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General News

IOBC Establishes an Access and Benefits Sharing Commission

The International Organization for Biological Control (IOBC) has formed a commission to discuss the problematic situation concerning the finding and use of new natural enemies, with the proposed name, 'IOBC Global Commission on Biological Control and Access and Benefit-Sharing (ABS)'**.** The proposal to establish the commission was unanimously supported by Executive Committee and Council members, and biological control scientists from various Regional Sections are being approached to take part.

The Convention on Biological Diversity (CBD) promotes the equitable and respectful sharing of access and benefits to genetic resources. A primary goal is to protect genetic resources that potentially have commercial value for biomedical and agricultural applications. Parties to the CBD have agreed to elaborate an International ABS Regime to be effective in 2010. In the meantime, a number of countries have restricted access to their often unexplored biological resources. Government policies and regulations on biological diversity can have critical disincentives to biological control. Research on biological diversity, and discovery and export of new biocontrol agents are now on hold in some countries. ABS currently seems to be a constraint to developing and implementing appropriate biological control programmes worldwide. There is a need to reach an international mutually-acceptable agreement on ABS, in which attention must be given to the economic, environmental, social and cultural aspects related to the exploitation of the biological diversity.

The mission statement of the new IOBC Commission envisages that it will provide scientific advice to oversee and advise the design and implementation of an ABS regime that ensures practical and effective arrangements for the collection and use of biological control agents which are acceptable to all parties.

Further details are given in: Brodeur, J. & van Lenteren, J.C. (2008) IOBC Global Commission on Biological Control and Access and Benefit Sharing. IOBC Global Newsletter No. 84, pp. 5–7.
Web: www.unipa.it/iobc

Patience Rewarded: Birch Leaf Miner Biocontrol in Northeastern USA

Patience and perseverance are character requirements that should appear in job descriptions for budding classical biological control (CBC) scientists. Occasionally CBC achieves a quick breakthrough; more often than not it takes decades. Yet it can be worth the wait, as extensive surveys in the northeastern USA for birch leaf miner (*Fenusa pusilla*) and its introduced parasitoid *Lathrolestes nigricollis* have shown.

The birch leaf miner is of European origin and has been present in North America for at least 85 years. It is thought to have arrived in the USA in 1923, probably in a shipment of plant material sent to Connecticut. From there it spread throughout the Northeast and into the Midwest. Heavy infestations cause disfiguring 'browning' of the foliage in these ornamental trees.

Under a classical biological control programme, four parasitoids were introduced between 1974 and 1982, first to Canada and then to the northeastern USA, where Roger Fuester and colleagues at the USDA-ARS (US Department of Agriculture – Agricultural Research Service) Beneficial Insects Rearing Laboratory in Newark, Delaware, made the first releases. However, only *L. nigricollis* established and spread to any extent and, according to Richard Casagrande (University of Rhode Island), although these parasitoids spread quickly, the build-up in the pest population was slow. Preliminary surveys by Roy Van Driesche and his team at the University of Massachusetts at Amherst during the 1990s suggested it was having localized impact, but it was not until surveys were conducted across seven states (Massachusetts, Connecticut, Rhode Island, New York, Pennsylvania, New Jersey, Delaware) in spring 2007 that the area-wide extent of control was revealed.

The team conducting the surveys, which recorded current birch leaf miner levels in terms of percentage leaves mined in spring and parasitism, came from the University of Rhode Island (led by Casagrande), the University of Massachusetts at Amherst (Van Driesche), USDA-ARS Beneficial Insect Rearing Laboratory at Trenton, New Jersey (Mark Mayer) and Newark, Delaware (Fuester), and Cornell Extension at Long Island Horticulture Research Laboratory in New York (Daniel Gilrein).

They found birch leaf miner had declined dramatically in five states (Massachusetts, Connecticut, Rhode Island, New York, Pennsylvania) and in northern New Jersey. According to Casagrande, it is no longer a pest here. Scientists conducting the sampling found it hard to find mined leaves, to the extent that too few larvae were recovered to estimate parasitism levels. Casagrande says they have not seen any damage from birch leaf miner in Rhode Island in four years, and he thinks it highly unlikely that they will see problems with it again. There does seem to be a southern limit to *L. nigricollis*' ability to suppress the leaf miner populations, however, for *F. pusilla* is still abundant in southern New Jersey although parasitism levels are significant, and results from Delaware were variable. These situations are not yet fully understood although climate matching and availability of hosts may be implicated

Casagrande says it is satisfying to be able to state publicly that a biocontrol programme has succeeded – and this one has included a lot of people and a lot of cooperation. Biological control systems such as this can be relatively inexpensive given that they result in permanent, selective control of target pests. He describes the birch leaf miner programme as a good example of a coordinated, long-term approach to classical biological control – more than 30 years in this case for complete control.

The results of the survey are being published in a paper in *Florida Entomologist*:
Casagrande, R., Van Driesche, R.G., Mayer, M., *et al.* (2009 in press) Biological control of *Fenusa pusilla* (birch leafminer) (Hymenoptera: Tenthredinidae) in the northeastern United States: a thirty four year perspective on efficacy. *Florida Entomologist.*

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Progress in Biocontrol of Ambermarked Birch Leaf Miner in Alaska

The ambermarked birch leaf miner, *Profenusa thomsoni*, is an invasive sawfly species from Europe that has reached extraordinarily high densities in Alaska[1], where it was first detected in the mid 1990s. Adult leaf miners lay their eggs in birch leaves in late June and early July. Larvae that hatch from the eggs feed by converting the green leaves into brown mines. In mid August – early September, mature larvae drop to the soil to overwinter[2]. Immediate damage to birch trees is aesthetic[1]. Long-term effects on tree health have not been assessed. *Profenusa thomsoni* was likely introduced to Alaska on infested nursery trees via western Canada, where it had invaded earlier. The pest was originally identified as *Fenusa pumila*, but later identified correctly as *P. thomsoni*[1]. This leaf miner attacks all species of Alaskan birch trees (*Betula* spp.). In Alaska it has been detected north to Fairbanks and south to Haines and Skagway, and it is still spreading.

In 2003, based on the studies in Edmonton, Alberta[3,4,5], a collaborative biological control programme against the ambermarked birch leaf miner was initiated by the USDA (US Department of Agriculture) Forest Service, the Canadian Forest Service, and the University of Alberta (Canada). In 2006, the University of Massachusetts – Amherst (USA) continued and expanded the project. The goal of the biological control programme was to control the pest population in Anchorage by introducing the same ichneumonid parasitoid that successfully suppressed this pest in Edmonton, Alberta. Originally thought to be *Lathrolestes luteolator*, a revision of the genus (now underway as part of this project by Alexey Reshchikov of the St Petersburg State University, Russia) has determined the parasitoid being introduced is actually a new species, not matching any previously described Palaearctic or Nearctic *Lathrolestes*.

The two graduate students who have worked on the project (Chris MacQuarrie of the University of Alberta and, currently, Anna Soper of the University of Massachusetts) have succeeded in establishing the desired *Lathrolestes* sp. ('yellow face') parasitoid in Anchorage. At least 3636 individuals of the parasitoid were released there from 2004–2008. In 2007 and 2008 parasitoids of this species were recovered at several Anchorage release sites, indicating that it is now established and increasing in numbers. Research by Anna Soper found that the local leaf miner population is also attacked by a local presumably native parasitoid (*Lathrolestes* sp. 'black face', which is also a new species under description). The relative roles of the 'black face' and 'yellow face' *Lathrolestes* in parasitizing *P. thomsoni* have yet to be assessed. In addition, a facultative hyperparasitoid (*Aptesis segnis*) has been found to attack the local native *Lathrolestes* sp. and its future impact on the introduced species will be a subject of investigation. DNA (mitochondrial COI gene) sequences for each of the two *Lathrolestes* species have been identified that allow larvae dissected from hosts to be classified to species, a useful development as rearing of these univoltine species to obtain adults requires a ten month treatment in soil. Given events in Alberta, it is expected that the Anchorage population of ambermarked birch leaf miner will eventually collapse, but this may take five or more additional years. Population levels of the leaf miner and its parasitoids will continue to be monitored through ongoing support from the USDA Forest Service.

[1]Snyder C., MacQuarrie C.J.K., Zogas K., *et al.* (2007) Invasive species in the last frontier: distribution and phenology of birch leaf mining sawflies in Alaska. *Journal of Forestry* **105**(3), 113–155.

[2]Martin J.L. (1960) The bionomics of *Profenusa thomsoni* (Konow) (Hymenoptera: Tenthredinidae) a leaf-mining sawfly on *Betula* spp. *The Canadian Entomologist* **92**, 376–384.

[3]Barron, J.R. (1994) The Nearctic species of *Lathrolestes* (Hymenoptera, Ichneumonidae, Ctenopelmatinae). *Contributions of the American Entomological Institute* **28**(3), 1–135.

[4]Digweed, S.C. (1998) Mortality of birch leafmining sawflies (Hymenoptera: Tenthredinidae): impacts of natural enemies on introduced pests. *Environmental Entomology* **27**, 1357–1367.

