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General News

Can Wolbachia Halt Dengue Transmission?

The dengue virus, transmitted by *Aedes* (principally *Ae. aegypti*) mosquitoes, causes a severe flu-like illness and sometimes potentially lethal dengue haemorrhagic fever. According to the World Health Organization, it infects 50–100 million people every year and some 40% of the world's population, in tropical and subtropical countries, is at risk. Its geographic range is expanding and the severity of outbreaks is increasing. Two papers in Nature[1,2] report progress in developing a sustainable control strategy based on releasing *Aedes* mosquitoes infected with the insect bacterium *Wolbachia*, including the results of the first field trials in northern Queensland, Australia. The research is being conducted by the Eliminate Dengue programme, including scientists in Australia, Vietnam, Thailand, the USA and Brazil, led by Prof. Scott O'Neill from Monash University in Melbourne, Australia. Its approach differs from conventional vector control strategies whose aim is the suppression or elimination of the vector: Eliminate Dengue's goal is to replace the pathogen-susceptible *Aedes* population with a pathogen-resistant one.

Wolbachia bacteria occur in many insect species including mosquitoes and are transmitted by female hosts to their offspring. One of their impacts in the host is cytoplasmic incompatibility (CI), whereby uninfected females do not produce offspring if they mate with infected males; in contrast infected females produce (infected) offspring when mated with either infected or uninfected males. CI therefore confers reproductive advantage on infected females over uninfected ones. Theoretical considerations, backed up by observations of *Wolbachia* infection in wild *Drosophila*, suggest that CI allows *Wolbachia* to spread through a population – so long as the advantage conferred by CI outweighs other costs of infection (e.g. on fecundity, egg viability). It is this that first stimulated interest in *Wolbachia*'s potential as a tool in biological control.

Developing a *Wolbachia*-based strategy for dengue control faced considerable challenges – not least that *Wolbachia* do not naturally infect *Ae. aegypti*. This hurdle was shown to be surmountable and mosquitoes were artificially infected first with a *Wolbachia* strain from *Ae. albopictus*, for which a stable laboratory population with 100% infection was achieved, and next with a *Wolbachia* strain (*w*MelPop-CLA) that halves the lifespan of its natural host, *Drosophila melanogaster,* and proved to act similarly in *Ae. aegypti*. It was hoped that shortening the lifespan would not prevent the mosquito reproductive cycle from being completed and *Wolbachia* being disseminated to the next mosquito generation, but would prevent the dengue pathogen completing its life cycle, thus interfering with disease transmission. (See *BNI* 30(1), 9N–10N and refs therein.) Since then, it has emerged that some *Wolbachia* strains, closely related to *w*MelPop-CLA, interfere with RNA viruses in *Drosophila* – and dengue is an RNA virus. This raised an additional potential mechanism for *Wolbachia*-mediated control.

Assessment of the fitness costs associated with *w*MelPop-CLA in *Ae. aegypti* indicated that it might not be able to invade the mosquito populations effectively, and attention was turned to one of the related *Wolbachia* strains, *w*Mel, which had low fitness costs and thus more desirable invasion characteristics (indicated by its spread globally in *D. melanogaster* in the last century)[1]. Stable lines of *w*Mel-infected *Ae. aegypti* were established in the laboratory, and breeding tests indicated that these mosquitoes exhibited strong CI: mated to uninfected males, infected females produced no eggs that hatched, while matings of infected individuals resulted in 90% egg hatch. And in contrast to what had been found with *w*MelPop-CLA, there was no significant difference between the *w*Mel line and wild *Ae. aegypti* in terms of fecundity or viability of eggs over time; the latter finding is particularly significant for areas that experience a long dry season, such as northern Queensland.

Invasion potential was initially investigated in field-cage trials in northern Queensland[1], comparing the ability of the *w*Mel and *w*MelPop-CLA strains to invade uninfected mosquito populations. As anticipated, infection by the *w*Mel strain proceeded more rapidy and completely than for the *w*MelPop-CLA strain, reaching 100% in 30–80 days. The authors also looked at levels of dengue virus and found much lower levels of dengue DNA in extracts from *w*Mel mosquitoes than in infected wild mosquitoes. Moreover, they found no live virus at all in the salivary glands in the *w*Mel strain, indicating complete blockage of dengue transmission.

Given these results, the team proceeded with a deliberate introduction of mosquitoes infected with the *w*Mel *Wolbachia* strain into two wild *Ae. aegypti* populations[2]. The introduction was conducted at sites around Cairns in northern Queensland with the approval of the Australian Pesticides and Veterinary Medicines Authority (APVMA) and with strong community support – following an extensive period of community engagement. Almost 300,000 mosquitoes were released over 9–10 weeks, beginning in the wet season in January 2011. Results of monitoring during and after the releases indicated that, despite the depredations of Cyclone Yasi in the release area, *w*Mel successfully invaded the two *Ae. aegypti* populations within a few months: infection had reached 100% in one population and 90% in the other just five weeks after releases ceased.

