Biocontrol News and Information **27**(3), 47N–62N
pestscience.com

General News

Glassy-Winged Sharpshooter K.O.'ed – First Round – in French Polynesia

Glassy-winged sharpshooter (GWSS), *Homalodisca coagulata*, has proven to be an extraordinary and highly invasive insect pest with a well documented ability to achieve incredible population densities in new areas when dislocated from its suite of natural enemies. This xylem feeding cicadellid is native to the southeast USA and northeast Mexico and in its native and invaded ranges is a major threat to agricultural, native, and urban landscapes because of its ability to acquire and transmit a lethal xylem-dwelling plant pathogenic bacterium, *Xylella fastidiosa*. This bacterium is native and widespread within the Americas and may exist in other countries outside of the native range having been unknowingly imported in ornamental plants from areas with endemic *X. fastidiosa* populations.

GWSS began its range expansion in the late 1980s, moving into California, USA, probably from the southeastern USA, on ornamental plants. Unparasitized egg masses on the undersides of leaves or small flightless nymphs were mostly likely the original inoculative propagules into California. Adult GWSS are extremely flighty and unlikely to stay on plants that are being subjected to vigorous handling and transport. Inordinate densities of GWSS developed in California and began to spread rapidly out of southern California where populations were originally highly localized. Despite widespread insecticide use in ornamental nurseries to produce uninfested plants for sale and citrus orchards to reduce immigration into vineyards and other crops, immense propagule pressure still resulted and California was most likely the source for GWSS entering Tahiti (Society Islands of French Polynesia) in 1999, and Hawaii in 2004. Easter Island (GWSS detected in 2005) was probably infested with material originating from French Polynesia.

Distribution in French Polynesia

In French Polynesia, GWSS reproduced and spread very rapidly and is currently found in almost all islands in the Society Island group (Tahiti [invaded in 1999], Moorea [2002], Tahaa, Raiatea, Huahine, Bora Bora, Maupiti [2001–2005]) and has also been recorded in Nuku Hiva in the Marquesas (2004), and in Tubuai and Rurutu (both 2005) in the Australs (2005). It is unknown if GWSS is in the Tuamotu group of islands. Widespread and rapid movement of GWSS in French Polynesia most likely occurred via unregulated movement of plants that carried GWSS egg masses or nymphs between islands and island groups by plane and boat. GWSS populations in Tahiti and Moorea reached densities far exceeding those observed in its native range or even California where populations were much greater than those observed in the southeastern USA.

The Problems Caused by GWSS in French Polynesia

High GWSS densities are a major annoyance for people in French Polynesia because feeding adults and nymphs produce astonishingly high quantities of watery excreta that 'rains' from heavily infested trees. This makes utilization of shade trees impossible when trying to find respite from the hot sun and has earned GWSS the common local name *mouche pisseuse* ('pissing fly'). Buildings and vehicles under infested trees are drenched with excreta to the point that water runs off structures and pools on the ground. Such high and continuous removal of xylem fluids by thousands of feeding nymphs and adults is thought to have had a detrimental impact on many plant species in French Polynesia. GWSS is suspected of retarding plant growth and causing declines in fruit production, especially in mangoes and other fruit trees. Large numbers of flying adults are attracted to lights at night, and they invade houses and businesses through open windows and doors, and on occasion adults may 'bite' people as they presumably probe salt glands. But the major concern for French Polynesia is the possibility that this pest could acquire and vector *X. fastidiosa*, which potentially would have a disastrous impact on the agriculture and biodiversity of these isolated islands. Finally, the immense propagule pressure emanating from French Polynesia represents a major invasion threat to other South Pacific countries. Adult *H. coagulata* have been found on planes originating from Tahiti arriving in Japan and in Australia.

Factors Promoting Establishment, Proliferation and Spread

The rapid proliferation and spread of *H. coagulata* in French Polynesia can be explained by four main factors: First, environmental conditions in these tropical islands are ideal for reproduction. Moderate temperatures and high rainfall in some areas ensure ideal breeding conditions year round on abundant native and exotic host plants. We estimate that in Tahiti, there are 6–8 overlapping *H. coagulata* generations a year, compared to 2–3 generations in California and northern-central Florida (USA). In California, cold winters retard egg production and egg laying in *H. coagulata*. Consequently, cold temperatures do not inhibit reproduction by *H. coagulata* in French Polynesia. Instead, reproductive potential appears to be more strongly influenced by wet and dry seasons, with greater populations being observed during wet periods.

Second, our surveys in French Polynesia indicate that there appear to be no effective natural enemies regulating *H. coagulata* populations. Surveys of *H. coagulata* egg masses on Tahiti and Moorea in 2003 showed very low levels of parasitism; less than 5% of the egg masses were attacked by parasitoids. The parasitoid species that was reared from *H. coagulata* egg masses was an unidentified encyrtid. Female parasitoids only exploited 1–3 eggs in an attacked egg mass (egg masses typically contain on average around 7–10 eggs) and only male eggs were oviposited suggesting that parasitism was opportunistic and that *H. coagulata* eggs were assessed to be of low quality as only haploid male eggs were laid. This obvious dearth of effective indigenous natural enemies is highly likely to have facilitated the establishment and rapid spread of *H. coagulata* in French Polynesia.

Third, *H. coagulata* may pose a substantial risk to generalist arthropod predators on invaded islands in French Polynesia. Controlled feeding experiments have revealed that some species of spiders can be killed following predation on *H. coagulata.* Mortality in both the native crab spider *Misumenops melloleitao* and the pan-Pacific orb-weaving spider *Cyrtophora moluccensis* appeared to result from lethal intoxication, although no form of chemical defence has been reported in *H. coagulata.* In both spider species, approximately half of all spiders that attacked individual *H. coagulata* nymphs or adults died. As *H. coagulata* populations increase in size and range on invaded islands in French Polynesia, this insect will be increasingly encountered by these and other arthropod predators, raising the possibility of population-level impacts on susceptible predator species.

Fourth, the cicadellid fauna of French Polynesia is impoverished with few known native species and a substantially greater number of exotic species that have established accidentally. Consequently, competition by other proconiine cicadellids is non-existent as this tribe within the Cicadellidae is unique to the Americas and lacks naturally-occurring representation in the South Pacific. When taken together, these four major factors, permissive environment (mild climate and abundant year-round feeding and oviposition substrates), natural enemy free space, predator intoxication, and lack of competition have facilitated invasion, a situation that is common for many successful invasive species.

Biological Control Decided as a Sustainable Management Strategy for GWSS in French Polynesia

Consequently, there is an urgent and immediate need to control high density populations of GWSS in French Polynesia. By reducing population densities many problems, both actual (human nuisance, and continued range expansion) and potential (widespread vectoring of *X. fastidiosa*) would be mitigated. A review of potential control options was commissioned in 2003 by the French Polynesian Ministry of Agriculture. The conclusion reached by Ministry officials was that biological control potentially offered the most effective and permanent management solution for GWSS. In 2004, a classical biological control programme using the mymarid egg parasitoid *Gonatocerus ashmeadi* was given approval. This biological control programme was initiated by the University of California (Berkeley and Riverside campuses) via the University of California Richard B. Gump South Pacific Research Station on Moorea. An alliance between University of California personnel and scientists with the French Polynesian Agricultural Research and Plant Protection departments guided the development of the GWSS biological control programme.

Determining the Risk Posed by GWSS Egg Parasitoids to Native Insects

An over-riding requirement for classical biological control of GWSS in French Polynesia is safety and a demand for minimal to non-existent non-target impacts. Particular attention is being paid to the identification and assessment of risk to non-target native fauna, in particular native cicadellids. As with many small isolated islands, French Polynesia is extremely susceptible to invasions by exotic organisms. Unfortunately, French Polynesia has a poor track record in biological control safety and programme efficacy. Consequently, this pest control technology is viewed with scepticism by many officials managing invasive species in French Polynesia. The most egregious example of a 'biological control disaster' in French Polynesia was the unintentional extirpation of native *Partula* snails on many islands by the predatory snail, *Euglandina rosea*, which was released for the biological control of the giant African land snail, *Achatina fulica*, in 1977. Biological control programmes for arthropod pests are consequently being held accountable for greater levels of safety than has been required in the past, and determination of host specificity and assessment of expected levels of safety and impact are emerging as rapidly developing new areas in classical biological control of arthropod pests.

Gonatocerus ashmeadi is a specialized parasitoid that attacks cicadellid eggs in the tribe Proconiini. Hence introduction of *G. ashmeadi* in French Polynesia is considered low risk for native cicadellids as there are no known indigenous representatives in the tribe Proconiini that may be potential hosts for these parasitoids. Furthermore, all the known native cicadellids are relatively small compared with GWSS and survey results indicate that they lay small eggs, often singly and not in egg masses typical of GWSS. This difference in egg laying biology is important as non-target impact research in California indicates that *G. ashmeadi* does not recognize small single cicadellid eggs as potential hosts. While the *a priori* risk appears to be low based on phylogenetic, morphological, and ecological criteria, a major caveat is our limited knowledge of the native cicadellid fauna (most notably in the Society Islands). Consequently, surveys and preparation of an inventory of native species have been initiated to reduce the possibility that overlooked indigenous species that could be inadvertently put at risk are not overlooked in French Polynesia.