[5]Digweed, S.C., McQueen, R.L., Spence, J.R. & Langor, D.W. (2003) Biological control of the ambermarked birch leafminer, *Profenusa thomsoni* (Hymenoptera: Tenthredinidae), in Alberta. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, Edmonton, Alberta. Information Report NOR-X-389.

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Hard Evidence for Melaleuca Biocontrol

Evidence for the success of classical biological control of weeds is valuable on many levels. Most post-release studies are carried out at the plant level, or are purely correlative. While such evidence can be compelling, it is open to misinterpretation because of the absence of experimental controls, but these are difficult to maintain in the face of agent dispersal. A paper in *Biological Control* describes how a study of the population dynamics of *Melaleuca quinquenervia* (melaleuca) in Florida, USA, in the presence and absence of insect herbivory has demonstrated its significant population-level suppression[1].

Melaleuca, an Australian tree, was introduced to southern Florida in the late nineteenth century and by the 1990s had infested some 610,000 ha of its wetlands. Constant propagule pressure via a continuous seed rain from the canopy facilitated its extensive recruitment into native plant communities, enhanced by fire which disproportionately damages native plants while adding a layer of high nutrient ash to the soil. The net result has been replacement of native communities with virtual monocultures of melaleuca; it has dominated every freshwater plant community in southern Florida. Two biological control agents have been introduced: a curculionid weevil, *Oxyops vitiosa*, in 1997 and a psyllid, *Boreioglycaspis melaleucae*, in 2002 as part of an overall integrated melaleuca management project.

Plots were established in March 2002 among a cohort of melaleuca in an area of cypress–pine wetland where a destructive crown fire in 1998 had led to a major population recruitment of the weed. Half the plots were sprayed with a broad-spectrum, systemic insecticide (acephate) every 4–6 weeks for five years to reduce herbivory by both agents. Half were untreated and thus experienced no constraints on herbivory. The plots were assessed annually from 2003 to 2007. The results were startlingly clear: the invasion by this 1998 melaleuca cohort was halted and reversed in terms of density, biomass, and seed production by biological control. Specifically, while melaleuca density was essentially unchanged after five years compared with initial densities in sprayed plots, density decreased about 48% in unsprayed plots. Mean tree height increased some 20% on sprayed plots, but actually decreased about 30% in unsprayed plots. Tree mortality never exceeded 6% a year in sprayed plots, and most of that was attributed to self-thinning. In contrast, average tree mortality ranged from 11–25% in unsprayed plots. Sprayed trees began to produce seeds in 2005, but no seed production ever occurred in unsprayed plots. The absence of seeds from unprotected trees for the first two years probably reflects the fact that these young trees were subjected to herbivory before the experiment began. However, larger and older melaleuca trees in the same area, which are not protected from herbivory, continue to produce seed, albeit at a reduced amount, indicating that tree age is a factor in assessing the impact of the biocontrol agents.

The effectiveness of the biological control programme against melaleuca had been indicated by previous correlative studies, but this study provides the first conclusive evidence that the two introduced agents are suppressing melaleuca at a population scale. It highlights the importance of prioritizing and budgeting long-term evaluation components for classical biological control projects so success can be measured and quantified. The design of such evaluations will vary, but establishing and maintaining true experimental controls, where possible, will often provide the most dramatic and irrefutable evidence of efficacy.

[1]Tipping, P.W., Martin, M.R., Nimmo, K.R., *et al.* (2009) Invasion of a west Everglades wetland by *Melaleuca quinquenervia* countered by classical biological control. *Biological Control* **48**, 73–78.

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First Releases Against Erythrina Gall Wasp in Hawaii

The Hawaii Department of Agriculture (HDOA) released the first batch of parasitoids in November 2008 that it hopes will bring about control of the erythrina gall wasp (*Quadrastichus erythrinae*; EGW). This invasive eulophid has devastated endemic and introduced *Erythrina* (erythrina) trees in natural and landscaped areas in Hawaii. Staff from HDOA's Plant Pest Control Branch released about 500 *Eurytoma erythrinae* in a stand of native wiliwili trees in Liliuokalani Botanical Gardens on the island of Oahu. Thus far, more than 3000 parasitoids have been released on the islands of Oahu, Maui, Kauai, and Hawaii (Big Island).

It is not clear where the EGW infestation in Hawaii originated from, but Asia seems likely. Although the species is of African origin, it was first described in 2004 by Il-Kwon Kim (CSIRO [Commonwealth Scientific and Industrial Research Organisation] Australia), Gerald Delvare (CSIRO France) and John La Salle (CSIRO Australia) from specimens from Singapore, Mauritius and Reunion, and was subsequently reported from various countries in Asia and the Pacific.

EGW was first detected in Hawaii on Oahu in April 2005, but it proved to be already established and widespread on the island. It spread rapidly to neighbouring islands over the ensuing months. Adult EGW females lay eggs in the leaves of erythrina trees, which include native wiliwili (*Erythrina sandwicensis*) and other introduced species such as coral tree (*E. variegata*), including a tall form of this species which has been widely planted as a windbreak. The larvae cause severe galling and deformities in the leaves, leaf petioles and shoots, and eventually the leaves drop. Infested trees suffer a decline in health and eventually die. EGW was rapidly recognized as a serious threat to the survival of wiliwili in particular. A classical biological programme was quickly launched, and foreign exploration was underway before the end of the year.

Eurytoma erythrinae was the dominant parasitoid of gall-formers attacking the African species *Erythrina abyssinica* in many localities in Tanzania, from where it was collected by HDOA's exploratory entomologist, Mohsen Ramadan in early 2006. It was subsequently described as a new species by Michael Gates (US Department of Entomology – Systematic Entomology Laboratory) and Delvare, and has since been subjected to rigorous safety testing. Ramadan spent several months in 2005–06 and in 2007 in areas of Africa collecting and shipping insects back to HDOA's quarantine facility, as did a team from the University of Hawaii College of Tropical Agriculture and Human Resources. The female *Eurytoma erythrinae* inserts its eggs into EGW galls. On hatching, the larva feeds ectoparasitically on an EGW larva, and will tunnel into to adjacent gall chambers to feed on further gall wasp larvae.

Once the samples from Tanzania were received in Honolulu, HDOA insectary staff began rearing the insects in quarantine and conducted host-specificity testing to assess whether *E. erythrinae* would attack non-target galling insects. From choice tests and behavioural responses conducted on seven species (a Hawaiian endemic psyllid, three tephritids and one eriococcid used in biological control, and two exotic Hymenoptera), it was concluded that the potential biocontrol agent was specific to EGW. Permits to release the biocontrol insects were obtained from HDOA in 2007, and from the US Department of Agriculture in November 2008.

According to Neil Reimer, manager of HDOA's Plant Pest Control Branch, biological control is the only way that EGW can be controlled and wiliwili saved in remote and forested areas. He also says that the first releases were being made at the optimum time, because the young leaves are just emerging, and as the gall wasp population increases, so will the predatory wasp's.

Source: Hawaii Department of Agriculture.
Web: http://hawaii.gov/hdoa

University of Hawaii at Manoa – Botany
Web: www.botany.hawaii.edu

Biocontrol Agent Reveals Biosecurity Weakness

The introduction of the mymarid egg parasitoid *Gonatocerus ashmeadi* against glassy-winged sharpshooter (*Homalodisca vitripennis*; GWSS) in Tahiti provided swift and excellent control of this invasive pest [see refs in [1] and *BNI* 27(3), 47N–49N, 'Glassy-winged sharpshooter K.O.'ed – first round – in French Polynesia']. The subsequent rapid spread of the biocontrol agent to other, nearby and far-flung, islands of French Polynesia also afflicted with GWSS was on the face of it a good thing. However, although there were plans to extend the biocontrol programme, approval to release *G. ashmeadi* had been obtained only for the island of Tahiti and the agent unexpectedly spread to distant island groups that had not been fully assessed for non-target impacts.

As a paper by Petit *et al.* in *BioControl* explains[1], a number of features of this potentially embarrassing event for classical biological control redeem the situation. Control in the islands to which *G. ashmeadi* spread was as dramatic and rapid as it was in Tahiti, and fortuitously there do not appear to have been any non-target effects on native cicadellids. In addition, introduction of the biocontrol agent to Tahiti, effectively an insular natural laboratory, provided an opportunity to study the spread of the biocontrol agent as a model invasive insect in a new ecosystem. And unintentionally, this post-release monitoring process gave early warning as *G. ashmeadi* spread to other islands and island groups, and illustrated why the quarantine measures implemented to slow spread of GWSS had failed.

GWSS, a cicadellid native to the southeastern USA and northwest Mexico, is a highly invasive pest able to reach extremely high population densities in the absence of its natural enemies, and is also a threat because it vectors the lethal plant pathogen *Xylella fastidiosa*. GWSS was first found in French Polynesia in 1999 in Tahiti. Despite the introduction of special quarantine measures, by 2005 it had spread to most of the other Society Islands, and also to the Marquesas (2004) and Austral (2005) island groups. GWSS was likely exported from French Polynesia to Easter Island in 2005, and by 2007 it had established in the Cook Islands. GWSS achieved unprecedented densities in French Polynesia, which has been put down to four factors: (1) ideal environmental conditions, with a mild, wet climate and abundant year-round feeding and oviposition sites, (2) absence of effective natural enemies, (3) toxicity to generalist predators (native spiders) and (4) lack of competition owing to an impoverished native cicadellid fauna.