Unless the overall fitness costs of the *Wolbachia* strain are zero (i.e. the cost of the pathogen set

against any benefits – e.g. a possible decreased cost from a lower dengue virus load), the researchers think that the *Wolbachia*-carrying mosquito strain is unlikely to disperse outside the release areas, and is instead likely to be swamped by local wild type mosquitoes in the absence of further releases. The authors note[2], however, that the study has demonstrated how *Wolbachia*-infected mosquito populations can be created to act as 'nursery' areas from which infected mosquitoes can be collected and further disseminated. They argue that the model could be used for sustainable dengue control at low cost: the 'nursery' populations eliminate the need for insect rearing facilities and, together with a relatively simple deployment system, make the system suitable for implementation in developing countries.

Although this is not the first time *Wolbachia* has been deployed to control mosquitoes (*Wolbachia*-infected males have been used to suppress natural populations of *Culex* mosquitoes through CI), the authors say[2] they are reporting the first use of *Wolbachia* to reduce the ability of an insect population to vector human disease in the wild. Prof. O'Neill says the results indicate that *Wolbachia*-based strategies are practical to implement and might hold the key to a new sustainable approach to dengue control, an approach that should be particularly suited to large cities of the developing world where conventional control with insecticides is largely ineffective and prohibitively expensive.

The next step in the Eliminate Dengue programme is to test the efficacy of the method for dengue and dengue haemorrhagic fever control, to continue monitoring in and around the release areas to test for persistence, and to conduct further releases to assess the spread of the infection across a populated area. Following the success of this Australian field trial, regulatory approval is also being sought for trials in Thailand, Vietnam, Brazil and Indonesia, which would determine the effectiveness of the method in reducing dengue disease in human populations.

[1] Walker, T., *et al.* (2011) A non-virulent *Wolbachia* infection blocks dengue transmission and rapidly invades *Aedes aegypti* populations. *Nature* 476, doi:10.1038/nature10355.

[2] Hoffmann, A. A., *et al.* (2011) Successful establishment of *Wolbachia* in *Aedes* populations to suppress dengue transmission. *Nature* 476, doi:10.1038/nature10356.

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Does Biocontrol Have a Role in Protecting Amphibian Populations from Chytridiomycosis?

The emerging fungal pathogen *Batrachochytrium dendrobatidis,* which colonizes amphibian skin and causes the disease chytridiomycosis, is responsible for unprecedented amphibian population declines and extinctions around the world – events that have been collectively called "the most spectacular loss of vertebrate biodiversity due to disease in recorded history"[1]. *Batrachochytrium dendrobatidis* was identified only in 1998 and is the first known pathogen of vertebrates from the little-studied phylum Chytridiomycota[2]. Amphibian species vary in susceptibility, but high mortality is common and local/global extinction has occurred. Even where amphibian populations start to recover, diversity is reduced on a regional basis, ecosystems altered, and *B. dendrobatidis* becomes established, often persisting in less-susceptible species.

In the decade since *B. dendrobatidis* was discovered, studies of its biology and ecology and the host–pathogen relationship have facilitated a strategic consideration of how the threat can best be managed – although the information available is still incomplete. Attempts at local eradication have not so far been successful, not least because there are gaps in knowledge about the pathogen's ecology. The focus is therefore on disease mitigation or prevention. A recent paper in *Frontiers in Zoology*[3] identifies current conservation priorities as: (i) preventing pathogen spread to unexposed populations, (ii) establishing ex situ assurance colonies, and (iii) developing in situ preventative treatment or remedial disease strategies. The authors identify some of the options being researched as including: reducing host density, treating hosts/habitats, re-introductions with assisted selection, and using climate refugia, immunization, habitat bioaugmentation/host biotherapy and biocontrol. The expectation is that no single option will be sufficient, and the most effective combination of measures will vary between situations.

One possibility for controlling *Batrachochytrium* may be to control its infective stage. Unlike the 'higher' fungi, the asexual spores of chytrids (or zoospores), are free-living flagellates that are subject to predation by zooplankton. Filter-feeding crustaceans including *Daphnia* spp. inhabit amphibian breeding sites where *Batrachochytrium* transmission occurs. Preliminary laboratory work at California State University at Bakersfield (CSUB) in the USA indicated that even low densities of *Daphnia* could significantly reduce the *B. dendrobatidis* populations and there was a correlation between numbers of *Daphnia* and *Batrachochytrium* zoospore abundance[3]. Scientists at Oregon State University in the USA[4,5] have confirmed, using fluoroscopic and PCR-based techniques, that *D. pulex* (originally identified as *D. magma*) ingest laboratory-reared *B. dendrobatidis* in isolation from the host. There is a long way to go before *Daphnia* can be put forward as a potentially useful biocontrol agent. The next step in this research is to determine whether zoospore consumption by *Daphnia* can protect amphibians from *Batrachochytrium* infection in the laboratory and in natural populations, and whether they have the same impact if a choice of prey is available – especially important given the complex predator–prey interactions of pond ecosystems.