Importation and Release of Gonatocerus ashmeadi

In September 2004, the classical biological control programme against *H. coagulata* commenced when populations of *G. ashmeadi* (adult parasitoids and parasitized GWSS egg masses) sourced from the University of California Riverside were established in the Service du Développement Rural (SDR) quarantine facility at Papara (Tahiti). Following intensive field survey work and difficult lab studies on native cicadellids it was concluded that *G. ashmeadi* posed negligible risk to native cicadellids. The apparent lack of potential non-target impacts combined with increasing public and political pressure to release *G. ashmeadi* from quarantine resulted in the decision to begin parasitoid introductions in Tahiti and Moorea. However, at the time of the release decision, the risk posed by *G. ashmeadi* to non-target cicadellids was shown to be very low for several native species, but some level of uncertainty persists because the inventory of native species was not completed, and some collected species were undescribed and in need of detailed studies. To have a more accurate assessment of the potential non-target impact of *G. ashmeadi*, studies would have needed to be continued, but indeterminant continuation of this work could delay indefinitely the introduction of *G. ashmeadi* and increase substantially risks associated with unregulated proliferation and spread of GWSS.

Consequently, available data on native species and potential non-target impacts were presented to the Council of Ministers and the Conservation Committee (composed of representatives from: Commission of Natural Monuments and Sites, the Environment, Research, Tourism and Equipment ministries, etc.) in April 2005 for a decision to release *G. ashmeadi* in French Polynesia against *H. coagulata* in May 2005. The two main factors taken into account by regulatory authorities when assessing the risk of releasing *G. ashmeadi* in French Polynesia were: (1) the likelihood of continued unregulated population growth and rapid spread of *H. coagulata* through French Polynesia and elsewhere in the South Pacific, and the possible acquisition and vectoring of *X. fastidiosa* to agricultural, ornamental and native plants by high density pest populations; and (2) the risk that *G. ashmeadi* would cause substantial and unexpected collateral damage to rare native non-target cicadellid species.

The French Polynesian Government considered that the benefits of controlling *H. coagulata* with *G. ashmeadi* outweighed possible negative ecological impacts on native species and decided releases of *G. ashmeadi* from quarantine for liberation and establishment in the field should be initiated in May 2005. The first releases of *G. ashmeadi* commenced on 2 May 2005 in Tahiti. A total of 13,786 parasitoids has been released in 27 sites located all around the island of Tahiti (except in the southwestern part of the island where non-release control sites were located) between May and October 2005. The released parasitoids were between 1 and 4 days old, and the sex ratio was about 70% female. Surveys indicated that *G. ashmeadi* readily established at release sites.

Assessing the Impact of G. ashmeadi on GWSS in French Polynesia

The impact of *G. ashmeadi* on GWSS and possibly on native cicadellids is currently being monitored. GWSS abundance at parasitoid release sites paired with control parasitoid non-release sites was assessed by examining ten shrubs of a preferred plant species (i.e. *Scaevola* sp.) on which GWSS readily feeds and lays eggs. The same ten trees were sampled each time at each survey site when census data were collected. GWSS adults, nymphs and egg masses were searched and counted on each tree for a fixed time: 2.5 minutes for the adults and nymphs, and 2 minutes for egg masses. Egg masses found during visual counts were collected and returned to the laboratory where the number of eggs in each egg mass was counted with a microscope and the percentage of eggs parasitized determined.

By October 2005, the parasitoid had completely colonized Tahiti (including non-release control sites), and was even found in the mountains at elevations of 1400 m. Survey results indicate that *G. ashmeadi* has had a catastrophic impact on GWSS populations. Prior to parasitoid release, GWSS densities on Tahiti were averaging around 100 to 240 nymphs being collected in a sweep net per minute of sampling effort. After the parasitoid release, an abrupt decline in GWSS abundance was observed at all release sites. Parasitism of GWSS eggs has averaged around 88–100%, and since December 2005, the number of GWSS nymphs has been maintained at a very low level with less than three nymphs per site on average. This represents a decrease of ~97–99% in GWSS nymph densities.

Conclusions

The results obtained from this classical biological control project have demonstrated that the parasitoid *G. ashmeadi* readily established in Tahiti and rapidly colonized the whole island including high elevation mountainous interior sites. The results of egg parasitism and the comparison of GWSS abundance before and after releases at the release sites and parasitoid invasion into control sites indicated clearly an extremely large decrease in *H. coagulata* abundance in Tahiti (>95%). This observed population collapse is due directly to the action of the introduced egg parasitoid. As *G. ashmeadi* attacks the eggs of its host, the initial impact on pest population structure was first seen on the abundance of nymphs (maximum impact observed 2–3 months after the parasitoid arrival), then on adults (maximum impact observed 5–6 months after the parasitoid arrival) and finally on the number of egg masses (maximum impact observed 6–7 months after parasitoid release) being counted in surveys. Since very good results were obtained by *G. ashmeadi* in Tahiti, the biological control programme will now be extended to all islands in French Polynesia infested with GWSS. More information on the GWSS biological control programme in French Polynesia can be found on the Internet at: http://moorea.berkeley.edu/research/health/.

By: Mark S. Hoddle[1], Julie Grandgirard[2], Jérôme N. Petit[2], George K. Roderick[3] and Neil Davies[2]

[1]Dept. of Entomology, University of California, Riverside, CA 92521, USA.
Email: mark.hoddle@ucr.edu

[2]Richard B. Gump South Pacific Research Station, University of California, Berkeley, BP 244, 98728 Moorea, French Polynesia.

[3]Environmental Science, Policy and Management, Division of Insect Biology, University of California, Berkeley, CA 94720, USA.

Fall Webworms Face Mass Attack in China

Augmentative releases of a native eulophid parasitoid on a monumental scale are planned to help combat the invasion of an alien arctiid moth in China. Over 10 years work by Chinese scientists led by Professor Yang Zhong-qi has developed a method for mass rearing the natural enemy on oak silkworm pupae, which are then hung in trees in infested areas.

The fall webworm, *Hyphantria cunea*, was first reported in China in 1979 in Liaoning Province, in the northeast of the country. It has since spread through the eastern coastal provinces and now infests five other provinces and municipalities: Beijing, Tianjin, Hebei, Shandong and Shaanxi. The polyphagous defoliator has become a serious invasive pest of forests, city ornamental trees and agricultural crops due to its wide host range, which in China includes 175 species of broadleaved trees, shrubs, orchard trees, field crops and vegetables.

The moths overwinter as pupae in sheltered sites, emerging in late April to mate. Moths are slightly attracted to light and fly up to 100 m, during which time females select host plants for mating and subsequently prolific egg laying (averaging 800–900 and maximally 2200 eggs per female). The larvae of the fall webworm have six instars; the first four instars live in the web collectively and the last two instars disperse to feed on host tree leaves. The first signs of attack are usually a large, silken web and skeletonized leaves. The silken web, which generally contains large numbers of caterpillars, is itself a nuisance in ornamentals although ultimately total defoliation is the most serious impact. The moth has two or even three generations per year in north China. Mortality of the overwintering generation is about 15–26% owing to low temperatures, disease, predators and parasitoids.

As the pest spread through China, costs of control increased, with an estimated 20 million RMB (US$2.4 million) spent on control in Liaoning Province alone in 1998.

A management plan was developed and implemented, which includes: strict quarantine procedures, specifically targeting late-instar larvae and pupae to prevent long distance spread by human activities; encouraging the planting of mixed forest stands to restructure plantations; manual removal of webs during the 2nd–4th larval instars; spraying HcNPV (*Hyphantria cunea* nucleopolyhedrovirus) virus during the larval stage; and augmentative releases of a pupal parasitoid.

Surveys of native natural enemies recovered 27 species of insect natural enemies of the fall webworm, including an effective parasitoid of a new genus and species of eulophid from *H. cunea* pupae in Shaanxi Province. It was subsequently described as *Chouioia cunea* Yang. The gregarious pupal endoparasitoid was found at parasitism levels of more than 83% in the outbreak area of *H. cunea* in Shaanxi Province and was also recovered from other lepidopteran defoliators. On average 274 wasps (from 120 to 365 wasps) emerged from a fall webworm pupa, with a female:male ratio of 45~96:1; in size the wasp was only 0.9~1.2 mm long. All these characteristics showed that the parasitoid is a superior natural biological control agent for the webworm.

Research on *C. cunea* between 1990 and 2003 suggested it had good potential as an augmentative biocontrol agent. It has seven generations per year; it was able to use alternative hosts (particularly *Clostera anachoreta* and *Acronicta increta* [*A. intermedia*]) in periods when *H. cunea* pupae were not available. The parasitoid proved to be widespread in China and its populations were relatively stable. Alternative hosts of *C. cunea* were tested to find potential substitute hosts for mass rearing the parasitoid. The saturniid moth *Antheraea pernyi* was chosen as a surrogate host as a single pupa produced a maximum of 11,256 wasps and an average of 6552 wasps. Successful mass-rearing and release techniques for this parasitoid were developed. From field studies conducted over 5 years to assess the sustainability of biological control, it was found that releasing the wasps during the mature larval and pupal stages of each generation gave parasitism levels in *H. cunea* pupae of over 92% in the first year, and the pest was brought under control with only 1.25% of trees in the test area infested. Control was maintained over the next 4 years with fewer than 0.1% of trees suffering infestations while *H. cunea* parasitism rates remained at over 92%. Dalian City of Liaoning Province, and Yantai and Qingdao cities of Shandong Province have kept the fall webworm under control for 7 years by applying the biocontrol technique.

