauvery River Delta in Tamil Nadu state with a mean annual rainfall of 1500 mm and where floods and inundation are common occurrences. The species is able to withstand being submerged in water for prolonged periods with the branches and canopy protruding from the water (and can even survive shorter periods of complete immersion, after which the withered leaves regrow). On the other hand, in the southern dry districts of Tamil Nadu, where tank irrigation is the popular and only source of irrigation, and village tanks provide domestic water supplies, large catchment reservoirs (in which rainwater collected during the monsoon is stored for use in subsequent drier seasons) have been invaded by *P. juliflora*. The invasive behaviour of naturally regenerated strands of the weed is posing a threat to India's watersheds and agricultural sector, which is vital as a foreign exchange earner – and because it grows 90% of the food its population eats.

Negative impacts of *P. juliflora* in arid regions should also not be underplayed. The plant's wide ecological amplitude has contributed to its explosion in saline areas such as the Rann of Kutch in Gujarat state as well as the sand dunes of the Thar Desert in Rajasthan. In the Thar Desert it has displaced the native climax vegetation that communities had traditionally relied on, and although *P. juliflora* is valued by them it is less amenable to use than the species it replaced. Wildlife in these fragile environments is also at risk. In Gujarat *P. juliflora* is threatening the survival of the last wild population of Asia's remaining wild ass (*Equus hemionus* subsp. *khur*) in the Little Rann of Kutch Wild Ass Sanctuary on the southern edge of the Thar Desert[7,8]. This area of saline, seasonally inundated saltmarsh is interspersed with sandy, salt-free 'bets' habitat, which rises a vital few metres above the saltmarsh and traditionally provides a wet-season refuge for the wild ass and over-wintering sites for the threatened Houbara bustard (*Chlamydotis macqueenii*). In recent decades, the bets have been invaded by *P. juliflora*. Although the ass falls back on *Prosopis* in times of hardship (feeding on the pods) the plant's aggressive and coppicing growth habits lead to impenetrable thickets which crowd out native vegetation and impede wildlife access.

P. juliflora has been recorded in a wide variety of situations, as described above. In short, any disturbed, eroded, over-grazed or drought-affected land associated with unsustainable management practices is vulnerable. While managed afforestation can successfully restore damaged habitats, aggressive invasion by *P. juliflora* causes suppression of native biodiversity and species diversity in pastures, woodland and arable land – and in water catchment areas it causes increased evapo-transpiration losses and increased siltation. In arid and semi-arid regions, nearly 70% of plant density comes from regeneration from weedy invasion by *P. juliflora*, and fertile lands and watersheds are threatened by invasion.

Control or eradication is a very difficult process. The options are further constrained when the bushy thickets occur in revenue lands (Government lands that are permanently fallow) and when *P. juliflora* woodlands are found in Common Property Resources (catchments areas of village water reservoirs), sites designated to honour village deities preserved with care on socio-religious grounds and grazing lands. This, besides the cost involved, restricts the use of the best possible option for control i.e. felling and uprooting the entire plant stand using heavy equipments like bulldozers. In sparse stands, cutting the aerial shoots and digging out the root mass might serve the purpose well and prevent regeneration of the weed for many years. This activity needs to be done using labour available from rural people as the cut stems and buried root mass could serve as incentives (stems for fuel wood and the root mass for charcoal making) besides the wages paid. Use of herbicides that are commercially available in India often fails due to climatic extremes that hinder the persistence and efficacy of the chemicals and the better adaptability and rejuvenating capacity of the weed in such climatic extremes.

A short term study at the Department of Agronomy, Annamalai University compared the efficiency of different control options including slashing close to the ground, slashing followed by digging out the root mass, slashing followed by burning the residual stumps using kerosene, and slashing followed by treating the left over stumps with a herbicide paste of 2,4-D (60 g a.i. per plant). Naturally regenerated stands of the weed are better managed by slashing and digging out the roots followed by measures to rehabilitate the land such as cropping with fodder grasses, planting smother crops or using self sown live mulches. Another study by the same Department compared the efficiency of different crops/plants for preventing regeneration of *P.juliflora* after slashing and digging out roots. Among a number of different rehabilitative cropping patterns comprising fodder grasses, prostrate legumes and self sown live mulches, prostrate legumes intercropped with sunflower performed better in restoring land and returning it to use.