Daphnia spp. are common constituents of global aquatic systems but clearly do not exert effective control of *Batrachochytrium* where frogs are dying of chytridiomycosis. This may indicate a potential role

for augmentation biocontrol of chytridiomycosis in pond-breeding amphibians (there is generally little zooplankton in flowing water). It may also indicate something else: microcrustaceans such as *Daphnia* are sensitive to environmental changes – hence their use as indicator organisms. Is it possible that the devastation wrought in some locations by chytridiomycosis is exacerbated by low populations of species that prey on the pathogen's infective free-living stage? Current research by CSUB includes looking at seasonal variations in the diversity of microcrustaceans in the water column at sites in the foothills of the Sierra Nevada, USA, and also looking at diversity in an historical context by comparing present diversity with that in the sediment (where diapausing eggs can survive for hundreds of years)[3]. If low predator populations do turn out to have a role in the impact of chytridiomycosis in some situations, then habitat restoration and conservation biocontrol might play a role in raising *Daphnia* populations to useful levels.

[1] Skerratt, L.F., Berger, L., Speare, R., *et al.* (2007) Spread of chytridiomycosis has caused the rapid global decline and extinction of frogs. *Ecohealth* 4, 125–134.

[2] Rosenblum, E.B., Fisher, M.C., James, T.Y., *et al.* (2010) A molecular perspective: biology of the emerging pathogen *Batrachochytrium dendrobatidis*. *Diseases of Aquatic Organisms* 92, 131–147.

[3] Woodhams, D.C., Bosch, J., Briggs, C.J., *et al.* (2011) Mitigating amphibian disease: strategies to maintain wild populations and control chytridiomycosis. *Frontiers in Zoology* 8(8), 23 pp, doi: 10.1186/1742-9994-8-8.

[4] Buck, J.C., Truong, L. & Blaustein, A.R. (2011) Predation by zooplankton on *Batrachochytrium dendrobatidis*: biological control of the deadly amphibian chytrid fungus? *Biodiversity and Conservation*, doi: 10.1007/s10531-011-0147-4.

[5] Buck, J.C., Truong, L. & Blaustein, A.R. (2011) Erratum to: Predation by zooplankton on *Batrachochytrium dendrobatidis*: biological control of the deadly amphibian chytrid fungus? *Biodiversity and Conservation*, doi: 10.1007/s10531-011-0163-4.

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South African Weed Biocontrol

A special issue of *African Entomology*[1] is devoted to this topic, with 29 papers. While the introduction gives a historical and contextual perspective, 24 papers provide accounts of recent projects (emphasizing the period 1999–2010) against individual invasive alien plant species, or against taxonomically – or functionally-related – groups of species; 13 new programmes are reviewed for the first time, eight targeting incipient or rapidly-emerging weeds. Three papers deal with issues related to research and implementation of biological control (regulations and risk assessment, mapping, and cost–benefit analyses). The final paper provides a complete catalogue of weed biological efforts against invasive alien plants in South Africa since 1913, incorporating information from two previous reviews of the topic (1991 and 1999).

Moran, V.C., Hoffmann, J.H. & Hill, M.P. (eds) (2011) Biological control of invasive alien plants in South Africa (1999–2010). *African Entomology* (Special Issue) 19(2), 177–549.
Web: www.bioone.org/loi/afen

More Special Issues

Biological Control 59(1), edited by Dionyssios Perdikis and Oscar Alomar, is devoted to 'Heteropteran predators and their role in biological control in agroecosystems', with nine papers including the editors' introduction.

BioControl 55(4), edited by Helen Roy *et al.* includes 20 papers on 'Alien arthropod predators and parasitoids: an ecological approach'.

NeoBiota: Online Open-Access Journal

NeoBiota has been launched as a peer-reviewed, open-access, rapid online journal to accelerate research on alien species and biological invasions: aquatic and terrestrial, animals, plants, fungi and micro-organisms: www.pensoft.net/journals/neobiota. The journal *NeoBiota* is a continuation of the former NEOBIOTA publication series (see vols 1–8 at: www.oekosys.tu-berlin.de/menue/neobiota).

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AgriCultures Newsletter

AgriCultures is a bimonthly e-newsletter from ILEIA giving news from the field. The March 2012 issue will look at how insects contribute to strengthening the functions, processes and resilience of ecosystems, and how farmers support their 'successful integration'. It will focus on ways in which small-scale farmers benefit from insects, and on the steps they take in order to increase these benefits.

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Sirex Nematode Lacks Diversity

A paper in *Biological Control*[1] describes how the development and use of high-throughput microsatellite markers has revealed a lack of diversity of *Deladenus siricidicola* populations introduced in the southern hemisphere to control the woodwasp *Sirex noctilio*, although they are distinct from Canadian

populations. The authors say that data they provide should be used to adapt management strategies as lack of diversity can affect adaptation to different environments and host types.

[1] Mlonyeni, X.O., Wingfield, B.D., Wingfield, M.J., *et al.* (2011) Extreme homozygosity in southern hemisphere populations of *Deladenus siricidicola*, a biological control agent of *Sirex noctilio*. *Biological Control*, online 16 September 2011, doi:10.1016/j.biocontrol.2011.09.009.

Termite Microbial Research Criticized

A review in *Biological Control*[1] examines 50 years of research on microbial control of termites and concludes there is little evidence to support practical application. Although the use of pathogens as biocontrol agents has long been considered promising for termite control, these authors say conclusions about potential application have been overly optimistic and even misleading, and that there is little evidence for commercial application or continued research. They argue there has been unrealistic optimism, publication bias and poor understanding of termite biology.