In 1999, a national control project for *H. cunea* was initiated by the China State Forestry Administration (SFA) to control its further spread and reduce its population around Beijing and in Tianjing and Hebei provinces, with the priority to prevent its expansion into Beijing. The main tactics of the project, which covered 35,700 ha of infested areas, included use of HcNPV and light and pheromone trapping in conjunction with the measures above. Chemical pesticides were not used. By 2003 the infestation had been reduced to about 7000 ha, and the spread of *H. cunea* towards Beijing was pushed back eastwards some 20 km.

This bought only time. Latest reports from the SFA indicate that some 50,000 trees in Beijing are now affected and the moths are still spreading. In early March 2006, the General Office of the State Council (China's cabinet) issued a notice requiring the governments of *H. cunea*-infested areas to take immediate measures to curb its spread. In late March, the SFA announced that that Beijing and neighbouring Tianjin, Hebei and Liaoning would undertake releases totalling one billion wasps as part of a joint effort to combat the pest. Additional measures being implemented include aerial spraying of HcNPV biopesticide over some 667,000 ha of roadsides and key 'green' areas in Beijing, and the deployment of insecticidal lamps and sex pheromone attractants in parks and forests across the capital. The intervention is timely: the Beijing Forest Protection Station counted more than 27,000 adult moths between early April and late May 2006, a big enough base number to threaten all the capital's trees. However, the Forest Protection Station is confident that it can protect the city's woods and forests.

Sources/Further Information

Biodiversity Clearing-House Mechanism of China
www.biodiv.gov.cn

Yang Zhong-qi, Wang Xiao-yi, Wei Jian-rong, Wang Chuan-zhen & Qiao Xiu-rong (2006) Insect natural enemies of fall webworm *Hyphantria cunea* (Lepidoptera: Arctiidae) in China. *Canadian Entomologist* 129(12) (in press).

Yang Zhong-qi, Wei Jian-rong & Wang Xiao-yi (2006) Mass rearing and augmentative releases of the native parasitoid *Chouioia cunea* (Hymenoptera: Eulophidae) for biological control of the introduced fall webworm *Hyphantria cunea* in China. *BioControl* 51(4).
Online at: www.springerlink.com

Yang Zhong-qi, Wang Xiao-yi, Wang Chuan-zhen, Qiao Xiu-rong & Pang Jian-jun (2005) Studies on utilizing parasitoid *Chouioia cunea* Yang (Hymenoptera: Eulophidae) for sustainable control of fall webworm. *Scientia Silvae Sinicae* 41(5): 72–80.

Su Zhi, Yang Zhong-qi, Wei Jian-rong & Wang Xiao-yi (2004) Studies on alternate hosts of the parasitoid *Chouioia cunea* (Hymenoptera: Eulophidae). *Scientia Silvae Sinicae* 40(4): 106–116.

Wei Jian-rong, Yang Zhong-qi & Su Zhi (2003) Use of life table to evaluate control of the fall webworm by the parasitoid *Chouioia cunea* (Hymenoptera: Eulophidae). *Acta Entomologica Sinica* 46(3): 318–324.

Yang Zhong-qi (2000) A study on effective accumulated temperature and threshold temperature for development of *Chouioia cunea* Yang (Hymenoptera: Eulophidae). *Scientia Silvae Sinicae* 36(6): 119–122.

Yang Zhong-qi (1995) Anatomy of internal reproductive system of *Chouioia cunea* (Hymenoptera, Chalcidoidea: Eulophidae). *Scientia Silvae Sinicae* 31(1): 23–26.

Yang Zhong-qi (1989) A new genus and species of Eulophidae (Hymenoptera: Chalcidoidea) parasitizing *Hyphantria cunea* (Drury) (Lepidoptera: Arctiidae) in China. *Entomotaxonomia* 11(1–2): 117–130.

War on Weevil Well Underway in New Zealand

AgResearch entomologists are buoyed by the rapid initial establishment and behaviour of an Irish strain of the parasitic wasp *Microctonus aethiopoides*, first released in New Zealand in January 2006 (mid summer) to help counter pasture pest *Sitona lepidus* (clover root weevil). By May (late autumn), the parasitism levels in adult weevils present at the main release sites in the Waikato, Hawke's Bay and Manawatu regions of the North Island were all between 11–16% and in June there was evidence that the parasitoid was overwintering as first instar larvae in a state of suspended development.

Sitona lepidus was first discovered in New Zealand pastures in 1996. Since the species feeds exclusively on clovers, in particular white clover, the new arrival was considered a serious threat to the pastoral sector, but the extent of the infestation (200,000 ha) was such that containment or eradication was impossible. It spread rapidly throughout the North Island and in 2006 the first South Island infestations were confirmed.

Sitona lepidus is now one of New Zealand's most serious pasture pests. The weevil larvae attack white clover roots and nodules, limiting nitrogen fixation and clover growth. This can therefore impact on animal performance in terms of reduced milk yield and live weight gains, especially in spring and early summer. Where soil moisture and topography are not limiting factors, farmers have found the most effective way to overcome the financial impact of this loss in pasture quality is to apply nitrogen fertilizer. However, this solution is not available to all farmers and may not be economically or environmentally sustainable in the long term.

Two introduced weevil parasitoids already present in New Zealand pastures were tested to see if *S. lepidus* would provide a suitable host. The Moroccan biotype of *M. aethiopoides* was introduced in 1982 against the lucerne weevil (*Sitona discoideus*) while *M. hyperodae* had been released in 1991 for Argentine stem weevil (*Listronotus bonariensis*) biocontrol. Both parasitoids have had significant impacts on their respective target hosts, but the laboratory tests confirmed that neither the Moroccan biotype of *M. aethiopoides* nor *M. hyperodae* were effective against *S. lepidus*.

The search for an effective biocontrol agent for *S. lepidus* commenced in 1998 and involved collaboration with scientists in Switzerland, Italy, Romania, France, Netherlands, Norway, Finland, Ireland, UK and the USA. A European biotype of *M. aethiopoides* was identified as the best candidate biocontrol agent. However, as research had shown mating between the European and Moroccan biotypes produced hybrids with poor efficacy against target hosts, and that the Moroccan biotype attacked several native weevil genera, serious reservations were held about introducing the European biotype. These concerns were overcome with the identification of a parthenogenetic (asexual) strain of *M. aethiopoides* from Ireland, which has little risk of hybridization, and a narrower host range than the Moroccan biotype. Approval was sought and gained under New Zealand's Hazardous Substances and New Organisms legislation in November 2005 and the Irish wasp was released at an experimental site on a Waikato farm on 5 January 2006, with further releases in Hawke's Bay and Manawatu over the following 6 weeks.

The parasitoid injects the adult weevil with an egg which makes female weevils sterile thus providing an early disruption to the weevil life cycle. Within the weevil the larva goes through five stages with the host dying soon after the prepupal larva breaks out of the weevil's body. Pupation takes place in the leaf litter with the adult parasitoid emerging to start the next generation. Based on laboratory studies and field observations thus far, the Irish wasp is likely to have four or five generations a year, depending on the region.

The experimental release sites are being monitored to determine establishment, persistence and rate of spread by the Irish parasitoid and further releases are planned in other regions. The research team will be watching closely to see how well the parasitoid synchronizes its lifecycle to its host as unlike in Europe, where *S. lepidus* is regarded as univoltine, in New Zealand there are two generations a year with almost no adult weevils present in early spring. It is anticipated that most parasitoid dispersal will take place during summer when *S. lepidus* flight activity is common. Once initial results on dispersal are known, the AgResearch team will work with industry and regional government to develop a strategy to ensure the parasitoid gets to all farms in weevil-infested regions as quickly as possible.

By: Pip Gerard, Mark McNeill and Craig Phillips.

Contact: Dr P.J. Gerard, Biocontrol & Biosecurity, AgResearch Ltd, Ruakura Research Centre,
PB 3123, Hamilton, New Zealand.
Email: pip.gerard@agresearch.co.nz
Fax: +64 07 838 5073

Searching Europe for Swallow-wort Agents

Two European species of *Vincetoxicum* have invaded tracts of land extending from the northeastern USA to the Great Lakes area, and also into Ontario and Quebec provinces in Canada. These vines create large monocultures that threaten rare plant species and may adversely affect one of North America's flagship butterfly species. Scientists from the US Department of Agriculture – Agriculture Research Service (USDA-ARS) and Cornell University have begun investigating the ecology and taxonomy of this weed in North America and in its native area in Europe. ARS is also conducting foreign exploration, coordinated by personnel with its European Biological Control Laboratory near Montpellier, France, and has plans to conduct host-specificity testing on high-priority potential biological control agents, and extensive post-release monitoring of approved agents. Scientists at the University of Rhode Island in collaboration with CABI Switzerland Centre have focused on the exploration for potential classical biological control agents in central Europe and Ukraine. There is close collaboration with all partners on this project.