Balancing Solutions

In the Preface to the recent FAO publication[1], which also includes papers from Kenya, Sudan and Yemen, R. Labrada notes that *Prosopis* may not be dangerous if managed properly, but where it has been introduced solely to improve the environment and without any associated training in its use, plants have been able to spread unchecked. This has left a legacy of problems for which control and utilization have been touted as – often alternative – solutions. Labrada concludes that programmes combining control strategies and utilization are needed, and cites in particular biocontrol (by releasing seed-feeding *Algarobius* spp. bruchid beetles) to contain further spread. He also calls for donor funding to allow affected countries to develop sound farmer training and provide essential equipment for the removal and utilization of *Prosopis*.

P. juliflora has been widely introduced and planted in India, and has become indispensable as a fuel and fodder species in arid and semi-arid parts. The seeds are spread widely by grazing animals. Nitrogen-fixing, and very drought and salt tolerant, it can rapidly outcompete other vegetation. Its thorny bushy habit enables it quickly to block access and make areas impenetrable. But although it is not possible to ignore its negative economic effects as it invades agricultural and grazing land and watersheds, nor threats to biodiversity in the current socio-political climate, these are balanced by the resources it provides to poorer people – and in India this is a vital consideration as the Government struggles to lift the rural population out of poverty. A balance needs to be struck for, as R.M. Kathiresan sums up in his contribution in the FAO publication[1], *Prosopis* is like fire, too good for extinction but too dangerous to allow to spread without keeping watch.

Given enough people with enough motivation, invasive species may contained through utilization but, as China learned through its experience with water hyacinth, this is not necessarily a sustainable solution. There, promotion of water hyacinth as a fertilizer and bird feed led to its spread in the 1970s. When economic conditions improved, use fell and China was left with a water hyacinth explosion it is still trying to contain.

Government of India figures indicate that two-thirds of its population of 1.1 billion, and over three-quarters of its some 350 million poor, live in rural areas. In agricultural areas with large populations, labour for clearing and using *Prosopis* is for the time being not an obstacle, and while the rural population remains locked in poverty, it may provide an attractive economic proposition. Whether this would remain so should the rural economy pick up – as India's 11th Five-Year Plan intends it should – is questionable. Whether proliferation of rural industries based on *P. juliflora* at the expense of food production is desirable is another question. Whether utilization can make an impact on *P. juliflora* in remote and less populated desert areas, such as the Thar Desert – notwithstanding its benefits in the short term to the local people – is even less clear.

Learning the Hard Way

There is one final angle to consider. As countries around the world consider wide-scale introduction and planting of novel species as biofuel crops, experiences with once-lauded species such as *Prosopis* should serve as a lesson: today's miracle can become tomorrow's nightmare; biofuels is a very new sector and much has yet to be learnt about which crops will prove most suitable – agronomically, economically, and technically as fuels. If demand for a crop should peter out, countries need to be sure they will not be left with an incipient problem. In other words, crop introductions, for whatever reason and however strong the pressures, need to be paired with management plans and exit strategies, and this means good prior risk assessment.

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[2]Pasiecznik, N. Prosopis juliflora *(vilayati babul) in the drylands of India: develop this valuable resource – don't eradicate it.* A briefing paper for the Government of India, state governments and concerned ministries based on the project '*Prosopis juliflora* and related arboreal species: a monograph, database and extension manual' (R7295) funded by the DFID Forestry Research Programme. HDRA, Coventry, UK. 2 pp. www.gardenorganic.org.uk/international_programme/ip_publications.php

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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.