[1]Chouvenc, T., Su, N.-Y. & Grace, J.K. (2011) Fifty years of attempted biological control of termites – analysis of a failure. *Biological Control*, online 28 June 2011, doi:10.1016/j.biocontrol.2011.06.015.

Poor Uptake of Augmentative Biocontrol

An open-access review in *BioControl* by Joop van Lenteren[1] describes augmentative biological control as being "in a critical phase". Commercial mass production of biocontrol agents goes back over a century and has been an environmentally and economically sound alternative to chemical pest control in a number of crops. In recent decades it has been transformed from cottage industry to professional production, many efficient species of natural enemies have been discovered and developed, and 230 are currently commercially available. The industry has developed quality control guidelines, mass production, shipment and release methods, and adequate guidance for farmers. Yet despite these successes, "it is applied on a frustratingly small acreage." The author reviews trends in research and application, discusses causes of the limited uptake, and explores ways to increase application of augmentative biological control.

[1]van Lenteren, J.C. (2011) The state of commercial augmentative biological control: plenty of natural enemies, but a frustrating lack of uptake. *BioControl*, Online First™, 28 July 2011, doi: 10.1007/s10526-011-9395-1. Open access.

Harmonizing Microbials Regulation in Europe

A mini-review in *Journal of Entomology*[1] discusses major developments in the regulation and environmental risk assessment (ERA) of invertebrate biological control agents (IBCAs) in Europe over the last ten years including: the fragmented pattern of regulation between countries, variation in information requirements for release licenses, format and methods of ERA for different taxonomic groups of IBCAs, use and updating of the European Plant Protection Organization Positive List, sources of expert advice on ERA data, communication between IBCA regulators, and options for the provision of international leadership to coordinate regulatory and ERA-related issues with IBCA-based biocontrol in Europe.

[1] Bale, J. (2011) Harmonization of regulations for invertebrate biocontrol agents in Europe: progress, problems and solutions. *Journal of Applied Entomology* 137(7), 503–513.

Fynbos: Biocontrol Helping Preserve Unique Habitat

A paper in *BioControl*[1] uses four representative but contrasting case studies to illustrate the role of biological control as "an indispensible supplement to other management practices for long-term conservation of the remnants of the fynbos biome" in the Cape Floral Region (CFR) of South Africa; parts of the CFR are recognized as a 'serial' World Heritage site and acclaimed by UNESCO as the world's "hottest hot spot for plant species richness and endemism". The CFR has suffered habitat degradation and species losses – one culprit being invasive alien tree species. Since 1970, ten of these invaders have been subjected to biological control: six *Acacia* species, *Paraserianthes lophantha* , *Hakea sericea*, *Leptospermum laevigatum* and *Sesbania punicea*, with 19 species deployed as biological control agents. The overall result, often in combination with mechanical and chemical measures, has been a substantial decline in the abundance and/or aggressiveness of most targeted host plants.

[1] Moran, V.C. & Hoffmann, J.H. (2011) Conservation of the fynbos biome in the Cape Floral Region: the role of biological control in the management of invasive alien trees. *BioControl*, Online First™, 24 August 2011, doi: 10.1007/s10526-011-9403-5.

Biocontrol's Role in Everglade Restoration

A paper in *BioControl*[1] describes the importance of integrating biological control into conservation biology, citing the case of the Florida Everglades. Although the main thrust of restoration involves re-engineering hydrology to supply more water to the system at certain times of the year, this will not restore plant communities because of the habitat-transforming effects of the invasive plants, notably *Melaleuca quinquenervia* which has invaded vast areas and transformed diverse native marshes into dense, biologically impoverished, structurally altered forest habitats. An invasive species reduction programme combined mechanical removal and herbicidal control to remove mature trees, and classical biological control to suppress seed production and lower seedling survival. *Melaleuca* has now been removed from most public land while biological control has limited its ability to regenerate and re-

invade from nearby infestations, often located on unmanaged privately held land.

[1]Center, T.D., Purcell, M.F., Pratt, P.D., *et al.* (2011) Biological control of *Melaleuca quinquenervia*: an Everglades invader. *BioControl* Online First™, 29 July 2011, doi: 10.1007/s10526-011-9390-6.

Beehive Fences Deter Elephants

Although successful, elephant conservation in northern Kenya has increased human–wildlife conflicts and farm-based deterrents are being researched. A paper in *African Journal of Ecology*[1] describes the effectiveness of a novel method deployed in a Turkana community. Beehive fences were more effective than conventional thorn-bush barriers at deterring elephants. Honey harvested from the beehives may also improve crop production and enhance rural livelihoods through honey sales.

[1]King, L.E., Douglas-Hamilton, I. & Vollrath, F. (2011) Beehive fences as effective deterrents for crop-raiding elephants: field trials in northern Kenya. *African Journal of Ecology*, Early View, online 5 July 2011, doi: 10.1111/j.1365-2028.2011.01275.x. Open Access.

Annual Publications

There is a biocontrol-related chapter in *Advances in Ecological Research*: 'Body size, life history and the structure of host–parasitoid networks' by Dominic C. Henri and F.J. Frank Van Veen.