Pale swallow-wort (*V. rossicum*) from the Ukraine and southwest Russia thrives in both the forest understorey and open areas in New York, while the southwestern European black swallow-wort (*V. nigrum*) prefers open areas and forest margins. In North America the introduced swallow-worts are found in natural areas and abandoned pastures, in gardens and fields, along fencerows, roadways, grassy slopes, wooded edges and streambanks. They form tangled masses of vines that shade and suppress native plants, including rare and endangered species. They have adverse impacts on forest regeneration, and also encroach on reduced-tillage crops such as maize and soyabean.

The impact on the monarch butterfly, *Danaus plexippus*, is unclear but potentially serious where swallow-worts are common. North American native common milkweed, *Asclepias syriaca,* is the preferred host of the monarch butterfly. Both appear to be threatened by swallow-worts, because they may be replacing the native host species in the open fields where monarch larvae live. The larvae are unable to survive on either *Vincetoxicum* species. In addition, monarch butterflies lay eggs on *V. nigrum* and *V. rossicum*, which thus effectively act as a sink for them.

Current control measures for the swallow-worts are unable to alleviate their weedy impact and include mowing, hand pulling as pods form, and repeated herbicide (glyphosate) applications. Only one North American species*, Lygus lineolaris,* has been found feeding on *V. rossicum* or *V. nigrum*; it inflicted minimal damage and is itself an important economic pest. In contrast, the literature suggests that there are species in Europe that attack *Vincetoxicum* and may have potential as biological control agents. However, these agents have been reported feeding on another species of *Vincetoxicum* so their ability to develop on and control the target weeds is not clear.

Because the target weeds have invaded such a diversity of habitats in North America it will be important that the agents have the ability to locate and develop on the weeds under a variety of conditions. So far, the phytophagous insects of European native *Vincetoxicum hirundinaria*, including *Abrostola asclepiadis* (noctuid)*, Eumolpus asclepiadeus* (chrysomelid), and *Euphranta connexa* (tephritid), are currently the most appealing agents, but further exploration should identify other herbivores in Europe.

Sources:

US Department of Agriculture – Agriculture Research Service:
www.ars.usda.gov/research/projects/projects.htm?ACCN_NO=409618

Tewksbury, L., Casagrande, R. & A. Gassmann (2002) Swallowworts *Vincetoxicum* spp. In: Driesche, R.V., Lyon, S., Blossey, B., Hoddle, M. & Reardon, R. (eds) *Biological control of invasive plants in the eastern United States.* USDA Forest Service, Publication FHTET-2002-04, pp. 209–216.
Online at: www.invasive.org/eastern/biocontrol/16SwallowWorts.html

Contacts: Richard Casagrande, University of Rhode Island (casa@uriacc.uri.edu).
André Gassmann, CABI Switzerland Centre (a.gassmann@cabi.org).
Lindsey Milbrath, USDA-ARS (lrm32@cornell.edu).
Walker Jones, USDA-ARS (ebcl@ars-ebcl.org).

Renewed Efforts to Identify Hydrilla Biocontrol Agents in Asia and Africa

Expanded surveys are being conducted by two labs in Florida for classical biological control of the submersed aquatic weed *Hydrilla verticillata*. The University of Florida, in collaboration with Kenya-based ICIPE (International Centre for Insect Physiology and Ecology) and national programmes in Uganda and Burundi, is starting a project to explore for natural enemies in eastern Africa in August 2006. Additionally, the USDA-ARS (US Department of Agriculture – Agriculture Research Service) Invasive Plant Research Lab in collaboration with CSIRO (Commonwealth Scientific and Industrial Research Organisation) in Australia and the Chinese Academy of Sciences is conducting surveys in Southeast Asia and China.

Hydrilla is the most severe invasive weed in Florida's freshwater ecosystems. Recently, hydrilla populations resistant to fluridone, the single most widely used herbicide for its control, were found. If new methods of control are not discovered and implemented in the next 3–5 years, the plant is likely to cover major portions of Florida's shallow aquatic ecosystems causing significant ecological and economic impacts. One possible strategy to suppress hydrilla is classical biological control. The native range of hydrilla includes much of Asia, parts of northern Australia and a few lakes in East/Central Africa. The University of Florida is initiating efforts in Africa. In the late 1970s and early 1980s, the Commonwealth Institute of Biological Control (now CABI) and USDA-ARS scientists found potentially interesting candidate biological control agents (chironomid flies, *Polypedilum* spp.) in Lake Tanganyika, but due to other priorities, did not pursue this lead.

A preliminary visit to Burundi and Uganda in 2005 by University of Florida scientists rediscovered *Polypedilum* and also found a *Bagous* sp. weevil. These agents, and others yet to be found, need to be laboratory colonized for host range testing and then imported into Florida for additional quarantine tests. With funding from several Florida state agencies, the scientists plan to return to Africa to continue the search for candidate biological control agents. The University of Florida will collaborate closely with ICIPE, which in turn will work with national scientists in Uganda, Burundi and other countries.

Hydrilla work directed by Matt Purcell at the CSIRO facility in Brisbane, Australia focuses on host range testing of an aquatic moth from Sumatra, *Paracymoriza vagalis*. This species has been found in the wild in very high densities but progress has been hampered by difficulties associated with rearing in quarantine. Finally, surveys conducted in China in July 2006 recovered an aquatic leaf beetle. Ding Jianqing and colleagues of the Invasion Biology and Biological Control Lab in Wuhan found 100 larvae and ten pupae of this Donaciinae beetle. Possibly a *Donacia* or a *Macroplea* sp., studies are underway to rear the insect and to determine field specificity.

Contacts: Bill Overholt, University of Florida (billover@ufl.edu).
Greg Wheeler, USDA-ARS (wheelerg@saa.ars.usda.gov).

Coffee-Friendly Birds

Can birds reduce pests in coffee? Recent research indicates they can.

It is common for the modern coffee consumer, in selecting from among the scores of products on the market today, to come across 'bird friendly' labels in addition to the more familiar 'organic' and 'shade-grown' certifications. While the production techniques behind such specialty coffees may benefit birds, is it possible that the birds in turn may benefit the coffee farmer? Indeed, coffee is subject to many insect pests throughout its global tropical production zone while many tropical bird species are insect eaters. Might ecosystem services be provided in the form of pest control by birds? If proven effective, it would offer farmers an incentive to encourage birds in their plantations, for example, by retaining traditional techniques involving shade trees attractive to birds.

To examine pest control services provided by birds, we have implemented an experiment on coffee farms in the Blue Mountains of Jamaica. Producing some of the world's most expensive coffee, Blue Mountain farms employ a range of production techniques, from large full-sun plantations, utilizing large amounts of chemical fertilizers and pesticides, to small, multi-crop, organic shade-grown farms. We are focusing our research on a common global coffee pest, the coffee berry borer, *Hypothenemus hampei*. By comparing pest levels inside bird 'exclosures', mesh cages preventing birds from accessing certain coffee plants, to nearby 'control' plants in which birds can forage freely, we are seeing ecosystem services in action. Coffee plants from which bird activity is excluded have higher proportions of berry borer infestation. We are finding this effect at varying levels across all farm types. Additionally, the farms with greater tree cover have the greatest overall bird diversity, especially of Jamaican endemic species; Jamaica has more endemic species than any other Caribbean island, making bird conservation there of heightened importance.

Through our continued research we plan to further examine the role of birds in providing pest control, the relationship between amount of shade and levels of pest control by birds, and any additional ecosystem services provided by birds, shade trees, and nearby natural forest areas to coffee production in the Blue Mountains.

By: Jherime L. Kellermann & Matthew D. Johnson, Dept. of Wildlife, Humboldt State University, Arcata, CA 95521, USA
Email: jlk55@humboldt.edu / mdj6@humboldt.edu

IPM Systems

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

Biopesticide for Balsam Fir Sawfly

The balsam fir sawfly (*Neodiprion abietis*) is a native North American defoliating insect. In the Canadian eastern provinces of Ontario, Quebec, New Brunswick, Nova Scotia and Newfoundland and Labrador outbreaks have become a source of concern over the last half-century. It has grown in importance as a pest of young and semi-mature balsam fir, particularly in thinned stands. Now the Forestry Services Branch, Newfoundland and Labrador, has a microbial insecticide to deploy against it.

The sawfly overwinters in the egg stage in fir needles. Hatching varies with seasonal development but usually occurs between late June and mid July. Larvae feed on needles from the previous and earlier years for a number of weeks before pupating. Adult sawflies emerge in August and mate, and females lay eggs in the needles of the current year. Outbreaks are not uncommon, occurring every 12–15 years in various places, but they have generally been of short duration (3–4 years) and are terminated by natural factors including a nucleopolyhedrovirus (NPV) disease. However, an outbreak in western Newfoundland which was first detected in 1991 still shows no sign of abating and continues to expand to the north and northeast into previously unaffected areas. To date over 200,000 ha of forest have been infested, and a further 7000 ha of pre-commercial thinnings (PCTs) are within the forecasted 41,000 ha predicted to suffer moderate to severe defoliation in 2006. The PCTs have been established, at an average cost of more than Can$1000 per hectare, to enhance growth and are critical to maintaining an adequate wood supply for the forest industry.