Overcoming Sugar's Growing Pains in its PNG Homeland

New Guinea is the centre of diversity for the genus *Saccharum* with several species, including sugar cane – *Saccharum officinarum,* and hundreds of cultivars found there. Nonetheless, a commercial sugar industry was begun in Papua New Guinea only in 1980 when Ramu Sugar Ltd planted fields in the

Ramu Valley, at Gasap, in Madang Province. Until then, sugar had been imported, so the aim was to grow enough to meet local demand. The first crop was harvested in 1982, and by 2002 there were 8500 ha of sugarcane producing just over 49,000 tonnes of sugar, about 2.5 million litres of ethanol and 19,000 tonnes of molasses. But this simple picture of growth masks two decades of hiccups. With extensive stands of wild canes along rivers and roadsides, and domesticated canes growing in village gardens, it is not surprising that Ramu Sugar experienced problems with co-evolved pests and diseases.

From the outset, the presence of some diseases known from other sugarcane-growing countries, such as downy mildew caused by *Peronosclerospora sacchari*, made finding varieties that could be grown successfully at Ramu difficult. However, by 1984 it seemed that an Australian variety, Ragnar, was suited to the environment and gave high cane yields with high sugar content. But in 1985 cane yields were beginning to show an unexpected decline accompanied with unusual leaf symptoms: leaves were short and spiky and developed a mottled and partially bleached appearance. In some cases ratoon crops would struggle to re-grow, and in extreme cases died. Between 1984 and 1986, sugar production at Ramu dropped from 34,000 tonnes to less than 10,000 tonnes.

It was eventually deduced that a new disease of sugarcane was present. Now known as Ramu stunt, it is caused by a virus and transmitted by the leafhopper *Eumetopina flavipes*. By planting resistant cane varieties the problem was overcome and sugar yields exceeded 50,000 tonnes in 1988. Other new diseases have emerged since, but none so serious as Ramu stunt – which is, however, now a potential threat to the sugar industries of neighbouring countries such as Australia.

Then in the late 1980s and early 1990s, insect pests began to impact on the Ramu crop, notably a number of native sugarcane stemborers including a weevil, *Rhabdoscelus obscurus*, and three caterpillars: the noctuid *Sesamia grisescens* and two pyralids, *Chilo terenellus* and *Scirpophaga exceptalis*. Of these, *Sesamia grisescens* was and remains the most serious. This was not unexpected: when commercial growing of sugar cane was first considered, periodic insect surveys of wild and domesticated small-scale sugar cane recovered some 60 insect species and *S. grisescens* was concluded to be the most important one. As well as causing direct losses in cane weight, *S. grisescens* affects cane juice quality and recovery of sucrose is lowered. It has the potential to cause annual losses in sugar cane of up to 31 tonnes/ha, or 18% of the total crop at Ramu, representing a loss of more than Kina 11 million; in addition, each year Ramu Sugar Ltd spends up to US$350,000 to control this species on 9,200 ha sugar cane. The weevil borer is a secondary pest, being strongly associated with damage from the moth borers, notably *S. grisescens*. Both *C. terenellus* and *Scirpophaga exceptalis* may be serious pests at times but crop losses are usually significantly lower than those observed for *Sesamia grisescens*.

S. grisescens is largely restricted to sugar cane and other *Saccharum* spp. with large diameter stalks. Eggs are laid behind green leaf sheaths and hatching larvae feed gregariously there for 2–3 days before boring into the stalk, 8–15 cm below the growing tip. Bored stalks usually die within 2 weeks and extensive rotting ensues as larvae continue to feed and saprophytic fungi invade. In the fourth or fifth instar, larvae migrate to fresh stalks and bore into them leaving large entry holes. Before pupating, the larvae cut an exit hole and then pupate inside the stalk. Some pupation also takes place inside leaf sheaths on the stalk. Population sampling has indicated that *Sesamia grisescens* populations increase during the northwest monsoon (December–March), reach a peak in April–May, and then decline. Life stages are strongly synchronized, with a generation time of 60–70 days and 5.5 generations per year. Field trials have indicated correlation between applied nitrogen and the percentage of stalks bored by *S. grisescens*, and synchronization has been attributed to a nitrogen boost at the start of the northwest monsoon.