Xylem-feeding cicadellids take in enormous quantities of plant sap to obtain nutrients and consequently produce copious amounts of watery excreta. The spectacular densities achieved by GWSS in French Polynesia meant that infested trees literally 'rained' excreta and were rendered useless as shade trees, while at night flying adults invaded lit buildings. Massed feeding on plants was thought to have adverse effects on the many host species of GWSS in the region and was implicated in retarded plant growth and declines in fruit production.

As part of the biocontrol programme, Petit *et al.* monitored the spread of *G. ashmeadi* through Tahiti and to nine other islands infested with GWSS in the Society, Austral and Marquesas island groups. They anticipated parasitoid dispersal would follow a stratified dispersal process; a combination of the organism moving short distances by walking or flying, and long distances assisted by abiotic (e.g.

wind) and biotic (e.g. human-mediated) factors. The island system in which studies were conducted made it easy to separate short- and long-distance movements. Although *G. ashmeadi* was released only on Tahiti (beginning in May 2005), within ten months it had colonized all ten surveyed islands, in some cases though multiple introductions, and in the process the parasitoid crossed up to 1400 km of ocean from the release sites on Tahiti. The authors conclude that the rapid long distance spread was via unregulated inter-island movement of plant material that carried – unbeknownst to the transporter – parasitized GWSS egg masses. They consider this more important than adult 'stowaways' on aircraft because first records for most islands were around ports rather than airports. Even on Tahiti, populations sprang up at locations far from the leading edge of the colonizing wave that emanated from release sites, which suggested human factors were involved although wind-assisted dispersal cannot be completely discounted.

In retrospect, it could be argued that non-target impact studies should have included the entire potential range of the biocontrol agent in the central and eastern Pacific. The biodiversity of island ecosystems is recognized to be at high risk from invasive species, which makes it all the more important to evaluate the potential impact of a potential natural enemy introduction. However, these studies are difficult because the fauna and flora of many islands have been little studied. The logistical difficulties, expense, and time of undertaking such a far-reaching study may have meant that GWSS remained uncontrolled in the South Pacific, with the accompanying risks that it might spread even further to threaten important agricultural nations (e.g. Australia and New Zealand) and/or acquire and begin to vector *Xylella fastidiosa* through the Pacific region.

Although it was not the purpose of the research, *G. ashmeadi* functioned as a 'biomarker' allowing Petit *et al.* to assess invasion pathways for GWSS as well as the biocontrol agent itself, and their studies provided an informal audit of the effectiveness of quarantine measures designed to curb the accidental spread of noxious organisms. With the advent of GWSS, heightened inter-island quarantine measures had been brought in, involving defoliation of plants, insecticide treatments, methyl bromide fumigation, and visual inspections. The monitoring programme in the ten islands of French Polynesia provided evidence of numerous human-mediated incidences of dispersal, and it is clear that quarantine measures failed. While classical biological control has given this particular tale a happy ending, the next invasive pest may be less amenable to suppression with natural enemies and another quarantine failure may be disastrous, especially if substantial non-target impacts result.

The regulatory problems facing the responsible authority, the French Polynesian Plant Protection Territorial Service, are immense. Although all inter-island plant movement should be authorized, this regulation is widely flouted amid lack of public awareness of its importance and in a Polynesian culture where inter-island exchange of plants, foliage, and flowers is a tradition; flower necklaces are best known internationally but other ornamental uses of plants together with horticulture/gardening promote massive unregulated inter-community and inter-island movement of plants. A change of attitude to the role of plants as potential carriers of plant pests, and indeed potentially invasive plants, needs not just better enforcement of regulations, and better infrastructure and personnel training, but also a concerted outreach and education effort together with stiff penalties for transgressors.

[1]Petit, J.N., Hoddle, M.S., Grandgirard, J., *et al.* (2008 online) Successful spread of a biocontrol agent reveals a biosecurity failure: elucidating long distance invasion pathways for *Gonatocerus ashmeadi* in French Polynesia. *BioControl*, Online First, 12 December 2008. DOI: 10.1007/s10526-008-9204-7.

Biofuels, Biocontrol and IPM

The corn [maize] ethanol industry in the USA has expanded rapidly in recent years. A proliferation of ethanol production facilities in major corn-growing areas has increased demand for corn and this is restructuring agricultural landscapes. A paper published at the end of December 2008 looked at how these changes have affected biocontrol services[1]. The analysis by Landis *et al.* highlighted how generalist natural enemies both cut pesticide use and boost farm profits. However, the increasing corn acreage has reduced the value of this natural pest control, and the biggest loser in this instance was soybean, in terms of both acreage and loss of biocontrol. It need not be so, and the authors explain how, if the industry were to embrace biofuels that can be produced from a greater variety of crops, the expanding biofuel crop area could actually enhance landscape diversity and ecosystem services

Landis *et al.* looked first at changes in acreages of maize and other crops in four US states: Iowa, Michigan, Minnesota and Wisconsin. Between 2006 and 2007, corn acreage increased between 12% and 20% in the four states, and this was primarily at the expense of soybean, which fell 13–20%. They found that the proportion of both corn and soybean area was negatively associated with landscape diversity but effects on biocontrol services differed. For biocontrol services, they focused on biocontrol of the soybean aphid, *Aphis glycines*, whose natural enemy complex is currently dominated by generalist predators and especially coccinellid beetles, which have most potential to suppress small, early-season pest populations. The authors devised a biocontrol services index (BSI), defined as "the proportional decrease in aphid population growth in the presence of natural enemies" to assess the impact of varying the proportion of corn and soybean areas on aphid biocontrol. They found that the BSI declined significantly as the proportion of corn area increased, but soybean area had no effect on the index.

Next, using the estimated relationship between the BSI and corn area, together with established models for soybean aphid population dynamics and yield loss from aphids, they estimated the economic consequences of changes in corn area on biocontrol in soybean for 23 site–year combinations. They looked at two aphid management strategies: IPM and biocontrol alone, which cover the range of approaches currently used by growers in these states. IPM included weekly scouting and application of insecticides when aphid populations exceeded an established economic threshold, which reduced the pest population by 98%; biocontrol meant relying solely on the prevailing natural enemy complex to suppress the pest. Data derived from exclusion experiments indicate the role the natural enemies play in keeping soybean aphid levels below the threshold at which insecticide spraying becomes necessary in the IPM strategy; the action of natural enemies in preventing the need for insecticide spraying is a major component of the value of biocontrol services.

Soybean aphid populations vary, and the years included in this study saw very different population levels. When aphid populations were high (in 2005) growers relying solely on biocontrol suffered heavy yield losses but the value of biocontrol services was also high (averaging $406/ha); increasing corn areas to 2007 levels reduced the average value of biocontrol services by more than a half. Losses were far less with the IPM strategy and so was the value of biocontrol services ($35/ha), but increasing the corn area (to 2007 levels) meant the value fell some 17%. When aphid populations were low (as in 2006), biocontrol service values were lower, and they and the impact of increased (2007) corn area were broadly similar for the two management strategies.

Taking average values for all site–year combinations, increasing the corn area to 2007 levels led to a decrease in the value of biocontrol services from $196 to $103/ha where biocontrol was the sole strategy, and from $33 to $25/ha in the IPM situation; this $8 difference represents almost 25% of the average cost of crop chemicals per hectare on soybean grown using IPM in 2006. The percentage of fields reaching the threshold level was increased from 30% for the 2005–06 corn acreage to an estimated 43% for the 2007 corn area with a knock-on effect on biocontrol services. Extrapolating from this, the authors estimated the value of biocontrol services for IPM farmers (the majority) in the four states to be at least $239 million annually at 2007–2008 soybean prices, and they estimated the 2007 expansion in corn area would represent a loss of $58 million per year from yield reduction and pesticide costs. Farmers who relied solely on biological control would suffer a far greater financial loss.

In terms of its effect on biological control in soybean, the growth of the corn ethanol industry suffers from an unfortunate coincidence. Since 2000 biocontrol of insect pests in soybean has become heavily reliant on generalist natural enemies following the arrival in the US Midwest of the Asian soybean aphid. This invasive aphid has expanded its range rapidly and is now the principal cause of yield loss – and insecticide application – in soybean. What is particularly striking is that before soybean aphid arrived, insecticides were rarely used in the crop. Although a multi-institutional classical biological control programme was rapidly organized and is making progress[2], this approach takes time to deliver results and the first exotic biocontrol agent (the braconid *Binodoxys communis*) was introduced only in 2007. At the present time biological control relies on generalist native agents to keep soybean aphid populations in check.