Historically the sawfly has not been a major problem and there was little impetus for developing specific control measures. But since 1998, research and experimental programmes have been looking for biological solutions for a number of sawflies including the balsam fir sawfly. With *Bt* ineffective against these hymenopteran pests, the interest of a team of scientists led by Edward Kettela and Christopher Lucarotti from the Canadian Forest Service – Atlantic Forestry Center (CFS-AFC) (part of Natural Resources Canada) focused on the naturally occurring NeabNPV, and whether it could be formulated into an effective product. In 1997, Dr Lucarotti isolated the NeabNPV from balsam fir sawfly populations in Newfoundland, and its role in localized collapse of the populations under natural conditions was confirmed. The collapse of balsam fir sawfly infestations occurs when serious damage has already occurred, so attention focused on the possibility of enhancing the natural biological control process. Between 1997 and 2004, the CFS-AFC team developed and tested NeabNPV. In June 2004, Dr Lucarotti submitted the NeabNPV registration package, under the trade name of Abietiv™, to Health Canada's Pest Management Regulatory Agency (PMRA). With that now approved, the Forestry Services Branch of Newfoundland and Labrador was able to deploy Abietiv™ via aerial application over some 15,000 ha of forest stands forecast to receive moderate to severe balsam fir sawfly defoliation in 2006, and at the leading edge of infestation.

Besides successful research, commercialization is also a key element in the success of a biopesticide. In May 2005, a licensing agreement was signed between Natural Resources Canada – Canadian Forest Service and Forest Protection Limited (FPL) of Lincoln, New Brunswick. FPL provides aerial forest protection services throughout North America, and is a long-standing partner of the CFS-AFC. FPL is now working with BioAtlantech, the lead agency for biotechnology incubation in New Brunswick, to develop a sound business model for Abietiv™ through a spin-off company, Sylvar Technologies.

Sources/Further Information

Contact: Dr Christopher Lucarotti
Email: clucarot@nrcan.gc.ca
Web: www.atl.cfs.nrcan.gc.ca

Web: www.forestprotectionlimited.com
Web: www.bioatlantech.nb.ca

Working Towards a Site-Specific IPM Strategy for Control of Water Hyacinth in South Africa

Water hyacinth (*Eichhornia crassipes*) is one of the most destructive aquatic weeds in terms of its invasiveness, its impact on aquatic ecosystems and the cost of controlling it[1]. First recorded in South Africa around 1900, it has spread across the country, and is found in water bodies in sub-tropical and temperate regions. Management methods include mechanical, herbicidal and classical biological control. Herbicides require repeated applications resulting in high costs and commitment to a rigorous follow-up programme, and there are concerns that herbicide treatments, even when used at recommended dosages, are lethal to several species, thus adversely altering the biodiversity and productivity of aquatic communities[2]. Biological control is environmentally friendly and low-cost; however biological control programmes have had variable results across South Africa despite the establishment of six natural enemies (five arthropods and one pathogen). A few water hyacinth populations have been successfully controlled, notably at New Year's Dam in the Eastern Cape[3], but the country-wide level of control achieved does not compare with that seen in Papua New Guinea[4], Lake Victoria in Uganda, Tanzania and Kenya[5], and southern Benin[6].

Inconsistent results from the water hyacinth biocontrol initiative in South Africa have been primarily attributed to variable climatic conditions (the agent may be less effective in temperate regions with winter frosts); eutrophication of water bodies; periodic removal of the weed and agent population through drought and flooding; and interference from other control methods, notably herbicide treatments[7]. Lethal doses of herbicides are often applied where plant growth is already being suppressed by control agents. Temporary eradication of weed populations causes mass agent mortality and premature dispersal of the adult agent population. Re-infestation of the weed occurs through seed germination or re-growth from untreated plants, and in the absence of herbivory, the weed population reaches problem proportions very quickly[8]. Hydrological features of some impoundments are thought to inhibit biological control successes: many infested water bodies in South Africa are small and therefore not subject to wind and wave action. The lack of physical stress on the mats prevents them from breaking up and sinking. Furthermore, in shallow waters, the roots rest on the substrate and the plants are unable to sink[7]. While it is clear that biological control may need to be augmented with other control methods at several sites, the assumptions for its failure as an exclusive solution are largely based on observations from case histories across South Africa, and not on rigorous scientific study.

In recent years, there has been a shift in approach towards 'maintenance management' of water hyacinth. The desired result of an integrated management programme is short-term mitigation of the infestation as required for continued ecosystem services and functions, and long-term control of the weed with as few financial and environmental costs as possible. Where properly managed, this has been shown to be the most cost-effective method of water hyacinth control in terms of economic investment per hectare cleared[1,9]. However, since the initiation of biological control programmes for water hyacinth in South Africa in 1973[10] 'maintenance management' has seldom been used in a coordinated way with biological control.

Managers of the water hyacinth control programmes in South Africa would benefit from a thorough analysis of control options. This would contribute towards achieving a co-ordinated and effective weed management plan that would potentially reduce economic and environmental costs. It is therefore the aim of the University of the Witwatersrand 'Team Water Hyacinth' (TWH), supported by the Water Research Commission and Working for Water, to develop a site-specific management plan for water hyacinth control in South Africa, combining biological with herbicidal and nutrient control where appropriate. To do this, TWH has set up a programme to monitor water hyacinth at 15 sites around South Africa, covering a variety of climatic regions with different nutrient regimes. The results summarized in this article are described in more detail on the project website, see:
http://www.wits.ac.za/apes/SAhyacinth/page_5.htm
The site includes an overview of water hyacinth in South Africa, the objectives and design of the project, its monitoring sites, and news of progress (preliminary findings and future plans).

The Effects of Temperature on Biological Control

Continuous measurements (every 30 minutes) of water temperature (5 cm below the surface), air temperature within the water hyacinth canopy, and air temperature 1.2 m above the water surface have been taken since August 2004. Data to date show that cold winters inhibit the biological control of water hyacinth in two ways. Firstly, as the rate of insect development/growth is determined by temperature, cooler average temperatures ultimately limit natural enemy population growth. Secondly, water hyacinth 'dies-back' when subjected to low temperature extremes, and is therefore unable to support its resident insect population. However, while the plant population recovers in the spring, the insect population recovers much more slowly, having been subjected to both cold- and reduced habitat- induced mortality (also see [7]). Laboratory experiments have shown that, when exposed to simulated winter conditions, mortality increases, oviposition is arrested, and feeding rates are significantly reduced for *Neochetina* weevils and the mirid *Eccritotarsus catarinensis*. When relating these physiological thresholds to field data, it is evident that temperatures seldom reach optimum at highveld sites (above 1500 m in altitude). In warmer lowveld and coastal regions, temperatures are favourable for rapid insect population growth. However in these systems, rapid plant growth stimulated by optimum temperatures and eutrophic waters outpace any deleterious effects natural enemies may inflict.

The Effects of Nutrients on Biological Control

Many South African water bodies are eutrophic due to run-off polluted with nitrates and phosphates from agricultural activities. That the biological agent population may flourish due to higher quality host plants may be off-set by enhanced plant growth as a result of rapid leaf production[7]. 'Team Water Hyacinth' research aims to determine the precise nutrient status of water hyacinth infested waters in South Africa, and to better understand the relationship between nutrient status, plant growth and insect population dynamics. Two conclusions arise from analysis so far. Firstly that the regression of phosphorus levels against nitrogen concentrations shows a 7:1 ratio of N:P, an ideal nutrient regime for water hyacinth growth. Secondly, all but one monitored site has an average phosphorus level greater than the 0.1 mg/l threshold, above which water hyacinth growth is unlimited by phosphorus availability. That this site (New Year's Dam) is the only one considered to be under biological control, suggests that water hyacinth cannot be suppressed by available natural enemies at high phosphorus levels. Circumstantial evidence to support this comes from Lake Victoria, where water hyacinth has been successfully controlled and phosphorus levels are below the 0.1 mg/l threshold. This hypothesis will be tested through manipulative laboratory trials.

Herbicide Applications and Biological Control

The use of sub-lethal or retardant doses of herbicide (0.8% glyphosate) offers several advantages over lethal doses of herbicide: biological control agent populations are less likely to be adversely impacted, as are non-target plant and animal species; biological control reserves do not need to be established and maintained; and low doses of herbicide are less likely to exert sufficient selection pressure on possible resistant biotypes to initiate development of herbicide resistance. While C. Ueckermann & M.P. Hill and A.M. Jadhav and co-authors have shown (unpubl. data) that adult *N. eichhorniae* and *N. bruchi* weevils are tolerant to most glyphosate-based herbicides when applied at recommended concentrations, the sessile nature of some of the immature stages results in a high mortality of eggs, larvae and pupae in herbicide treated water hyacinth plants. This is relevant when considering control options, as not only is larval feeding more destructive to water hyacinth plants than adult feeding but weevil population size is regulated during the larval stage[11]. The sessile nature of early larval instars makes them more susceptible to leaf mortality and competition for food, and therefore density-dependant mortality. Events that disrupt water hyacinth leaf dynamics, such as frost or applications of foliar herbicides, will therefore have a disproportionately large effect on the control agents and may reduce the level of control of the host[12].