In the *Annual Review of Entomology*, chapters relevant to biological control include 'Approaches and incentives to implement integrated pest management that addresses regional and environmental issues' by Michael J. Brewer and Peter B. Goodell, and 'Mites (Acari) as a factor in greenhouse management' by Uri Gerson and Phyllis G. Weintraub.

Conference Reports

Aloha Weed Biocontrol

The XIII International Symposium on Biological Control of Weeds (ISBCW) was held on 11–16 September 2011 on the beautiful Big Island of Hawaii. It was hosted by Tracy Johnson from the US Department of Agriculture (USDA) and colleagues, ably supported by an international team and the University of Hawaii at Hilo conference team. Funding was provided by numerous local and national bodies including USDA Forest Service. The conference, attended by more than 200 delegates, was organized over four full days and included 85 short presentations and 147 posters. This report covers what especially interested the author and hopefully the biocontrol community in general. Apologies to those whose contributions were, owing to space constraints, left on the cutting room floor.

The conference opened with a traditional islander welcoming ceremony, and an address by Bill Steiner (Dean Univ., Hawaii) showing the serious implications of invasive species on the environment and communities – yet the public in Hawaii believe that public funds are adequate.

The first session, on pre-release testing, began with May Berenbaum (Univ. Illinois, USA) giving a thorough presentation on the importance of chemical ecology and showing how the post-invasion evolution of a weed can alter the plant chemistry to the benefit and/or detriment of biocontrol. Lindsay Smith (Landcare Research, New Zealand) described the trials and tribulations of removing a gregarine parasite from *Tradescantia* beetles prior to release. The talk left this author wondering how many agents have been subjected to such scrutiny and care in the past. Rowan Emberson (Lincoln Univ., New Zealand) suggested that non-target feeding by *Bruchidius villosus* in New Zealand was not picked up in original testing due to variation at the individual level, and that group testing cannot distinguish low-level use by a whole population from higher-level use by a small part of a population. Andrew McConnachie (Plant Protection Research Institute, South Africa; PPRI) presented some promising data on *Liothrips tractabilis* against the remarkable pompom weed (*Campuloclinium macrocephalum*).

In the 'Emerging issues' session, Richard Hill discussed how ERMA (Environmental Risk Management Authority) evolved and operates in New Zealand. It has many strengths such as regulators being obliged to make a concrete decision within 100 days, the genuine public participation and interaction with applicants on early drafts. It would appear to be good for classical biocontrol – but expensive for glasshouse biocontrollers. Bill Palmer then gave a thorough review of new agent approval procedures in Australia.

Lincoln Smith (USDA Agricultural Research Service; ARS) reminded us of the worrying developments regarding regulations in the USA. He gave the examples of (i) an eriophyiid mite on Russian thistle (*Salsola tragus*) that was approved by the Technical Advisory Group in 2005 yet subsequently rejected by the Animal and Plant Health Inspection Service, after public comment, and (ii) a root weevil application that revealed an apparent sole focus on no-choice test results and no consideration of benefit. The implications are worrying as a no-risk model will hamper almost all future weed biocontrol efforts. Hariet Hinz (CABI) reinforced this by showing some of the most effective biological control agents (BCAs) we are benefitting from which would not be released under today's regulatory framework.

In a session on non-traditional biological control agents, Paul Pratt (USDA-ARS) took us back to the fascinating natural history so often integral to weed biocontrol research, using the example of a gall fly on

Frankinsonia which has an obligate synergism with a nematode on which it relies to initiate the gall. Alex Racelis (USDA-ARS) introduced the social and environmental issues presented by giant reed, *Arundo donax*, on the US/Mexican border and the joint desire to control it – and some of the innovative ways they are releasing 100,000 eurytomid wasps. Don Sands (CSIRO, Australia) gave an interesting and alternative talk on the potential for shredding organisms, rather than our usual species specialists, to reduce the standing flammable biomass and shocking impacts of invasive grasses.

Day 2 began with 'Target and agent selection'. Peter McEvoy (Oregon State Univ., USA) gave a keynote showing that *Longitarsus jacobaeae* had shown evolution in as little as 30 years but questioned whether it mattered. Evidence presented suggested 'not yet' but he recommended that evolutionary biology should be taught to all biocontrol scientists. Quentin Paynter (Landcare Research) showed that 36% of weed BCAs in New Zealand are parasitized and that local analogues (congenerics) of the BCAs are major sources of parasitoids and 8/10 parasitized New Zealand agents could have been predicted – a cautionary tale for biocontrollers. Pauline Syrett (Landcare Research) suggested the potential of sourcing BCAs from the weed's exotic range (i.e. new associations), giving the example of *Storeus albosignatus* on *Acacia* spp.