Landis *et al.* say that although farmers may currently be gaining from high prices paid for corn, and are increasing corn areas to maximize this gain, there are substantial but until now hidden costs to their soybean crops. Moreover, the authors say, their study probably underestimates this, because although most of the extra area planted to corn has been at the expense of soybean, minor crops and fallow areas, including conservation acreage, have also been affected which has further diminished habitat diversity – and the impact of corn area on natural enemies will also be having effects on biocontrol in other crops

Nevertheless, biofuel crops need not necessarily be bad news for biological control. Landis *et al.* note that, in their study area, corn supports very few aphids and thus few of the coccinellids critical for soybean aphid control, but other crops (wheat, alfalfa, vegetables) and non crop habitats do. Development of cellulose-based ethanol processing facilities that can use a greater variety of crops as raw material (grasses, woody plants) could have the potential to diversify agricultural landscapes and enhance biocontrol services.

[1]Landis, D.A., Gardiner, M.M., van der Werf, W. & Swinton, S.M. (2008). Increasing corn for biofuel production reduces biocontrol services in agricultural landscapes. *Proceedings of the National Academy of Sciences* **105**, 20552–20557.
Web (open access): www.pnas.org/content/early/2008/12/15/0804951106.full.pdf+html

[2]Wyckhuys, K.A.G., Hopper, K.R., Wu, K.-Ming., *et al.* (2007) Predicting potential ecological impact of soybean aphid biological control introductions. *Biocontrol News and Information* **28**(2), 30N–34N.

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Parasitoids: Introducing both Panaceas and Pandora's Box

A paper in the first 2009 issue of *Biological Invasions*[1] reviews the arguments surrounding the biosafety of classical biological control (CBC) since Francis Howarth opened the debate with his 1983 publication[2]. The author, Dylan Parry, argues that the debate remains polarized at least partly because of a lack of quantitative data on both sides of the argument. Looking specifically at introductions of exotic parasitoids, he discusses the use of quantitative approaches for assessing potential non-target effects.

Historically, the impacts of prospective parasitoid biocontrol agents on non-target insects were subject to limited investigation, apart from testing them against iconic species and economically important groups such as bees; expansion of host range by introduced parasitoids could even be viewed favourably. Parry says that the debate about the importance of parasitoid non-target effects has also been and continues to be hampered by a failure to distinguish between the frequency and the strength of an effect, which can lead to exaggerated or underestimated claims. He identifies three methodologies that can be used in a more rigorous, quantitative assessment of the non-target effects of introduced parasitoids, drawing on recent studies to illustrate these [see [1] for references].

Quantitative food webs do not by themselves allow direct assessment of the role of parasitism of a particular species, but they provide a starting point for investigating such effects in the context of community structure. M. L. Menneman and J. Memmot collected plants and lepidopteran herbivores from a relatively pristine habitat in Hawaii and then collected emerging parasitoids to construct quantitative food webs. They found 97% of the parasitoids were exotic and of these 83% had been deliberately introduced to Hawaii. They found parasitism levels by exotics of 25% in some species which could indicate significant impact at the species level, although further study of individual species would be needed to ascertain any effect.

Life table analysis by other researchers in Hawaii allowed M. T. Johnson and co-workers to examine the possible role of a tachinid parasitoid, *Trichopoda pilipes*, introduced for the control of the exotic southern green stink bug (*Nezara viridula*), on the decline of the koa bug, *Coleotichus blackburniae*; *T. pilipes* and parasitoid drift has been blamed for the decline of this endemic Hawaiian scutellerid and the bug is undoubtedly attacked by it. But the life table analysis showed that *T. pilipes* actually plays a minor role in koa bug mortality at many sites.

Turning last to experimental populations, Parry describes how this approach was used to confirm the role of another exotic tachinid, *Compsilura concinnata* (introduced a century ago to control gypsy moth, *Lymantria dispar*) in the decline of saturniids in northeastern North America. G. H. Boettner and co-workers used laboratory-reared individuals of two species to deploy sentinel larvae which were replaced with individuals of similar age every few days; retrieved larvae were reared through for parasitoids to emerge. This technique, although labour-intensive, is a powerful tool for estimating parasitism, and in this case showed *C. concinnata* to be the dominant parasitoid. However, work by two other groups of researchers indicated that one cannot generalize; they found that although *C. concinnata* was the culprit in the decline of some saturniids in some areas, it could not always be implicated, or only to a limited extent.

While quantitative evaluation of non-target effects on potential indigenous hosts has been limited, Parry points out that even less attention has been paid to possible detrimental effects on indigenous parasitoids; in general very little is known about the impact of introduced parasitoids on native ones. Nevertheless, drawing on the scant examples, he illustrates how suspected non-target effects on indigenous parasitoids can be quantitatively assessed.

Competition between introduced and native parasitoids was studied in New Zealand where a tachinid (*Trigonospila brevifacies*) introduced for control of tortricid pests on fruit trees had unexpectedly moved outside this environment and adopted native hosts that occurred in forests. When V. M. V. Munro and I. M. Henderson used connectance and quantitative food webs to identify host species used by the introduced tachinid and quantify parasitoid load, they found that numerical dominance and degree of overlap with native parasitoids suggested *T. brevifacies* is displacing them.

A method of experimental manipulation of population levels with modelling was used in the USA to assess whether *Aphidius ervi,* which had been introduced to control the pea aphid *Acyrthosiphon pisum*, was responsible for displacing what had previously been the dominant parasitoid: the native species *Praon pequadorum*. Initial results were puzzling as *P. pequadorum* proved the superior competitor at all population levels. However, *Aphidius ervi* turned out to have a far more efficient foraging strategy which gave it a particular advantage in the prevailing harvesting practices which cause pea aphid populations to plummet periodically.

Parry acknowledges that quantitative methods are harder to implement in natural environments, not least because rarely was much known about native parasitoid–host relationships at the time exotic natural enemies were introduced. Parry again cites the example of *C. concinnata*. The existence of survey records of native parasitoids from just after *C. concinnata*'s introduction to New England allowed him to use these as a baseline for contemporary studies. Using experimental populations of two native forest lepidopterans, he found evidence suggestive of the competitive displacement of a polyphagous native tachinid, *Lespesia frenchii*, by *C. concinnata.* Experimental population studies on host-specific parasitoids suggest impacts on them may be even greater. Parry says that although *C. concinnata* is an extreme case, it does illustrate the importance of looking beyond simple host–parasitoid interactions when assessing potential non-target impact of prospective parasitoid biocontrol agents.

Summing up, Parry concludes that the argument that most biocontrol 'mistakes' were made "in earlier less enlightened times" is supported, although some surprisingly poorly thought out introductions have been conducted even recently. He endorses the need for better host-range testing protocols for parasitoids which have lagged behind those for prospective insect biocontrol agents for plants, although he acknowledges the difficulty of working with parasitoids in the laboratory. However, if the types of study he describes were conducted more often, he suggests, this would "increase our understanding of the nature of non-target interactions with introduced parasitoids and bring more rigour to a debate often dominated by rhetoric."

[1]Parry, D. (2009) Beyond Pandora's box: quantitatively evaluating non-target effects of parasitoids in classical biological control. *Biological Invasions* **11**, 47–58.

[2]Howarth, F.G. (1983) Biological control: panacea or Pandora's box? *Proceedings of the Hawaiian Entomological Society* **24**, 239–244.

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What's on Old Man's Beard?

Unlike Edward Lear's old man, who had no difficulty identifying nests of "two owls and a hen, four larks and a wren" in his beard, Landcare Research has encountered problems with monitoring the fate of a fungus introduced as one of three agents so far introduced for the control of the invasive vine old man's beard (*Clematis vitalba*) in New Zealand. However, they are developing new methods that may make tracking such agents easier in the future.

Clematis vitalba is native to Europe where it occasionally causes weed problems in vineyards and forests. Its status in New Zealand, to which it was introduced as an ornamental in the first part of the twentieth century, is much more severe. It forms large vigorous thickets in lowland forest, and climbs forest trees forming a dense canopy which can reduce healthy native and exotic forest to a low thicket of vines. The Landcare Research-led classical biological control programme against *C. vitalba* in New Zealand, which began in 1989, has had to take account of the potential impact of introduced agents on native *Clematis* species, which means being able to keep track of the released agents and distinguish them from native natural enemies. This is particularly problematic for the fungus *Phoma clematidina*; the other agents are insects.

Phoma clematidina was selected following a survey for plant pathogens of *C. vitalba* in Europe and North America. A virulent strain of this fungus that caused extensive leaf necrosis was one of the potential agents prioritized for testing. A weakly pathogenic form of *P. clematidina* was known to be already present in New Zealand but appeared to cause only cosmetic damage to *Clematis* species, while the exotic strain looked as if it might be able to cause disease on *C. vitalba* early in the growing season and thus could have significant impact on weed growth. Following host specificity testing of the exotic strain, approval for its introduction was given in 1996 and releases were made. The fungus became established and initial results were promising, but ten years on this had not translated into the hoped for impact to weed populations and it was not clear why.