'Team Water Hyacinth' aims to document both the short-term (8 weeks, equivalent to one generation time) and long-term effects of retardant doses of glyphosate herbicide on both the weed and its biocontrol agents. This will indicate whether retardant herbicide applications interfere with natural enemies (as indicated by survival rates) and the physiology of the weed (such as compensation by increased growth or reproduction); or whether the herbicide would increase the palatability (as evidenced by weevil feeding scars or increased weevil reproduction) of the plants, thereby indirectly increasing the reproductive potential of the biological control agents.

The Way Forward

Field data show that weevil numbers peak at successively later months at cooler sites. The decline in adults and larvae during winter indicates that *Neochetina* over-winter as larvae, driving the population into a single cohort 'bottleneck'. Plant data show that winter is a period of asexual reproduction, with the production of new ramets occurring at all sites. Leaf elongation occurs during summer, while root length is less seasonally variable, but may be correlated to nutrient levels at different sites. These data suggest that the plant reproduces asexually at a time when weevil numbers are declining. This lack of phenological co-ordination between host plant and biological control agent may allow new ramets to escape colonization by the natural enemy. They also indicate that herbicides should be applied in late autumn, when plants are about to multiply. However, herbicide uptake may be inhibited by low temperatures. Both of these hypotheses will be investigated, as will the possibility that ramet production is driven by plant density rather than photoperiod or temperature. If water hyacinth responds to a decrease in plant density by reproducing asexually, this will influence when herbicides should be applied on any water body that is under integrated management.

Results so far support the view that biological control alone is unlikely to control water hyacinth at any of the monitored sites. Through successfully implementing a considered IPM strategy that is based on knowledge of the effects of climate, nutrients and herbicidal applications on biological control, it is hoped that herbicidal treatments will be reduced in both frequency and dosage, eventually becoming redundant as the biocontrol agents take hold.

References

[1]Van Wyk, E. & Van Wilgen, B.W. (2001) The cost of water hyacinth in South Africa: a case study of three options. *African Journal of Aquatic Science* **27**: 141–149.

[2]Relyea, R.A. (2005) The impact of insecticides and herbicides on the biodiversity and productivity of aquatic communities. *Ecological Applications* **15**(2): 618–627.

[3]Hill, M.P. & Cilliers, C.J. (1999) A review of the arthropod natural enemies, and factors that influence their efficacy, in the biological control of water hyacinth, *Eichhornia crassipes* (Mart.) Solms-Laubach (Pontederiaceae), in South Africa. *African Entomology* **1**: 103–112.

[4]Julien, M.H. & Orapa, W. (1999) Structure and management of a successful biological control project for water hyacinth. In: Hill, M.P., Julien, M.H. & Center, T.D. (eds) Proceedings of the 1st IOBC Global Working Group Meeting for the Biological and Integrated Control of Water Hyacinth, 16–19 November 1998, Harare, Zimbabwe, pp. 10–13. http://194.203.77.69/Waterhyacinth/ [see 'Management']

[5]Wilson, J.R.U., Ajuonu, O., Center, T.D., Hill, M.P., Julien, M.H., Katagira, F.F., Neuenschwander, P., Ogwang, J., Reeder, R.H. and Van, T. (2006) The decline of water hyacinth on Lake Victoria was due to control by *Neochetina* spp. *Aquatic Botany*, in press.

[6]De Groote, H., Ajuonu, O., Attington, S., Djessou, R. & Neuenschwander, P. (2003) Economic impact of biological control of water hyacinth in Southern Benin. *Ecological Economics* **45**(1): 105–117.

[7]Hill, M.P. & Olckers, T. (2001) Biological control initiatives against water hyacinth in South Africa: constraining factors, success and new courses of action. In: Julien, M.H., Hill, M. P., Center, T.D. & Ding Jianqing (eds) *Biological and integrated control of water hyacinth,* Eichhornia crassipes. Proceedings of the 2nd IOBC Global Working Group Meeting for the Biological and Integrated Control of Water Hyacinth. Beijing, China, 9–12 October 2000. ACIAR Proceedings No. 102, pp. 33–38. http://194.203.77.69/Waterhyacinth/ [see 'Management']

[8]Center, T.D., Dray, F.A., Jubinsky, G.P & Grodowitz, M.J. (1999) Biological control of water hyacinth under conditions of maintenance management: can herbicides and insects be integrated? *Environmental Management* **23**(2): 241–256.

[9]Haag, K.H. & Habeck, D.H. (1991) Enhanced biological-control of water hyacinth following limited herbicide application. *Journal of Aquatic Plant Management* **29**: 24–28.

[10]Cilliers, C.J. (1991) Biological control of water hyacinth, *Eichhornia crassipes* (Pontederiaceae), in South Africa. *Agriculture, Ecosystems and Environment* **37**: 207–217.

[11]Heard, T.A. & Winterton, S.L. (2000) Interactions between nutrient status and weevil herbivory in the biological control of water hyacinth. *Journal of Applied Ecology* **37**: 117–127.

[12]Wilson, J.R.U., Rees, M. & Ajuonu, O. (2006) Population regulation of a classical biological control agent: larval density dependence in *Neochetina eichorniae* (Coleoptera: Curculionidae), a biological control agent of water hyacinth *Eichhornia crassipes*. *Bulletin of Entomological Research* **96**: 145–152.

By: K.B.M. Lorentz & M.J. Byrne, University of the Witwatersrand, Department of Animal, Plant and Environmental Sciences, Private Bag 3, Wits, 2050, South Africa.
Email:klorentz@mweb.co.za or marcus@gecko.biol.wits.ac.za

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.

Making the Most of IPM Produce in Bangladesh

Recent initiatives in Bangladesh have created a model for developing local and export markets for pesticide-free produce from farmers practising IPM in developing countries. This is an area of great interest to donors/customers, given European demands for 'trade justice'.

The Danida-funded 'Strengthening Plant Protection Services' (SPPS) project in Bangladesh, executed by the Department of Agricultural Extension (DAE), started in 1997. By the end of phase II of the project in June 2006, 212,500 farmers throughout the country had been trained, through 8500 farmer field schools (FFS), in rice and vegetable IPM. More recently FFS graduates have been encouraged to form IPM clubs, which have since developed into community-based organizations and provide continuing support for farmers as they follow IPM practices and grow and harvest pesticide-free crops.

Marketing the pesticide-free produce presents the next challenge. Although many IPM farmers have been able to eliminate synthetic pesticides completely from their crops and there is considerable consumer demand for IPM produce locally and internationally, farmers are unable to benefit because there is no marketing system in place that can either retain the pesticide-free status of their produce or create consumer confidence in labelled products that reach the supermarket. A CABI consultancy to the project facilitated the process of designing a strategy to overcome these obstacles.

At first sight, the lucrative and growing international organic market might seem attractive. However, organic farming is proscribed by strict standards, laid down by IFOAM (International Federation of Organic Agriculture Movements), which bans the use of all synthetic pesticides and fertilizers to protect the environment and human health. In the case of smallholder farmers in developing countries, this means that no pesticides or fertilizers can be used in any of the crops that are grown, in any part of the farm. While it is possible for farmers to eliminate toxic pesticides from the system and use compost/manure to maintain soil fertility in small kitchen gardens, it will be extremely difficult to eliminate chemical fertilizers from field crops such as rice and wheat without compromising the yields of these crops. Considering the pressing need for the high productivity required in rice and wheat in order to sustain Bangladesh's growing population it would be irresponsible to recommend a programme of conversion to internationally certifiable organic agriculture for the majority of farmers in this country.

An alternative solution is to establish a local market for pesticide-free produce. This would meet consumer demand for fruit, vegetables and grain that they can be confident are free from pesticide residues while allowing the farmer to continue to use inorganic fertilizers as part of an integrated approach to maintaining soil fertility. It would also keep the door open for future moves into organic production. For this to succeed the following shortcomings need to be addressed:

- The current dependence on middle men to buy and transport produce to the wholesale market in Dhaka: they are unlikely to pay farmers a fair price for pesticide-free produce and are equally unlikely to keep it separate from sprayed produce.
- A huge information gap between IPM farmers and supermarkets/consumers in Dhaka.
- A lack of consumer confidence in produce labelled 'pesticide-free'.

CABI devised the following step by step approach to put in place a sustainable system for farmers to benefit financially from IPM:

1. Develop standards for IPM/pesticide-free production of fruit and vegetables in Bangladesh that can be easily reached by the most resource-poor farmers, without jeopardising food security.

2. Publicize these standards widely through a mass media campaign.

3. Conduct a farmer participatory market survey (FPMS) to familiarize IPM club farmers with the marketing system in Dhaka.

4. Establish a marketing system that operates through the local IPM clubs, supported by a labelling system that represents enforceable standards, which will facilitate the establishment of a local market in Dhaka and other large towns.

5. Plan 'Fair Trade' production of some high value spices and vegetables with longer shelf-life, e.g. garlic, ginger, turmeric, chilli, cardamom.