Ikju Park (Univ. Idaho, USA) introduced us to his 'double-stacked Y-tube device' for collecting volatiles from multiple plants in the field, which he proposed could be used to test rare plants 'virtually'. Rieks van Klinken (CSIRO) asked which weeds should be targeted next considering weed impact vs likelihood of success. He challenged some efforts at quantifying impact, highlighting the risk of overstating what could be temporary fluctuations from changing land management. He concluded that biocontrollers need to demonstrate continued success, and target selection should be a science-driven. This was followed by Bernd Blossey's (Cornell Univ., USA) controversial presentation on garlic mustard (*Alliaria petiolata*) which he asserts needs earthworms to thrive (offering a US$1000 reward to anyone finding an invasion free from them). Bernd presented 12 years of pre-release monitoring data which showed a decline in plant performance over time without biocontrol and suggested it was not a necessary intervention. Andy Sheppard (CSIRO) discussed how fireweed, *Senecio madagascariensis*, has become a target, despite the low likelihood of success, mainly because the social impacts are high. Lastly, John Gaskin (USDA-ARS) demonstrated the power of molecular tools in a revisitation of skeleton weed (*Chondrilla juncea*), showing the 13 different varieties in the invaded range and predicting which areas would be resistant to the *Puccinia* rust BCA.

The session 'Prospects for weed control in Pacific islands' began with Art Medeiros' (US Geological Survey Pacific Islands Ecosystems Research Center) eloquent and impassioned review of the situation in Hawaii, with around a hundred highly invasive plants and a pretty gloomy scenario under mechanical and chemical control alone. Despite a renaissance of national pride in forests and heritage and an annual US$40 million national spend, biocontrol is conspicuously absent in the strategy. Djami Djeddour (CABI) presented progress towards the biocontrol of wild gingers (*Hedychium* spp.) following surveys in the Himalayan foothills showing that potential agents exist for the many regions affected, not just New Zealand and Hawaii. Covering small islands, Iain Paterson (PPRI and for Secretariat of the Pacific Community) spoke about the African tulip tree (*Spathodea campanulata*) in Fiji, and Annastasia Kawi (National Agriculture Research Institute, PNG) about *Mikania* in PNG and Fiji where adaption of methods to local conditions has meant that out of 550 sites in PNG where the rust *Puccinia spegazzinii* was released, 160 sites have establishment.

Starting the session 'Integrating biocontrol and restoration of ecosystems', Tom Dudley (University of California – Santa Barbara, USA) revisited the US *Tamarix* (saltcedar) story and emphasized that the literature shows the endangered southwestern willow flycatcher much prefers mixed vegetation over saltcedar monocultures, and willows are clearly better for the bird than the invasive saltcedar. Later, Jack DeLoach revealed that a Tunisian *Diorhabda* beetle biotype that had been released in Texas is heading further south than expected and at an incredibly rapid rate. Dick Mack then gave a stimulating talk on invasive grasses and pathogens, highlighting the impacts of grasses which fuel huge burns and create a self-serving cycle. He emphasized the need for new tools, concluding that microbial BCAs are needed to fill the gap. Min Rayamajhi (USDA-ARS) showed that the suite of agents used against *Melaleuca* in Florida, USA work well together, e.g. the impact of a rust agent was only noticed after apical dominance in the plant had been removed by a weevil BCA. Plant species richness is increasing, with mostly natives reappearing, not exotics.

The session on 'Ecological and evolutionary processes' began with Andy Sheppard discussing studies which showed that over long time periods insects can expand their host ranges although most examples are not shifts but are within their fundamental host range. He argued that although rapid evolution should not lead to unpredictable host shifts, we should avoid introducing oligophagous BCAs since they have high ecological fitting capacity and high genetic variation. Ruth Huffbauer (Colorado State Univ., USA) considered what enables founding populations and how demography and genetics interact. Looking at *Bemisia tabaci* she showed that genetics can override propagule size and suggested that we should do more releases as experiments to inform our own work and theory. Gina Quiram (Univ. Minnesota, USA) presented preliminary studies on the evolutionary response of *Lythrum salicaria*.

Steven Hight (USDA-ARS) used life-table studies to look at *Cactoblastis* on native and exotic *Opuntia* in Florida and found natural enemies were not very important and, in general, the moth does not do well on Florida's native plants. Martin Hill (Rhodes Univ., South Africa) showed that *Hydrellia lagarosi-*

phon greatly reduced the competitive ability of *Lagarosipohon major* in favour of *Myriophyllum spicatum* but the addition of a fly parasitoid restored advantage to *L. major*. Phil Tipping (USDA-ARS) showed that *Melaleuca* BCAs have subsidized food webs and that psyllids have more connections than weevils. Brian Van Hezewijk (Agriculture and Agri-Food Canada) considered whether it was better to be a hare or a tortoise in the race for a BCA to conquer a weed. Using some fascinating and stimulating visual models he showed that faster-dispersing plant species need slower-dispersing insects, and slower plants need an intermediate-speed agent. Simon Fowler (Landcare Research) suggested that under climate change in New Zealand, weeds will move and new weeds will appear while new extreme climatic events will affect herbivores more than plants. There are possible indirect effects such as natural enemy pressure changing, rainfall washing out nitrogen, seasonal phenology being altered with a possible push towards non-target impact. The conclusion was that it would have little effect on costs but new agents might be needed for wetter areas.