Overall, the crop production system is based on an interaction matrix, which is used to identify factors impacting significantly on production – *S. grisescens* is one of the largest constraints and the elements making up its management strategy are outlined below. This is continuously refined as technology advances and knowledge of the pest grows, and since 1997 has succeeded in reducing insecticide use substantially; between 1997 and 2002, the area sprayed with insecticide fell from 19,400 ha to some 2560 ha, and the total of active ingredients applied also showed a strongly declining trend.

- *Monitoring:* For almost 15 years this was based on destructive sampling to monitor numbers of larvae in stalks, costing some US$2/tonne of sugar or $90,000/year, and representing a loss of 3% of the crop. Research into the composition of the *S. grisescens* sex pheromone led to the discovery that a blend of (Z)-11-hexadecenyl acetate, and (Z)-11-hexadecenol was the most effective bait; this is now deployed to monitor moth numbers, at a much reduced cost of $25,000/year. Moreover, the greater reliability and efficiency of the pheromone-based method has led to other gains: control measures can be implemented when moths are in flight, so the insecticide is in place on the plant surface by the time the hatching larvae start to feed there, rather than later, when they are inaccessible inside the stalk and have started to cause damage. Insecticides are also most effective against the young larvae, with up to 100% mortality recorded, and the strategy has seen moth numbers and damage reduced since its adoption.

- *Insecticide application and managing resistance:* Spraying increases yields, up to 200% for cane and 150% for sugar. To manage resistance, and drawing on the approach developed in Australia for *Helicoverpa zea*, insecticide groups are used in alternation in a manner that minimizes costs. An insect growth regulator specific to moths is used in July–October; the cost of this expensive product is offset by the fact it needs to be used on only a small area of young cane. Synthetic pyrethroids have a knock-down effect and their residues have a limited field life; they are also cheaper and are used December–April to protect the larger area of new cane when needed. If large areas need to be covered quickly, or ground-based application is inappropriate (e.g. crop too tall) aerial applications by aeroplane are made. A third type of product, an anti-cholinesterase which acts on the insect nervous system, has shown promise for use and, as an expensive product, may be most useful to treat small areas of cane in the November–December window. Using the resistance management strategy, no insecticide resistance has yet been reported from *S. grisescens*. With regard to safety issues, the pyrethroids are used closest to harvest, which begins in April, but they have short withholding periods of around 7 days only. The other products have longer withholding periods, but are applied months in advance of the harvest.

• *Varietal resistance:* Sites at high risk of infestation have been identified, usually along riverbanks, and are planted with resistant varieties. A particular effort is made to reduce spray drift from these areas into non-target areas by reducing the frequency of spraying.

• *Planting and ratooning times:* More than 60% of the 1800 ha sugar cane replanted each year is planted in March–June, so that by the time *S. grisescens* populations begin to increase in February–March the following year, the crop is semi-mature and less attractive to the pest. Some cane is planted or ratooned in September–November and is highly susceptible, but spraying this smaller area uses less insecticide than if the entire new crop had to be treated.