6. Progress towards organic production of these and other crops where possible.

The first step was taken in November 2005 when CABI facilitated a workshop of farmers, master trainers, extensionists and NGO workers. This resulted in draft Standards for Pesticide-Free Food Crops in Bangladesh that guarantee traceability. These were reviewed by a wider group of stakeholders and then finalized at a second workshop early in 2006. They are now due to be endorsed by the Ministry of Agriculture. The Standards will be represented by a labelling system to be enforced by a new Pesticide-Free (PF) Registration Authority. Terms of reference for the new authority (consisting of farmers, master trainers, supermarket buyers and NGOs) to enforce the PF Standards have been drawn up. An eye-catching label for PF produce has also been designed.

While this was taking place, steps were also being taken to develop a local marketing system for pesticide-free produce. Twenty IPM club farmers conducted a farmer-participatory market survey (FPMS) in five supermarkets and two markets in the Gulshan district of Dhaka. The results indicated an overwhelming desire for pesticide-free produce. So in a subsequent workshop the farmers formulated a strategy for the direct marketing of their PF produce to supermarkets and other outlets Dhaka. There are a number of essentials if this is to work:

- Traders need to be able to keep PF produce separate.
- Traders must be willing to pay farmers a fair price.
- The level of consumer demand must be known.
- Farmers must be able to meet the demand in terms of range and amounts of produce.
- Frequency of deliveries needs to be agreed and met consistently.

Farmers will have to negotiate contracts with traders and ensure continuity of supply, particularly through the summer. Specific supermarkets appealed to farmers who took part in the survey, or hiring stalls at one market to sell their produce themselves. For them to succeed they will need training in supervision of quality control and marketing, and in negotiating skills. To meet transport requirements, the use of readily identifiable, stackable crates was recommended, together with the provision of start-up funds to cover the costs of purchasing one or more vehicles; in time IPM clubs should accrue enough profit to buy their own vehicles.

Consumer confidence will be built through separating and labelling the PF produce. Marking produce with a registration code for the IPM club from which it originated will ensure traceability and ultimately allow the consumer to understand the conditions under which the crop was grown. Clearly defining these conditions and making sure both growers and consumers understand them will help bridge the information gulf between them – and this is one purpose of the Standards, described above.

Once the local PF market has been secured, further opportunities can be pursued; for example, exporting high-value crops such as hot peppers to the European Union under 'Fair Trade' or 'Organic' labels. The development of a local market for pesticide-free fruits and vegetables will create an income-generating opportunity for thousands of poor, mainly women farmers throughout Bangladesh.

Source: Page, S.L.J. (2006) Recommendations on organic farming in Bangladesh and the future role of SPPS II/III. Final report for Danida, 38 pp.

Contact: Sam Page, CABI European Centre (UK), Silwood Park, Ascot, Berks SL5 7TA, UK.
Email: s.page@cabi.org

Nazrul Islam, local consultant to Danida.
Email: danspps@bdmail.net

Announcements

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

New Zealand Risk Analysis

New Zealand has recently revised its risk analysis process and methodology for the development of sanitary and phytosanitary measures. The new process and procedures are now available at:
www.biosecurity.govt.nz/pest-and-disease-response/

surveillance-risk-response-and-management/risk-analysis

Contact: Dr Michael Ormsby, Senior Adviser,
Risk Analysis, Biosecurity New Zealand, Ministry of Agriculture & Forestry, P.O. Box 2526, Wellington, New Zealand.
Email: Michael.Ormsby@maf.govt.nz

Biotechnology for Smallholder Farmers in East Africa

A new volume[1] contains the fourth of a series of IFPRI (International Food Policy Research Institute) briefs on genetic resource policies. Both bananas and maize are devastated by pests and diseases in East Africa, particularly in lowland tropical environments. Chemical pesticides are not economically viable for most smallholder farm families, but varieties with genetic resistance could play a vital role in reducing their vulnerability to crop failure. For that reason, national research programmes in East Africa have targeted bananas and maize for genetic transformation. Eight policy briefs examine the potential impact of transgenic bananas and maize on smallholder farmers.

[1]Smale, M., Edmeades, S. & De Groote, H. (2006) Promising crop biotechnologies for smallholder farmers in East Africa. Bananas and maize. Research at a Glance: Genetic Resource Policies. Download from:
www.ifpri.org/pubs/rag/br1004.asp

Contact: Michael Rubinstein, IFPRI
Email: m.rubinstein@cgiar.org

New Aquatic Invasions Journal

Aquatic Invasions is a rapid on-line journal focusing on biological invasions in European inland and coastal waters and potential donor areas of aquatic invasive species for Europe. The journal allows timely publication of first records of biological invaders for consideration in risk assessments and early warning systems. It also publishes relevant technical reports and other accounts not publishable in regular scientific journals. *Aquatic Invasions* is a part of the developing European early-warning system for aquatic invasive species.

Web: www.aquaticinvasions.ru/

Contact: Vadim Panov, Information Management Department, Zoological Institute of the Russian Academy of Sciences, Universitetskaya nab. 1, 199034 St. Petersburg, Russia.
Email: rbic@zin.ru
Fax: +7 812 3282941

Taro Website

The first beta-version of TaroPest, an identification and information kit for pests (diseases, insects, nematodes, etc.) of taro in the South Pacific has been launched. TaroPest is the product of an ACIAR (Australian Centre for International Agricultural Research) funded project involving the SPC (Secretariat of the Pacific Community) Plant Protection Service, Papua New Guinea National Agricultural Quarantine and Inspection Agency, and the Queensland University of Technology.

TaroPest is aiming to be a one-stop-shop for information concerning regional pests of taro, with the target audience being quarantine/biosecurity officers, plant protection workers and field extension officers. While currently web based, TaroPest will eventually be available on CD-Rom, with printable hard-copy options. The product is free to access and use.

Web: http://taropest.sci.qut.edu.au

Second Berlin Symposium

Best Management Practice (BMP) in Disease, Pest and Weed Management, the second international symposium jointly organized by the German Phytomedical Society (DPG) and the British Crop Production Council (BCPC), in collaboration with the Faculty of Agriculture and Horticulture of Humboldt University, Berlin (LGF) and the Federal Biological Research Centre for Agriculture and Forestry (BBA), Germany, will be held on 10–12 May 2007 in Berlin.

Web: www.dpg-bcpc-symposium.de

Weed Conference in Israel

An international conference, Novel and Sustainable Weed Management in Arid and Semi-Arid Agro-Ecosystems, will take place at the Hebrew University of Jerusalem, Israel, on 15–20 October 2006. It will include a session on biological control of weeds.

The conference will also inaugurate two newly formed EWRS (European Weed Research Society) Working Groups: Weed Management in Arid and Semi-Arid Agro-Ecosystems and Parasitic Weeds.

Web: www.agri.huji.ac.il/aridconference

Tephritid Fruit Fly Manual

A new manual from the International Centre of Insect Physiology and Ecology (ICIPE) describes life cycles, damage symptoms, species composition, distribution and host plants of the major fruit fly species attacking fruit and vegetables in Africa. The purpose of and tools and methodology for fruit fly monitoring, suppression, and host fruit processing and handling, are also covered, with brief notes on safety precautions during monitoring and suppression. Advice on packaging, handling and shipment of specimens to facilitate identification is provided, and a simple user-friendly taxonomic key to all the common fruit flies in Africa is given, to allow for rapid identification of the major species found on fruits and vegetables in the continent. There is also a 12-page checklist of host plants.

Ekesi, S. & Billah, M.K. (eds) (2006) *A field guide to the management of economically important tephritid fruit flies in Africa.* ICIPE, Nairobi, 104 pp.

Contact: African Fruit Fly Initiative (AFFI), ICIPE, Box 30772-00100 GPO, Nairobi, Kenya.
Email: affi@icipe.org
Web: www.icipe.org

Pacific Invasives Learning Network

The Pacific Invasives Learning Network (PILN) aims to empower effective invasive species management through a participant-driven process. At its inaugural meeting in Palau in May 2006, teams from the founding countries (Palau, American Samoa, Guam, Niue, Pohnpei and Samoa) and the Cook Islands, Fiji and French Polynesia held discussions about ongoing projects and strategies for managing invasive alien species, and identified funding, public awareness, political support, invasive weeds and island restoration as among the most important issues.

Web: www.sprep.org.ws/PILN/index.htm

Contact: Dr Jill Key, Coordinator,
Pacific Invasives Learning Network (PILN), SPREP, PO Box 240, Apia, Samoa.
Email: jillk@sprep.org
Fax: +685 20231

DAISIE: a European Alien Species Initiative

The project 'Delivering Alien Invasive Inventories for Europe' (DAISIE) is designed to deliver an alien species gateway to act as a 'one-stop-shop' for information on biological invasions in Europe. The project is supported by the European Commission under the Sixth Framework Programme.

The DAISIE portal includes access to its European Expertise Registry, which aims to link and mobilize current expertise on biological invasions. It is inviting experts on invasive species to register details of their taxonomic group, geographic area and thematic area, and since species from all over the world can invade Europe, experts from all over the world are welcome. By August 2006 the registry included information on 1169 experts from 84 countries for 2221 taxa.