Monitoring the fate of the released agent proved to be unexpectedly difficult. It was often difficult to distinguish the native and exotic strains by morphological means and DNA studies revealed the situation to be more complex than anticipated. The results indicated that there are multiple strains of *P. clematidina* as well as several other *Phoma* species on *Clematis* species in New Zealand. Various fungi currently identified as *P. clematidina* may be different species; the genus is currently under review by researchers in the Netherlands. In terms of the exotic strain the news was good insofar as it was not found on non-target native *Clematis*, but bad in that neither was it found on the target weed *C. vitalba*.

Some strains of *P. clematidina* found are endophytic and cause no disease symptoms. Further studies with one of these strains indicated it was transmitted vertically; it was found infecting surface-sterilized seed. The endophyte release hypothesis proposes that plants harbouring endophytic fungi are rendered more resistant to other, pathogenic, fungi. It is possible that the existence of the endophytic strain is at least part of the reason why the introduced biocontrol strain has not inflicted the hoped-for damage and was not recovered during these studies; the endophytic strain may have led to the introduced strain becoming rare or even dying out.

The old man's beard project has highlighted the difficulties that can be encountered in tracking the movements and behaviour of introduced fungal biocontrol agents. Another strand of the research has been focusing on methods of marking fungal strains to allow them to be tracked more easily. The team selected spontaneous (naturally occurring) mutant strains of *P. clematidina* that are defective in the ability to use nitrate nitrogen for growth[1]. These strains, however, retain high pathogenic ability[2]. Experiments demonstrated that it was possible to infect *C. alba* with these strains, re-isolate them from plants once disease had developed, and distinguish them from each other and from non-mutant isolates. This proof-of-concept study indicates the possibility of marking fungi before they are released, which would make the monitoring task easier.

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[2]Parkes, S.L., Beever, R.E., Pak, H.A. & Pennycook, S.R. (2003) Use of Nit mutants to track fungi in the field. In: 8th International Congress of Plant Pathology, Christchurch New Zealand, 2–7 February 2003. Abstracts of offered papers, # 8.45 (p. 112).

Adapted from: Anon (2008) Fascinating fungal findings. Landcare Research New Zealand Ltd 2008, *What's New in Biological Control of Weeds?* No. 46, pp. 3–4.

Additional information: Gourlay, H., Wittenberg, R, Hill, R.L., *et al.* (2000) The biological control programme against *Clematis vitalba* in New Zealand. *Proceedings of the X International Symposium on Biological Control of Weeds,* pp. 709–718.

Defeating Dengue from Within

A paper in *Science* has suggested that a life-shortening strain of the bacterium *Wolbachia pipientis* found in the fruit fly *Drosophila melanogaster* could provide a new approach for controlling vector-borne diseases such as dengue[1].

Dengue is a viral infection transmitted by *Aedes* mosquitoes (principally *Ae. aegypti*) that causes a severe flu-like illness, and sometimes a potentially lethal complication, dengue haemorrhagic fever. According to the World Health Organization, the global incidence of dengue has grown dramatically in recent decades and about 40% of the world's population is now at risk. Dengue haemorrhagic fever is a leading cause of serious illness and death among children in some Asian countries. Dengue occurs in tropical and subtropical climates worldwide, mostly in urban and semi-urban areas where currently available control measures can be hard to implement. Moreover, *Aedes* mosquitoes bite during the day making bite-avoidance very difficult.

The potential for *Wolbachia* bacteria in biological control was suggested some years ago. These bacteria are found in many arthropods, especially insects. Transmitted through the female, they can have a number of impacts on their hosts' reproduction, including cytoplasmic incompatibility (CI). With CI, uninfected females that mate with *Wolbachia*-infected males fail to produce offspring; infected females can mate successfully with either infected or uninfected males. Mass-release of CI males was recognized as a potential new tool for the sterile-release approach, but there were limitations to its use that needed to be addressed.

Because uninfected females only produce viable young when mated with uninfected males, CI confers a reproductive advantage on infected females over uninfected ones. It allows *Wolbachia* to spread through the host population even if infected females suffer reduced fecundity, and this has been seen in *Drosophila* in the field[2]. More recently, interest in *Wolbachia* as a biological control agent for vector-borne diseases has focused on exploiting this ability to spread through a population in a strategy of population replacement. Such a strategy would entail a natural vector population being replaced by a population with a reduced capacity for disease transmission. A drive system capable of spreading the desired genotype into the target field population is critical for the approach, and that is where *Wolbachia* could come in.

The hitch for dengue control is that although *Wolbachia* infect many mosquito species – the first *Wolbachia* species to be described was from a mosquito – they do not infect *Ae. aegypti*. However, in 2005 researchers succeeded in micro-injecting *Wolbachia* derived from *Ae. albopictus* into *Ae. aegypti* embryos and achieved a stable infection[3]. The resulting infections had strong CI, and also highly efficient maternal inheritance, which is critical for successful population invasion; in the laboratory *Wolbachia* infection increased from 20% to 100% of mosquitoes in just eight generations. Since then, the question has been how to translate this advance into dengue control. Possible options suggested include genetically modifying *Wolbachia* to carry a transgene whose product attacks the dengue virus or the mosquito, or finding a *Wolbachia* strain that kills the host.

In an extension of this, the paper by McMeniman *et al.* in *Science* in November 2008 reported that they had been able to infect *Ae. aegypti* with the *W. pipientis* strain *w*MelPop, which halves the life span of its natural host, *D. melanogaster*[1]. Most pathogens transmitted by mosquitoes need to develop in their host before they can be transmitted to a new host. Mosquito survival is therefore a critical component of a vector population's capacity for pathogen transmission. The period from *Ae. aegypti* acquiring the dengue pathogen to being able to transmit it is about a fortnight (although development is temperature dependent and the interval can be as little as a week). The critical point is whether the life-shortening *Wolbachia* strain will allow its new host to survive for long enough to reproduce itself and transmit *Wolbachia* reliably to the next generation (and thereby also avoid selection for *Wolbachia* resistance in the mosquito population), but for a short enough time that its ability to transmit dengue virus picked up during blood feeding is curtailed and, on the population level, disease transmission is reduced.

McMeniman *et al.* reported that they obtained two stable lines of *Ae. aegypti* infected with *w*MelPop, with almost 100% infection frequency maintained for over 30 generations. They found that the lifespan of the new host was also halved, to about three weeks under laboratory conditions. They demonstrated strong CI in this system by crossing *Wolbachia*-infected males with *Wolbachia*-free females (these were from the same *Wolbachia*-infected *Ae. aegypti* line but had been treated with antibiotic to clear infection); for the two lines they obtained only two egg hatches from over 4400 embryos. In contrast, crosses of *Wolbachia*-infected males and females resulted in a very high egg hatch. CI was shown to be unaffected by male mosquito age (unlike in the natural host *D. melanogaster*). They found no apparent difference in fecundity between *w*MelPop-infected and uninfected females in one strain, but a 19% cost in the other (compared with an antibiotic-cleared control). Using PCR (polymerase chain reaction) they were able to show high maternal transmission over three reproductive cycles (i.e. in females 9–23 days old).

The authors say that comparing these results with simulations from theoretical models of *Wolbachia* in other systems indicates that *w*MelPop should be able to initiate a population invasion of *Ae. aegypti*, and if the life span is halved under field conditions as it is in the laboratory, this should skew the age structure of the mosquito populations towards younger individuals, thereby reducing dengue virus transmission without eradicating the mosquito population. They note that field trials are now needed to obtain quantitative data of the strategy's potential efficacy in nature, but suggest that the ability of *Wolbachia* to spread into *Ae. aegypti* populations and persist over time may provide an inexpensive approach for dengue control and one suited to urban areas where existing control measures have proved difficult to implement effectively. Finally, they suggest that as *w*MelPop is showing an ability to reduce lifespan in a number of insect species, the approach they have described could be more generally applicable for other insect vector-borne diseases, both medical and agricultural.

What hiccups might there be? The authors address the possibility of reduced virulence over time, saying that this has not been observed in this *Wolbachia* strain in *D. melanogaster* in the ten years since it was described. A commentary article by Read & Thomas in the same issue of *Science* considers a number of other factors[4]. They note that vector-control strategies that target older mosquitoes, as this one does, are not liable to suffer from the host population developing resistance – in contrast to insecticides which kill all age stages. Moreover, they suggest that although measures that alter the population age structure – other strategies such as biopesticides are under development – might select for faster developing pathogens, high natural mortality in mosquitoes must already place strong selective pressure for this, and the apparent absence of a response suggests that development time may be inversely related to pathogen fitness.

On the other hand, Read & Thomas say that determining whether *w*MelPop will remove enough infectious mosquitoes to be useful will be a challenge. It is not necessary to completely eliminate pathogen transmission to have a major impact on disease, but the question is whether *Wolbachia* could reduce it sufficiently to reduce the number of human cases or even break the transmission cycle altogether. Using McMeniman *et al.*'s finding that *Wolbachia*-infected mosquitoes had an average lifespan of three weeks in the laboratory, Read & Thomas say they could conceivably start to transmit dengue about a week before dying – but mortality in the field is higher, so under the right circumstances, and assuming the mosquitoes lifespan is halved in the field, dengue control is a theoretical possibility.