• *Biological control:* A parasitoid mass-rearing facility now routinely produces two biocontrol agents for release, both species have been used in biocontrol programmes against sugarcane and cereal stemborers in a number of countries: the braconid gregarious larval parasitoid *Cotesia flavipes* is reared from hosts raised on an artificial diet and the eulophid gregarious pupal parasitoid *Pediobius furvus* is reared on pupae. The dark-coloured strain of *C. flavipes* now prevalent at Ramu, which also parasitizes *Chilo partellus,* is thought to be native to the area, although an Indian strain was released as part of the biological control programme in the early 1990s. *Cotesia flavipes* attacks semi-mature to mature larvae; the migrating larvae of *S. grisescens* are particularly susceptible to attack. *C. flavipes* is the most important natural enemy of *S. grisescens* at Ramu with natural populations achieving up to 30% larval control. It has proved a good candidate for augmentation: augmentative releases now provide up to 80% control of *S. grisescens* larvae in the field. The Afrotropical species *P. furvus*, which attacks young pupae, was introduced in 1991 and slowly became established. Non-augmented parasitism in the field reaches at best 10%, partly because *S. grisescens* larval feeding frass blocks the pupal emergence hole, which prevents the emerging adult parasitoids from escaping. However, augmentative releases have increased pupal parasitism in the field to 50%. The ichneumonid *Enicospilus terebrus* is not reared in the laboratory but up to 10% of field collected larvae are usually parasitized by this parasite. Insecticides remain a crucial component of the management strategy for *S. grisescens*, and efforts have gone into ensuring the integration of biological and chemical control: augmentative releases of *C. flavipes* and *P. furvus* can be integrated with the use of synthetic pyrethroids and adverse effects can be avoided if releases are delayed until 10–14 days after insecticide application.

• *Non-target insects:* In 1988–89 up to 30% of the area under sugarcane was treated with carbofuran insecticides to control larvae of *S. grisescens*. This treatment, however (as it was later realized), affected the ant populations especially *Pheidole megacephala* responsible for controlling cicada nymphs. Consequently the cicada *Baeturia papuensis* became a significant pest causing up to 40% ratoon failure in 1989–2001 crops. The withdrawal of this insecticide from use has seen the cicada situation returned to normal again with ants providing effective control. Therefore, ants are currently being used as ecological indicators for the current spraying programme being undertaken at Ramu. Insecticides found to also affect the ants either have very limited use or are being withdrawn.

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Training News

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

Weed Warriors: Catching Them Young

Engaging young children in science and keeping them interested – so eventually some of them become adult scientists – is something educationalists struggle with.

Weed Warriors is a programme developed in 2001 by the Cooperative Research Centre for Australian Weed Management (Weeds CRC). Initially it involved schools in Victoria, but now extends nationally. So far, hundreds of schoolchildren have taken part in classroom projects, experiments and field activities. The aims of this community programme are to:

- Make students more aware of weed management issues and options at a local and regional level
- Actively involve students in a local programme to manage weeds using biological control
- Create links between the community, public land management agencies, local government and industry

At local level implementation is supported by a network of schools, mentors/community groups and individuals – key contacts – who are interested in engaging people in local weed issues and who have knowledge about the management of weeds and/or natural resources in a local area. As well as carrying out weed control on the ground, students are gaining knowledge and awareness of environmental issues, new skills, a sense of stewardship and involvement with community organizations. The programme gives participants the opportunity to learn, hands-on, about invasive weeds and to become part of the solution to the problem. It also addresses a number of key learning areas within state education curricula, is easy and fun for schools to participate in – and creates a bridge to link science and learning in school to the world outside and everyday life.

The programme encourages students to express through words and images what they what have learnt, experienced or enjoyed about being a Weed Warrior. In doing so participants develop a sense of pride in their accomplishments and are given an opportunity to help to educate and encourage others in their community and, through the Mentor Program 'Linking Weed Warriors', across Australia. Encouraging creative communication extends the benefit of the Weed Warriors programme beyond teaching and learning opportunities in science and the environment through to outcomes across a broad spectrum of the education syllabus.

In the first 2 years, Weed Warriors targeted bridal creeper (*Asparagus asparagoides*), a weed found in southern Australia which smothers other vegetation and forms dense mats under the soil surface that can prevent native seedlings from establishing. As part of the project, students reared and released two biocontrol agents: leafhoppers and rust fungus.

Next, the programme focused on gorse, *Ulex europaeus*. This prickly invasive weed is widespread in southern Australia, and if left unchecked forms thickets that provide refuges for feral cats and rabbits and restrict agricultural production. To help the gorse biocontrol initiative, students reared and released gorse spider mites, *Tetranychus lintearius*, an effective biological control agent for the plant. In November 2002, Ardtornish Primary School, north of Adelaide in the foothills of the Mount Lofty Ranges SA, joined the programme and took possession of gorse spider mites, as gorse is prolific in the Mount Lofty Ranges and is having a significant impact on both biodiversity and farmland. Through the programme, the students were committed to breeding the spider mites in their classroom for 6 weeks before releasing them at a local bushland reserve. The students also marked the historic occasion in some more traditional primary school activities – writing songs and stories and making artwork.