Other elements under construction include the European Alien Species Database (delivery date November 2006), the Invasive Alien Species Accounts (delivery date June 2007) and Distribution Maps and Spatial Analysis (delivery date August 2007).
Web: www.europe-aliens.org/

Conference Report

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

Invasive Plants Meeting in the Azores

Europe remains a backwater as far as implementing weed biological control is concerned. The International Symposium on Intractable Weeds and Plant Invaders (ISIW&PI), which was held on 17–21 July 2006 and hosted by the Universidade dos Açores in Ponta Delgada, São Miguel Island, the Azores (Portugal), was important in the context of promoting biocontrol as a management option for invasive plant species in Europe. The 4-day conference was organized by the European Weed Research Society (EWRS) and the International Bracken Group (IBG) and had contributions from 226 authors, with 53 papers and 39 posters.

It was recognized that weeds had some terrible implications, not only for agriculture but also for the environment in general. Field trips to areas of the island particularly affected served to emphasize the threats posed to the endemic flora and fauna by the encroaching weeds; 69% of the 1000 plant species in the Azores are introduced.

The International Bracken Group (IBG) hosted a day-long session which gave an opportunity for the biocontrol sector, in the person of Djami Djeddour (CABI), to ask 'Whatever happened to the biocontrol of bracken?' This reminded the bracken community that an off-the-shelf agent, a *Conservula* sp. moth, had been fully tested in the UK and could provide a potential alternative to herbicides if the conflicts of interest can be overcome. The weed is a serious problem in the Azores and is continuing to expand in many parts of the world; for example it is believed that 15% of the UK could soon be covered in bracken. The presentations on the impact on livestock through cancers made horrifying viewing.

The urgent need for European countries to address regulation in biological control was clear in discussions between the few biocontrollers working in Europe. The scientists at CERNAS (Escola Superior Agraria de Coimbra, Portugal) anticipate difficulties in seeking permission to release an Australian pteromalid, *Trichilogaster acaciaelongifoliae*, against invasive *Acacia* spp. in Portugal. The agent has been previously released in South Africa, and the Portuguese team worked closely with South African scientists to confirm its suitability for Portugal. These fears are also held by scientists from CABI working on Japanese knotweed, *Fallopia japonica*.

There was a good deal of discussion about raising EU (European Union) awareness of invasives and biocontrol's legislative challenges during the EWRS Biocontrol Working Group meeting. The main concern is that revisions to the EU pesticide regulations could entrench the default by which classical fungal agents are treated in the same way as chemical products under Directive 91/414. This would clearly have disastrous effects and may limit options for managing a number of invasive weeds in Europe. Weeds such as *Ambrosia artemisiifolia*, which had many presentations associated with it, *Solanum eleagnifolium* and *Impatiens glandulifera* are amongst the prime targets.

Thanks to the efforts of biocontrol scientists promoting what is effectively a new concept in weed management in Europe, this strategy is talked about in the same breath as more traditional techniques. The presence of representatives from USDA (US Department of Agriculture) and CSIRO (Australia's Commonwealth Scientific and Industrial Research Organisation) who are able to refer to their long experience of actual implementation of projects certainly helps dismiss the usual concerns at meetings such as these. It cannot be long before the first classical release in Europe takes place.

By: Dick Shaw, CABI.

New Books

Economic Impact Assessment of Australian Weed Biological Control[1]

Over recent decades there have been many high profile debates about the pros and cons of biocontrol (here defined as the use of natural enemies) but most of these have revolved around the issue of whether the science is safe and how to make it safer. How much the outcomes of these debates have helped those involved in the field address a major constraint in implementing biocontrol – access to adequate funding – is unclear. Interestingly, one subject that could help in the promotion of and increased funding for biocontrol, but that has not received the attention it should, is economics. The situation has not been helped because biocontrol workers themselves have tended to shy away from this, yet it is perhaps the subject that stakeholders as a whole, and the wider public, are most interested in. This may not be an entirely fair comment because when biocontrol works (say in classical releases of exotic agents), the target pest frequently 'disappears' in such a spectacular way that most stakeholders rapidly forget there was a problem in the first place! Thus the biocontrollers then have a problem in securing new funding to follow through on monitoring.

There have of course been some classic studies on the economics of biocontrol, probably starting with DeBach's groundbreaking work published in 1964[2] that analysed the benefits and costs of biocontrol programmes in California. But globally, the subject has never really hit the limelight and good studies are few and far between, although Australia is a particular exception with a tradition of economic analyses. The general paucity of studies is unfortunate because even where analyses have been less than rigorous, tremendous benefits have been shown to accrue, e.g. biocontrol of the coffee mealybug (*Planococccus kenyae*) in Kenya in the 1950s.

This new volume by Page & Ryder[1] on the economics of weed biocontrol in Australia, commissioned by the CRC for Australian Weed Management, is a positive major step in a new direction in the economics of biocontrol, and builds on the Australian tradition and authority in the field. The book is inspirational in more ways than one but above all finally proves that effort in biocontrol is literally worth it (provided it is rooted in good science).

Why a focus on weeds? Australia, like many other countries, is affected by an increasing tide of invasive alien species problems; alien plants are some of the most serious of the invaders. Published estimates[3] indicate that invasive alien plants in crops and pastures cost Australia US$2.4 billion [>Au$3.1 billion] per year. Australia has invested much in biocontrol, particularly of invasive plants. And much of the investment in Australia (an average of Au$4.3 million/year) comes from private industry. In this day and age when invasive species impacts are hitting headlines across the globe, people, politicians and industries want solutions – and economic ones. Hence there is an increasing pressure on pest managers to deliver sustainable and economic packages.

This new study is refreshing because it provides an overview and analysis of the economics of a substantial and distinct biocontrol effort conducted over 100 years (since 1903). And it does it rigorously and is presented in a very readable and information-accessible manner. The book is divided into two major sections: an overview of methodology and a discussion of findings; and a detailed cost–benefit analysis (CBA) of those biocontrol projects where sufficient information was available. Two appendices at the end of the first section give details of the economic tools employed but these can be skipped by the non-economist as the results are explained very clearly in the rest of the book.

For the study, all weed biocontrol projects conducted in Australia have been assessed for inclusion; apart from recent projects where the field impact of agents is still unknown. As one might guess, a wide range of data sources have been consulted for the study; the authors particularly acknowledge the significant work undertaken earlier by Colin Wilson to collate information on the economics of biocontrol. A total of 76 programmes were identified. Out of these, 36 were deemed to have sufficient information for a detailed CBA. Twenty-nine of these 36 programmes (with the most informative data) are then used to provide an assessment of the overall return on investment from the biocontrol effort. Common data limitations included lack of information on the distribution and impact of a weed, research and development costs of biocontrol and impact of agents.

The authors highlight the significant differences in the various 'cost components' between the programmes discussed. For example, it has been demonstrated that some weeds have a huge impact on one sector or industry alone; blackberry is estimated to affect 8.8 million hectares of grazing land. Likewise, investment in biocontrol (where there has been a successful outcome) has varied enormously.

Fourteen of the 29 programmes assessed in detail returned a definite positive net benefit. From this perspective, some of the most successful programmes include prickly pear (benefit:cost ratio – BCR – 312:1), skeleton weed (112:1), rubber vine (108:1), annual ragweed (103:1), and Paterson's curse (52:1). Overall, the programmes provide a staggering annual benefit of Au$93.3 million, equating to a BCR of 23.1 (based on the annual investment in biocontrol). An estimated Au$71.8 million of the annual benefit flows into the agricultural sector through cost control savings and increased production. The authors point out that for most of the programmes, it was not possible to quantify the social and environmental benefits; thus the calculated BCRs are conservative in many cases. Good examples of benefits for conservation come from the successful biocontrol of rubber vine and bridal creeper.

There have been failures, for example, mistflower, fireweed and sicklepod, but the losses on these investments are more than compensated for by the returns on the successful programmes. Frequent causes of failure have been a lack of host-specific agents or a lack of establishment or significant impact of agents that have been released.

The principal conclusion of this work has already been mentioned – that in Australia's case, weed biocontrol really pays. But there are other important messages which really gravitate around one central point: the importance of gathering quantitative information on the economics of a weed's impact and information on a biocontrol programme at all stages of the programme. For Australia, many of the biocontrol programmes were stated as addressing industry or environmental needs but as the authors say "there is only limited evidence available to demonstrate how the weed biocontrol responded to identified industry needs." And this is largely because of a general lack of quantitative impact data.

Are there faults with the book? Only that the binding needs to be stronger, given the amount of reading the book is likely to get!

In conclusion, I hope this book will inspire and catalyse other biocontrol workers to look at the subject of economics more seriously (or to try and do more to include funding for an economist in their biocontrol projects). The study has been conducted by professional economists so it is 'robust' and it is stacked full of information. This reviewer is not an economist but most of the points are well explained and the 'take home' messages very clear.

[1]Page, A.R. & Lacey, K.L. (2006) *Economic impact assessment of Australian weed biological control*. CRC for Australian Weed Management, Technical Series No. 10, 151 pp.
Available online: www.weeds.crc.org.au/publications/technical_series.html
Orders: weeds.crc.publications@adelaide.edu

[2]DeBach, P. (1964) *Biological control of insect pests and weeds*. Chapman & Hall, London.

[3]Pimentel, D. (2002) (ed) *Biological invasions: economic and environmental costs of alien plant, animal and microbe species*. CRC Press, Washington DC.