Read & Thomas also query whether CI would allow *w*MelPop to spread through the population as McMeniman *et al.*'s theoretical calculation suggests. They discuss the varied effects of virulence, pointing out that while greater virulence and thus impact on mosquito lifespan might seem to equate to greater disease control, excessively virulent strains may spread very slowly, if at all because there is a limit to what CI can achieve. They explain that the reproductive advantage conferred by CI comes largely from infected males and females mating with each other, which means large numbers of infected individuals will need to be released – and the numbers required increase markedly with virulence. What sort of numbers are we talking about? McMeniman's co-author Scott O'Neill says that as *Ae. aegypti* (unlike *Anopheles* malaria vectors) exists at low density in the field (usually around 2–5 adult mosquitoes per house), it should be feasible to swamp the natural adult population in a given area. So long as sufficient numbers of released mosquitoes mated successfully, this could have the potential to drive *Wolbachia* into the population and thus potentially to establish a spreading wave to carry infection into adjoining populations.

Read & Thomas caution that releasing highly virulent *Wolbachia* may have its own evolutionary consequences, e.g. in terms of *Wolbachia*-resistant mosquitoes, more benign *Wolbachia*, etc. They say that all the evolutionary 'unknowns', together with the environmentally sensitive nature of *Wolbachia* virulence, pathogen incubation period and other determinants of disease transmission, emphasize the need for some epidemiological models of dengue into which 'evolutionary' factors are inserted to see whether *w*MelPop has the capacity to have a significant impact on dengue transmission and, if so, to judge the optimum level of virulence for maximum but stable disease control under diverse conditions. They argue this is essential to ensure that a first trial of the approach has maximum chance of success.

Nonetheless, Read & Thomas say that although it is important to understand the evolutionary issues, they may be of less impact than the development of insecticide resistance, which followed the insecticide-based vector-control efforts of the twentieth century.

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[3]Xu, Z., Khoo, C.C.H. & Dobson, S.L. (2005) Wolbachia establishment and invasion in an *Aedes aegypti* laboratory population. *Science* **310**, 326–328.

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Turning the Tables on the Black Rat

The black rat (*Rattus rattus*) is an urban pest that defies control in many countries, but scientists in Australia are trying out a new strategy. Australia has long experience of introduced mammals and the devastating impacts they have had on its unique native fauna and flora. The native fauna may be about to begin to change this, with the fight back beginning in New South Wales in the perhaps unlikely setting of Sydney's leafy harbourside suburbs.

Mosman, a peninsula on Sydney's Lower North Shore, is a primarily residential suburb and also includes sections of Sydney Harbour National Park. Research in the grounds of nearby Taronga Park Zoo, which opened in 1916, is trialling a plan to drive the black rat out of natural areas around Mosman using the native bush rat (*R. fuscipes*), or bogul to give it its aboriginal name. The project marks the beginning of the first management programme to use a native mammal species as a biological control against the introduced rodent in the Mosman and Sydney Harbour National Parkland region.

The project is a collaboration between Dr Peter Banks of the University of New South Wales, Prof Chris Dickman of Sydney University and Taronga Zoo's ecological researchers Dr Gráinne Cleary and Wendy Gleen, and has received joint agency support from Mosman Council, National Parks and Wildlife and Taronga's Association of Zoo Friends.

The first test to see whether the bogul can outcompete the black rat is being conducted in naturally vegetated enclosures on Zoo grounds. The aim is to see whether the bogul can reclaim and establish residency in bushland habitats; if this happens, it should be able to outcompete the black rat. But unlike the black rat, the bogul is not vermin: it does not carry the human, pet and wildlife diseases vectored by the black rat, does not climb trees to raid birds' nests, and will not become a pest of suburban neighbourhoods, but will remain in the bush and keep the black rat population at bay.

Introduced in 1788 with European settlement, the black rat quickly replaced the native rat which had co-evolved with Australia's bushland. The colonists disturbed the environment making it more suitable for the pest rodent, while the species' fast breeding rate helped this opportunist to take over. While people may be more aware of the black rat's status as an urban pest, it has serious adverse impacts on natural environments, feeding on sapling vegetation and hunting small animals such as reptiles and especially birds' eggs.

Taronga's bush regeneration specialist, Wendy Kinsella, has spent a decade working with local people to return the Harbour foreshore around the Zoo to what it was 200 years ago, even abseiling on the cliffs to remove lantana (*Lantana camara*), so some ideal habitat for boguls has been re-established. However, survey work across the Sydney Harbour National Park suggests that native small mammal communities, such as pygmy possums (*Burramys parvus*) and boguls, are largely extinct and have been replaced by black rats.

If the enclosure trials are successful the second phase of this project will involve an expansion of the bogul re-introduction. Black rats around Mosman and Cremorne will be vastly reduced and boguls will be re-introduced into four bushland sites in the area in a larger trial. The areas will then be monitored to confirm not only that boguls establish and repel reinvasion by black rats, but also that this leads to a decrease in black rat impacts on native biota.

The project has support of the local Mosman Council and community, with Mayor Councillor Dom Lopez saying that the Council is committed to supporting the project as it will benefit both the environment and the Mosman community. Zoo friends, volunteers and students from Mosman High School are also involved in the project; students are learning about the native rat and will help educate the local community about this re-introduction programme.

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Aphids Win at Hide and Seek

You might think aphid parasitoids have it all their own way, seeking out largely sessile prey that live in nice large colonies. What could be easier to find? The aphids' exuviae (moulted exoskeletons), apparently. According to a paper in the open access journal *BMC Evolutionary Biology*[1], parasitoid wasps are likely to attack the empty shells, resulting in a lower attack rate on their previous occupants, Thus by leaving exuviae in and around their colonies as decoys, the aphids gain some measure of protection from attack.

Frédéric Muratori and co-workers from the Université Catholique de Louvain, Belgium, and McGill University, Canada, studied the behaviour of the parasitoid *Aphidius rhopalosiphi* foraging on patches of the grain aphid, *Sitobion avenae,* in an effort to explain aphids' tendency to leave exuviae around their colonies, behaviour the authors describe as 'bad housekeeping' because it made detection easier for the parasitoids. Aphid exuviae are covered by waxes that have kairomonal (attractant) properties for the parasitoids so it might be expected that aphids would either moult outside the colony or remove the exuviae; that they do not has been thought counter-selective.

The authors predicted that the areas littered with exuviae decoys would be seen as poor hunting grounds by wasps seeking hosts in which to lay eggs, and that they would move on to other patches. In fact, Muratori *et al.* found that parasitoid females spent more time in patches that contained exuviae than in patches that contained only aphids, suggesting that they either did not recognize exuviae as low quality hosts or needed time to correctly identify them. The potential gain for the individual aphid comes from the increased time available to escape from the colony while the wasps are investigating the decoys. According to the authors, the aphids release an alarm pheromone when they are under parasitoid attack, giving other aphids time to escape by dropping off the plant.

Muratori, F.B., Damiens, D.D., Hance, T. & Boivin, G. (2008) Bad housekeeping: why do aphids leave their exuviae inside the colony? *BMC Evolutionary Biology* **8,** 338.
Web: www.biomedcentral.com/bmcevolbiol/

IPM Systems

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

Biopesticide Protects India's Teak

Teak has been recognized for centuries for its strength, durability, pest and rot resistance, attractiveness and workability. It occurs naturally in forests in India, Myanmar, Thailand and Laos, and timber was extracted from them until demand outstripped supply. Since the first plantations were established in India in the mid-nineteenth century, teak has been planted in the tropics and subtropics in 64 countries in Asia and other continents. There are now some nine million hectares of teak plantations worldwide, including about 1.9 million hectares in India.

With the establishment of plantations came pest problems. The most serious is teak defoliator (*Hyblaea puera*), first identified in India's Kerala State in 1898 and now found throughout South and Southeast Asia to New Guinea and Australia, and more recently reported from the New World. Outbreaks are sporadic, hitting one area but not another, they occur suddenly and are often spectacular. Millions of caterpillars can defoliate thousands of hectares of teak forest in as little as a fortnight. While they are feeding, the falling frass can sound like rain.

A five-year study conducted by Kerala Forest Research Institute (KFRI) showed that defoliator infestations led to a 44% loss of potential volume increment in four- to eight-year-old teak plantations. Extrapolating from this, trees protected from infestation would be ready for harvest in 26 rather than the usual 60 years. Apart from the loss in volume increment, when the teak defoliator attacks young teak saplings, the terminal bud may be eaten off leading to forking of the main stem. Once forked, the tree would take a long time to recover. KFRI researched the ecology of the pest to try and understand why outbreaks occurred, and to try and develop methods for detecting outbreaks early enough for control measures to stand a chance of halting the damage – a tall order given the speed with which defoliation occurs. The studies revealed that small area, high density 'epicentre' populations of teak defoliator which occur during the flushing of teak after the natural defoliation is the start of a sequence of large area outbreaks. Investigations were also made into various sustainable control options, and eventually these focused on a naturally occurring virus as a promising approach.