In late 2006, New South Wales saw Weed Warriors in action: students from the coastal town of Port Kembla, near Wollongong. Their first task was to rear and release agents of bitou bush (*Chrysanthemoides monilifera* ssp. *rotundata*) on a local infestation. Bitou bush, a Weed of National Significance which causes significant damage to the local environment and economy, is being targeted by leafroller moths, which were first released in Australia in 2001. The biocontrol agent is now causing significant impact on bitou bush infestations elsewhere along the NSW coast.

With a long list of newspaper articles and radio programmes about them, Weed Warriors are also raising the profile of invasive weeds and biocontrol with the general public.

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www.weedwarriors.net.au

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www.environment.gov.au/biodiversity/invasive/publications/weed-success.html

Fruitful Sharing of Knowledge

A new initiative in Australia's Far North Queensland (FNQ) is encouraging fruit growers to share their knowledge and experience of orchard pests to help scientists assess and design sustainable crop protection measures.

Scientists from CSIRO (Commonwealth Scientific and Industrial Research Organisation) together with an industry group, Growcom, and FNQ Natural Resource Management Ltd, are conducting the CSIRO Orchard Pests and Protection Survey, a region-wide survey to investigate the pros and cons of different pest control methods from the growers' perspective. The hope is that the responses from the survey will provide insights into which pests have, from 2004 onwards, had the greatest impact on different orchard types across the region. The scientists are particularly interested in understanding the real costs and effectiveness of exclusion netting.

The survey team hopes to gather first-hand information about the habits and impacts of a range of pests affecting fruit orchards – both 'hobby' and commercial growers. They are aware from discussions with a range of fruit growers across the region that the problem pests vary: parrots may be the main threat to specific fruit crops in one season, but in another it might be fruit moths or flying foxes. Faced with the difficulties of managing orchard pests, growers have developed some innovative strategies to protect fruit trees, and the survey team are keen to find out about these – what works and what does not.

A number of points make this survey particularly interesting. Cyclone Larry (March 2006) had a significant impact on flying fox distribution and behaviour, and this may show up in the growers' experiences of impacts since then. This is also the first survey of FNQ growers to be interpreted using sound ecological data on spectacled flying fox roosting and movement patterns. And it is the first FNQ-wide survey since the use of lethal electric grids was banned as a method of controlling flying foxes.

Source

www.csiro.au/science/FNQOrchardSurvey.html

Announcements

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

Third ISBCA

The 3rd International Symposium on Biological Control of Arthropods (ISBCA), with the theme 'Maximising Success while Minimising Risk', will be held in Christchurch, New Zealand on 8–13 February 2009. Interest can be registered on the website, where suggestions for discussion topics can also be made. A call for proposals for session topics and organizers will be made shortly, and potential organizers are asked to make contact.

Information/Contact:
H. Shrewsbury, Professional Development Group, PO Box 84, Lincoln University, Canterbury,
New Zealand.
Email: shrewsbh@lincoln.ac.nz
Web: http://events.lincoln.ac.nz/isbca09/
Fax: +64 3 325 3685

Biopesticides Meeting in India

A Biopesticides Conference will be held on 28–30 November 2007 in Palayamkottai, Tamil Nadu, India, "focusing on crop protection and production, which are the mantra for sustained and safe food supply." The conference will include the following sessions: Plant products in pest management; Microbial control of crop pests; Natural enemies in biological control; Integrated pest management (IPM); GM crops and nanotechnology in pest management; and Risk management for genetically engineered crops

Contact: K. Sahayaraj, Department of Advanced Zoology and Biotechnology, St. Xavier's College, Palayamkottai 627 002, Tamil Nadu, India.
Email: ttn_ksraj@sancharnet.in
Web:
www.idosi.org/conferences/BIOICON%20circular.doc
Fax: +91 462 256 1765

Bridging the Gap: Population Biology and Biocontrol

The UK Association of Applied Biologists (AAB) is holding a meeting at Studley Castle, Warwickshire on 5–6 December 2007 with the theme: 'Theoretical population ecology & practical biocontrol – bridging the gap'.