In the first presentation for the session 'Social and economic assessments of biocontrol', Martin Hill gave a thought-provoking presentation on implementation. After showing some amusing historical Heath Robinson-style approaches to release and implementation, he spoke about the Working for Water programme in South Africa and the advantages of engaging with the local population and involving them as implementers and educators. He ended by pointing out we have a handful of papers on release strategy but a mountain on host specificity and this balance needs to change. Jean-Yves Meyer (Délégation à la Recherche, French Polynesia) described the transformation of public opinion during the control programme against *Miconia* in French Polynesia. Against a background of distrust of the government and scientists, the project team adopted a strategy of simple honest messages and explanations, and informing local authorities and the public. As a result an excellent pathogen was released and is now recognized as an efficient and safe tool. This has set the bar high and demand for classical biological control (CBC) is now high.

Michael Thomas (Florida A&M Univ.) brought the insight of an economist to the meeting and showed many flaws in previous published work. It became clear that there is a lack of economics knowledge in the invasion/biocontrol community and inappropriate conclusions are often drawn. For example, the reduction in other costs may seem a benefit but is actually a cost! He also suggested that most economic assessments are post hoc and should be ex ante. Keith Warner (Santa Clara Univ., California) brought another perspective to the proceedings with his presentation on the social side of biocontrol. He said that we no longer work in isolation and we need more than passive assent. Using 183 interviews with CBC researchers, regulators and critics he assessed the challenges facing the field and concluded that reaching those willing to engage is hard but necessary and those with strong opinions either way are key.

Opening the final session, 'Post-release evaluation and management', Jim Cullen (CSIRO) reviewed 100 years of biocontrol in Australia. Most targets have been agricultural weeds. Biocontrol has had a high profile in Australia and investments made have been very rewarding both economically and environmentally. Two talks followed on non-target effects, with Mark Schwarzländer (Univ. Idaho) showing that we can predict houndstongue (*Cynoglossum officinale*) agent damage to threatened and endangered species using field observations of current populations, and Haley Catton (Univ. British Columbia, Canada) showing that the spill-over of an agent on *Hackelia* in aspen groves was temporary and disappeared after two years. Fritzi Grevstad (Oregon State Univ.) considered release strategies by looking back at 611 releases in Oregon concluding that environmental effects dominate and that more small releases are probably best. Jerome Grant (Univ. Tennessee, USA) examined the US musk thistle (*Carduus nutans*) programme using the seed-head and rosette weevils (*Rhinocyllus conicus* and *Trichosirocalus horridus*) and showed that public concerns switched from the weed to non-target effects as the agents are now found on >25% of North American thistles. Lars Baker (Fremont Co. Weed & Pest, Wyoming, USA) showed the massive decline in leafy spurge (*Euphorbia esula*) after *Apthona* beetle introduction in Wyoming is correlated with *Apthona* density. Michael Day (Biosecurity Queensland) gave the final talk, on *Chromolaena odorata* and the success of the stem galler *Cecidochares connexa* in PNG leading to 70% of respondents to a questionnaire saying yields had increased, and reflecting wide public acceptance and appreciation of the biocontrol programme.

Among several evening workshops, 'Is classical biological control an "old science" paradigm that is losing its way?' was chaired by Andy Sheppard. Key points raised were: in New Zealand and South Africa where CBC is a stakeholder-driven process the discipline is doing well and is well-supported by the public; stakeholders need to be involved from the onset; for many resource-poor countries CBC is often the only option; CBC impact needs to be documented in long- term studies; and CBC must be embedded in good land stewardship, and conservation and biocontrol goals linked. Negative issues mentioned included: the anticipated success of CBC has frequently been oversold; competition with other disciplines needs to be avoided; and people often do not perceive invasive species as a problem.

Hugh Gourlay (Landcare Research) hosted a workshop on 'Access and benefit sharing' which was found to be a major issue for some biocontrollers; one outcome will be a questionnaire to determine the extent of the problem and possible solutions. Djami Djeddour and Andy Sheppard hosted species-specific workshops on wild gingers and fireweed, respectively. Keith Warner and Darcy Oishi (Hawaii Department of Agriculture) facilitated a workshop on best practices for communication in weed biocontrol, a topic which is becoming increasingly important in today's society.

All in all it was an excellent meeting, certainly helped by the amazing venue and good organization

but mainly by the quality of the talks and posters. There was rather more introspection than celebration in the topics covered but this is a reflection of the changing world. Despite a strong proposal from Canada, the delegates voted for the equally attractive South Africa as the next venue in January 2014 to coincide with that country's 100th year of biocontrol.

By: Dick Shaw, CABI.

X International Bioherbicide Group Workshop

The International Bioherbicide Group (IBG), composed of researchers interested in all aspects of inundative biological control of weeds, meets every other year. The workshops are generally held as satellite meetings to an international discipline-related conference. This year the X IBG Workshop took place in Hawaii on 10 September 2011, preceding the XIII International Symposium on Biological Control of Weeds, and sponsored by Scotts (Marysville, Ohio, USA) and Novozymes. Organized by the chairperson of the IBG, Dr Karen Bailey (Agriculture and Agri-Food Canada; AFFC) the workshop was attended by 17 participants from eight countries. Compared to previous IBG meetings, such as the previous one in Orlando, Florida, USA in 2009, the attendance was noticeably lower, most likely due to a combination of the economic difficulties and monetary cuts experienced by many organizations and institutions and the remote geographic location of the venue. Eleven talks were presented covering general aspects of biopesticide development and delivery as well as research conducted for the control of specific target weeds using the inundative approach.