Large-scale mortality of *H. puera* caterpillars from disease was reported by India's first colonial Forest Zoologist, E. P. Stebbing, as far back as 1903 but the cause was unknown until V. V. Sudheendrakumar and colleagues at KFRI identified it as a nuclear polyhedrovirus (HpNPV) in 1985. NPVs have a long history of safe and effective use in pest management worldwide. They are highly specific and lethal to their target hosts and non-toxic to vertebrates. Ingested HpNPV can kill even a mature *H. puera* larva in 60–72 hours, making it one of the fastest-acting insect viruses (many take 100 hours or more). This made it a promising candidate as a control agent. It proved to have poor persistence in the field, but disease could be induced by spraying it onto foliage. In collaboration with Forest Research (UK), KFRI developed protocols for its field application.

The amount of virus this approach demanded meant developing a mass production system for HpNPV. The team overcame one disadvantage of NPVs – they cannot be multiplied in artificial media but only in live host cells – by developing a standardized protocol for multiplying HpNPV in *H. puera* larvae and harvesting it so that NPV production was maximized.

The team has developed several formulations of HpNPV (wettable powders, a flowable concentrate and a microencapsulated product) to improve quality, shelf life and application, and to maximize the biological activity and persistence of the NPV. These can be applied using various kinds of spraying equipment. A wettable powder formulation of HpNPV used against a natural outbreak of teak defoliator in 12-year old teak provided 18.5% extra protection to the foliage compared with the unformulated virus.

The active ingredient of the biopesticide – the virus – propagates itself inside the host insect; a dying caterpillar contains some thirteen million times as many virus particles as it ingested. Transfer of this virus from one insect to another (horizontal transmission) magnifies the impact of treatment. This makes containment of large-scale outbreaks of teak defoliator a feasible objective, and KFRI has worked on a variety of spraying regimes to optimize use of the product while controlling the pest. It is also drawing on the knowledge it has gained about the ecology of teak defoliator to develop landscape-level management. With the support of the Department of Biotechnology(Ministry of Science and Industry), it is assessing a novel paradigm: to deliver sublethal doses of HpNPV to the 'epicentre' teak defoliator populations so that the moths emerging from epicentres pass on the virus to the next generation, even if they mate with uninfected moths immigrating to the area. This paradigm is being tested since wiping out the epicentre population may be defeated by the occurrence of new epicentres caused by immigrant moths.

Initial results are turning out to be interesting and helpful in developing a landscape level management strategy for the teak defoliator.

Main source/further information: Sajeev, T.V. and Sudheendrakumar, V.V. (2005) *HpNPV technology for biocontrol of teak defoliator* – Hyblaea puera. Kerala Forest Research Institute, Peechi, 28 pp.

Contact: Dr V. V. Sudheendrakumar, Scientist, Forest Protection Program Group, Kerala Forest Research Institute, Peechi, Thrisur - 680653, Kerala, India.
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Pink Hibiscus Mealybug Pheromone Licensed

The US Department of Agriculture – Agricultural Research Service (USDA-ARS) has granted an exclusive license to South Carolina Scientific, Inc., of Columbia, South Carolina to produce and market an ARS-developed insect sex pheromone that could help control the pink hibiscus mealybug (*Maconellicoccus hirsutus*; PHMB). This pest can cause up to US$750 million in damage annually to US crops alone; PHMB is native to Asia but now causes severe economic problems worldwide by attacking a wide range of plants, including vegetable and citrus crops, forest trees, and many species of ornamental plants.

USDA's Animal and Plant Health Inspection Service (APHIS), headquartered in Riverdale, Maryland, introduced two exotic wasps to control PHMB infestations in the USA and the Caribbean but encountered problems detecting the mealybug's presence and prevalence. The sex pheromone, placed inside sticky traps, effectively traps mealybug males in the field. Pheromone technology thus provides a way of surveying the extent and size of mealybug pest infestations as well as tracking the effectiveness of biological control efforts.

The pheromone, a combination of two components isolated and identified from female PHMB, was developed by a team led by chemist Aijun Zhang at the ARS Invasive Insect Biocontrol and Behavior Laboratory in Beltsville, Maryland. Initial pheromone development was performed under a research agreement between ARS and South Carolina Scientific, Inc. Work is now under way to improve the production process for the pheromone.

By luring males to traps, the sex pheromone provides an economical, convenient, and useful detection and monitoring tool, and also has the potential for direct use in a PHMB control strategy. Zhang found that relatively high concentrations of the pheromone repel males away from the pheromone source, indicating potential for a mating disruption approach. On the other hand, natural enemies of the pest are not lured to the pheromone source. This allows biocontrol scientists to chart the effectiveness of biocontrol agents being used against the mealybug without artificially concentrating these natural enemies near the traps.

Source/further information: Durham, S. (2008) Pink hibiscus mealybug pheromone licensed. USDA-ARS Information Service, 16 December 2008.
Web: www.ars.usda.gov/is/pr/2008/081216.htm

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.

ENDURE newsletter

The first issue of a regular e-newsletter from ENDURE was published in January 2009. Its lead story is about action needed for developing IPM schemes that contribute to sustainable development while keeping European agriculture competitive.

ENDURE, the European Network for the Durable Exploitation of Crop Protection Strategies, is a network of excellence (NoE) funded by the European Union under the Framework 6 programme. Its purpose is to achieve a durable restructuring of European research and development. The network aims to establish itself as a world leader for the development and implementation of sustainable crop protection strategies.

Other items in the first issue include news, 'focus' articles on specific pests, crops and crop management programmes, and information about training and forthcoming events, together with updates about new content on the ENDURE website.

To subscribe to the newsletter:
Web: www.endure-network.eu
Email: endure_newsletter@cirad.fr

EMAPi in South Africa

The 10th International Conference on the Ecology and Management of Alien Plant Invasions (EMAPi 10) will be held near Stellenbosch, South Africa, on 23-27 August 2009.

The scientific programme will cover: Molecular ecology of plant invasions, Invader-induced trophic cascades, Novel ecosystems, Human dimensions of plant invasions, Mapping & modelling of plant invasions, Methods for risk analysis in biosecurity, Managing invasive plants – learning from successes and failures, Plant invasions in protected areas, Plant invasions in arid systems – special problems, special solutions, Plant invasions in mountains – ecology and management, Theories in plant invasion ecology, Nurseries – never-ending source of invasive species, and Biofuels - a major source of problems with invasive plants in the future?

Contact: Dave Richardson,
Chair, Organizing Committee.
Email: rich@sun.ac.za
Web: www.emapi2009.co.za/

Invasive Ladybirds Conference

The new IOBC-WPRS (International Organization for Biological Control, West Palaearctic Regional Section) Study Group 'Benefits and Risks of Biological Control' is organizing its first conference, '*Harmonia axyridis* and other invasive ladybirds' which will be held in Engelberg in the Swiss Alps on 7–9 September 2009.

Discussion topics will include: Risk assessment in biological control, Invasion ecology, Spread, Genetics of invasion, Management, Ecological impact on native fauna, Agricultural impact, Association with symbionts, Tri-trophic interactions. Invited keynotes will cover the invasion of *H. axyridis* (and other ladybirds worldwide) as well as the ecology of *H. axyridis* in its area of origin. The conference will also offer a unique platform for developing multilateral collaboration activities and concerted research strategies.

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Mike Majerus, 1954–2009

As this issue went to press we learnt of the untimely death of Professor Mike Majerus; an evolutionary biologist in the Department of Genetics at Cambridge University, UK, he was best known to the biocontrol world for his knowledge and understanding of ladybirds, and in particular *H. axyridis*. An appreciation on the Department website describes how: "In 2004 the arrival of the Harlequin ladybird in Britain was a disaster for native species but catapulted Mike into the public eye and on to the front page of *The Times*." He used the publicity to good effect, setting up the Harlequin Ladybird Survey (www.harlequin-survey.org) with the Centre of Ecology and Hydrology and Anglia Ruskin University, which engaged the public in monitoring the spread of the insect in Britain.

Semiochemicals without Borders

This Joint Conference of the Pheromone Groups of IOBC-WPRS and IOBC-EPRS (IOBC East Palaearctic Regional Section) will be held in Budapest, Hungary, on 3–8 October 2009. The meeting, which aims to provide an overview of the recent results and discoveries about semiochemicals worldwide, is taking place in the 25th anniversary year of the first joint WPRS–EPRS Pheromone Conference (Balatonalmádi, Hungary, 1984).

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Biocontrol Manufacturers 2009 Meeting

The 4th Annual Biocontrol Industry Meeting (ABIM-Lucerne 2009) will be held on 19–20 October 2009 in Lucerne, Switzerland.

The aims of this meetings series are to discuss issues of common interest, such as regulations and policies, learn about new developments in the field of applied biocontrol and related diseases, weeds and pest control methods, discuss business opportunities, meet each other, encourage interaction between industry, distributors, public funded research, and administration, and provide a convenient venue for meetings of national and regional industry associations. It is specifically tailored to the needs of biocontrol manufacturers and distributors, but also provides an excellent meeting place for interaction with consultants, regulators and researchers.