Although effective methods for sustainable control of pests of agricultural, veterinary, medical and domestic importance need to be developed, there is a widening gap between practical biocontrol on the one hand, and population ecology and its associated theories on the other. There is a view that those developing commercial biocontrol solutions are not benefiting from new insights provided by academic population ecologists. Equally, population ecologists in academic institutions are becoming less aware of the needs of biocontrol practitioners and the opportunities that their work provides. The aim of this meeting is to explore why the gap exists, and the associated consequences and opportunities. Keynote speakers will address whether there are benefits to be gained from increased dialogue between population ecologists and biocontrol practitioners. Presentations will be given by population ecologists and biocontrol researchers/practitioners. Sessions will be organized around the different strategies used for biocontrol: classical, augmentation and conservation.

Contact: Association of Applied Biologists,
HRI, Wellesbourne, Warwick, CV35 9EF, UK.
Email: Carol@aab.org.uk
Web: www.aab.org.uk
Fax: +44 1789 470234

Hemlock Woolly Adelgid Symposium

The 4th Hemlock Woolly Adelgid (HWA) Symposium will be held on 12–14 February 2008 in Hartford, Connecticut, USA, the state that first expressed concern about the spread and impacts of HWA. The focus of the symposium will be information acquired since the February 2005 symposium, and elongate hemlock scale will be highlighted. The program will include biology, biological control, chemical control, survey and monitoring, hemlock impacts, hemlock management, and hemlock resistance.

Contact: Dennis Souto [USDA Forest Service.
Email: dsouto@fs.fed.us] and
Vicki Smith [Connecticut Agricultural Experiment Station.
Email: victoria.smith@po.state.ct.us].

Distribution Maps of Plants Diseases

CABI in partnership with EPPO (European and Mediterranean Plant Protection Organization) have published the one-thousandth 'Distribution Map of Plant Diseases'. First published in 1942, for the first 50 years distributions were hand drawn on a standard map of the world. Digitization began in April 2006. Now maps can be browsed, searched and used via the CAB Abstracts Plus website (see below). To allow non-subscribers to see the maps and how they have changed over the years, every 100th map will be made open-access – including the 1000th. Suggestions for improving and developing the maps to make them more usable and useful are welcome.

Contact: maps@cabi.org
Web: www.cababstractsplus.org/DMPD/

African Mycology Newsletter

The first issue of *MycoAfrica*, the new newsletter of the African Mycological Association, was published in March 2007. Short (<800 words) mycological articles of African relevance are welcome. Input is also encouraged for news, dates of upcoming events, a classified section, and websites relevant to African mycology. The newsletter aims to include sections dedicated to institute profiles as well as information about mycological projects and activities from across the continent. A regular section will be the African Mycologist Profile which will feature mycologists from around Africa.

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Web:www.arc.agric.za/uploads/images/0_MycoAfrica_vol1_iss1.pdf

New Invasive Plants Journal

The Weed Science Society of America (WSSA) is launching their new peer-reviewed journal, *Invasive Plant Science and Management*, to be edited by J. M. DiTomaso (University of California, Davis). Calls are out for case studies, reviews, symposium papers and other materials such as commentaries on both fundamental and applied research on invasive plant biology, ecology, management, and restoration of invaded non-crop areas; the aim is to cover the increasingly important educational, socio-political and technological aspects of invasive plant management.

Further information: www.wssa.net/WSSA/Pubs/IPSM/AnnouncementCall.pdf
Editor: JMDiTomaso@ucdavis.edu