Web: www.abim-lucerne.ch/

BIOLIEF Conference in Portugal

The World Conference on Biological Invasions and Ecosystem Functioning (BIOLIEF) will be held in Porto, Portugal on 27–30 October 2009.

The BIOLIEF conference aims to cover the biology, ecology and population dynamics of biological invasions, dealing with as many ecosystems and kingdoms as possible. Presentations relating to biological invasions and changes to the functioning of ecosystem are particularly welcome. The deadline for submitting an abstract (poster or oral communication) is 31 May 2009.

Further information: Carlos Antunes, Ester Dias, Pedro Morais and Ronaldo Sousa (organizing committee), BIOLIEF – CIIMAR, Rua dos Bragas 289, 4050-123 Porto, Portugal.
Email: biolief@ciimar.up.pt
Web: www.ciimar.up.pt/biolief

Beneficials in Germany

A list of 81 beneficials (nematodes and arthropods) for biocontrol in Germany is presented on the website of JKI (Julius Kühn-Institute, Federal Research Centre for Cultivated Plants).

Web:www.jki.bund.de/cln_045/nn_807134/DE/Home/pflanzen__schuetzen/biologisch__alternativ/nuetzl__anbiet/nuetzl__anbiet__node.html__nnn=true

Information given for the biocontrol agents species includes pest species they are active against, together with contact details (address, email and web address) of producers and distributors in Germany.

Annual Reviews

Readers may be interested in one or more of the following papers from recent Annual Reviews.

- Pyke, G.H. (2008) Plague minnow or mosquito fish? A review of the biology and impacts of introduced *Gambusia* species. *Annual Review of Ecology, Evolution, and Systematics* **39**, 171–191.
- Gassmann, A.J., Carrière, Y. & Tabashnik, B.E. (2009) Fitness costs of insect resistance to *Bacillus thuringiensis*. *Annual Review of Entomology* **54**, 147–163.
- Libersat, F., Delago, A. & Gal, R. (2009) Manipulation of host behavior by parasitic insects and insect parasites. *Annual Review of Entomology* **54**, 189-207.
- Hazarika, L.K., Bhuyan, M. & Hazarika, B.N. (2009) Insect pests of tea and their management. *Annual Review of Entomology* **54**, 267–284
- Gray, M.E., Sappington, T.W., Miller, N.J., *et al.* (2009) Adaptation and invasiveness of western corn rootworm: intensifying research on a worsening pest. *Annual Review of Entomology* **54**, 303–321.

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 here.

Annual Biocontrol Industry Meeting (ABIM) – Lucerne 08

The third Annual Biocontrol Industry Meeting held in Lucerne, Switzerland on 21–20 October 2008 (ABIM-Lucerne) was again a great success. Under the sponsorship of the European Commission, organized jointly by the International Research Institute for Organic Farming (FiBL, Frick, Switzerland) and the International Biocontrol Manufacturers Association (IBMA), ABIM-Lucerne was attended by 340 participants, representing 200 companies coming from all parts of the World: this represented a 30% increase in numbers from 2007.

It was good to see representatives from government agencies present, as their presence is vital and has been lacking in past ABIMs. However, the meeting would benefit from more scientists attending and perhaps this will happen next year as ABIM-Lucerne grows in size and importance.

The conference started with important news relating to the new European Union (EU) pesticides regulatory framework, and information on biocontrol market development in significant countries such as Spain, France, Czech Republic, Slovakia, Hungary and Brazil. Due to the efforts undertaken by the biocontrol manufacturers which benefited from political change in favour of safer plant protection strategies, exceeding all forecasts, the sales of biologicals increased at a rate of 25% in 2007–2008 over the previous year (sales represented 2.5–3% of the total world plant protection market). In all countries, efforts are being undertaken to strongly promote IPM in which, as the new European Union Framework Directive emphasizes, biologicals must have a preferential place. A presentation on the European Network of Excellence ENDURE by its coordinator Pierre Ricci, in which IBMA is a partner, is a clear demonstration of the efforts being undertaken at the European level. ENDURE is working on a "Foresight Study 2030" which, presented to biocontrol manufacturers, stimulated a lot of questions and excitement.

As usual, ABIM was the place for manufacturers to present to participants their new products and systems: the control of soil insects in outdoor crops by nematodes, control of pests in citrus, pest control in stored products, new systems for the control of *Cydia pomonella* (codling moth), as well as an extensive list of microbials used in many crops against pests and diseases: viruses against codling moth and cotton pests, extension of *Bt* uses, *Trichoderma* against several plant diseases, etc. (All the papers are published on the ABIM website, see below).

Demonstrating that biocontrol is becoming an important business, ABIM-Lucerne was also the place for intensive meetings and talks amongst manufacturers, distributors and potential users, paving the way for an even more successful meeting in October 2009 where several sessions will be dedicated to selected crops.

ABIM-Lucerne 09, the annual meeting of the biocontrol industry, will take place in Lucerne, Switzerland on 19–20 October 2009. See information on line: www.abim-lucerne.ch

By: Bernard J. Blum,
IBMA Head International Affairs.

European Water Hyacinth Workshop and Proceedings

The proceedings have been published of a workshop on *Eichhornia crassipes* (water hyacinth) organized by EPPO (European and Mediterranean Plant Protection Organization) and the Council of Europe in June 2008 in Mérida, Spain. The proceedings of this meeting, which used water hyacinth as a case study for managing invasive alien plants in Europe, appear in *EPPO Bulletin* No. 38(3), pp. 451–495. An EPPO datasheet for *E. crassipes* is also included in this issue (pp. 441–449).

Eichhornia crassipes is a floating aquatic plant originating from South America sold for ornamental purposes. The plant is recognized as one of the most invasive alien plants in the world. It has huge detrimental economic impacts: it is a threat to agriculture, plant health, environment, public safety, recreation activities, water quality and quantity and human health. The meeting was attended by 40 participants from Czech Republic, Croatia, Estonia, France, Germany, Morocco, the Netherlands, Portugal, South Africa, Slovenia, Spain, Turkey, and Zambia. EPPO sought advice from experienced scientists to try and learn from their experiences, and the proceedings contain the following presented papers, which cover the biology, distribution, pathways of introduction and impacts of water hyacinth:

- Integrated control of water hyacinth in Africa (M. P. Hill & J. A. Coetzee)
- Biological control of water hyacinth – the South African experience (J. A. Coetzee & M. P. Hill)
- Public awareness activities on *Eichhornia crassipes* in the Victoria Falls World Heritage Site, Livingstone, Zambia (M. Nang'alelwa)
- The environmental and socio-economic impacts of *Eichhornia crassipes* in the Victoria Falls/Mosi-oa-Tunya World Heritage Site, Livingstone, Zambia (M. Nang'alelwa)
- Plant biology and other issues that relate to the management of water hyacinth: a global perspective with focus on Europe (M. Julien)
- *Eichhornia crassipes* control in the largest Portuguese natural freshwater lagoon (C. M. Laranjeira & G. Nadais)

Emphasis at the meeting was given to management measures taken against *E. crassipes* in Africa (South Africa, Zambia) and in the EPPO region; accounts of the latter indicate the economic cost of the weed. In Spain, the removal of nearly 200,000 tonnes of the plant from a 75-km length of the Guadiana River over the period 2005–08 cost €14,680,000. In Portugal, management action carried out by the Municipality of Agueda from December 2006 to May 2008 cost €278,000.

The Spanish case is an example of mechanical control working on a large scale, but it is the only one, and at what cost? It is not sustainable, but other options are limited. Restrictions on herbicide use in or near water bodies will become even tougher as the European Union's groundwater-protection directive (part of the Water Framework Directive) comes into force into 2009; Member States will be required to take "all measures necessary to prevent inputs into groundwater of any hazardous substances". Classical biological control forms a key component of the integrated management of water hyacinth in other parts of the world, and was described with enthusiasm by participating scientists who had experience of this. However, there was only moderate acceptance from European participants that it might be an option – an indication perhaps of how it continues to be perceived as a 'novel' approach in Europe, but also reflecting the long timescale for implementing weed biocontrol in Europe where there is not as yet the relevant legislation in place. In any case, biological control itself has a long way to go, especially in more temperate environments where current biocontrol measures do not seem to control the weed.

The first step in controlling water hyacinth, and this was the one the meeting tried to take, is to stop trade in the plant.

A Pest Risk Analysis performed during the Workshop concluded that *E. crassipes* has the potential to establish and cause detrimental effects in the whole Mediterranean Basin. It was therefore agreed that *E. crassipes* should be proposed for regulation as a quarantine pest (EPPO A2 List) in 2008, and that an EPPO Standard on National Regulatory Control Measures should be prepared.

A Council of Europe draft recommendation was also prepared, which invited Member Countries to prohibit the sale, movement, possession and planting of the plant; to monitor the species and share information with other countries; and to draft a national action plan to manage the plant.

The workshop presentations are also online at:
http://archives.eppo.org/MEETINGS/2008_conferences/eicchornia_workshop.htm

The Pest Risk Analysis is available at: www.eppo.org/QUARANTINE/Pest_Risk_Analysis/PRA_documents.htm

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