The meeting was opened with a welcoming note from Karen Bailey, after which Susan Boyetchko (AFFC) presented the first paper entitled 'The Biopesticide innovation chain'. She detailed the interdisciplinary approach taken by AFFC scientists and the partnership with universities and industry in a stepwise R&D process for new biopesticide products, from the onset of research up to industrial scale-up, commercialization and adoption. Gavin Ash (EH Graham Centre for Agricultural Innovation, Australia) subsequently explored the use of genomics to advance biopesticide development through increased information about individual hosts and pathogens and their specific interactions, highlighting the ease with which molecular data can nowadays be collected due to advances in technology. The international collaboration between New Zealand and Canada in the development of a bioherbicide against *Cirsium arvense* in New Zealand following the stages of the aforementioned biopesticide innovation chain was the topic of a presentation by Graeme Bourdôt (AgResearch Ltd, New Zealand). The potential bioherbicide, based on a pathogenic fungus associated with the weed in New Zealand, is currently going through the 'technology development stage' of this chain. Louise Morin (CSIRO, Australia) gave an overview of lessons learnt from unsuccessful weed biocontrol initiatives and discussed key hurdles to bringing bioherbicides to the market, such as a small market potential, no severe impact exerted by the pathogen on the target weed, technical challenges to cost-effective production and unreliable field efficacy. Lessons learnt include the necessity of an early market analysis to assess potential demand for a bioherbicide, the need to identify key issues with future registration, and the need to establish a multidisciplinary research team and to involve a suitable industry partner. Technical aspects of the delivery of bioherbicides through improvement of granular formulations was the focus of a talk given by Russell Hynes (AAFC) in which he concluded that the ability to produce granular formulations with specific bioherbicide release characteristics allows the active ingredient to be delivered to the weed at its most susceptible stage, thus increasing overall efficacy.

Presentations reporting research for controlling specific target weeds with bioherbicides included a talk by Sheng Qiang (Nanjing Agricultural University, China) on the potential of a selected strain of *Sclerotium rolfsii* associated with Canadian goldenrod (*Solidago canadensis*) in China, and a talk by Angela Post (Virginia Tech, USA) who is evaluating two pathogenic microorganisms showing good potential for the control of silvery threadmoss (*Bryum argenteum*) on golf putting greens. Robert Barreto (Universidade Federal de Viçosa, Brazil) explored the potential of selected indigenous pathogens for an inundative approach against problematic invasive weeds in Brazil such as wild poinsettia (*Euphorbia heterophylla*).

The pathogen *Phoma macrostoma,* soon to be marketed as a bioherbicide against broadleaved weeds in turf grass in North America, was the topic of two talks. Marion Seier (on behalf of Harry Evans) (CABI, UK) gave an overview of survey work in the UK which confirmed the presence of white tip disease of *Cirsium arvense* caused by *P. macrostoma.* Most UK isolates of the pathogen showed comparable bioherbicidal activity and a similar genetic make-up to the Canadian isolate on which the new mycoherbicide is based. It is postulated that the disease originated in the UK and was introduced with its host, *C. arvense,* into Canada. Karen Bailey (AFFC) subsequently presented research showing how *P. macrostoma,* formulated as the active ingredient of the bioherbicide, emerges from granules in the soil environment to infect and colonize susceptible weed species like dandelion. Stanley Bellgard (Landcare Research Ltd, New Zealand) presented the last talk of the workshop in which he gave an overview of plant pathogens associated with *Cortaderia selloana* and *C. jubata*, both in Argentina as the native range and New Zealand as the introduced range of these plant species, and ranked them for their potential as biocontrol agents in New Zealand.

As part of the workshop a business meeting, chaired by Karen Bailey, explored options on how to raise the critical mass of the group, which has dwindled over the years, and rekindle interest in the IBG newsletter. Suggestions included a merger with researchers in the field of insect pathology and increasing links with governmental and non-governmental organizations as well as the inclusion of commercial groups; discussions will continue between IBG members.

The talks presented at this year's IBG Workshop will be available on the IBG website (http://ibg.ba.cnr.it/), where all issues of the IBG newsletter can also be accessed. The next IBG meeting is to be held in conjunction with the 10th International Congress of Plant Pathology in Bejing in 2013 which will also include a session on biological control of weeds and other invasives.
www.icppbj2013.org/file/congress.asp.

By: Marion Seier, CABI.

New Books

Nicot, P.C. (Ed) Classical and augmentative biological control against diseases and pests: critical status analysis and review of factors influencing their success. 1st edn. IOBC/WPRS (2011) 194 pp. ISBN 9789290672432
Free e-book download.
Web: www.iobc-wprs.org/pub/biological_control_against_diseases_and_pests_2011.pdf

Hoy, M.A. Agricultural acarology: introduction to integrated mite management. CRC Press (2011) ISBN: 9781439817513 Price: £63.99, $99.95.
Email: orders@taylorandfrancis.com / international.orders@taylorandfrancis.com
Web: www/crcpress.com

Knutson, L.V.; Vala, J.-C. Biology of snail-killing Sciomyzidae flies. Cambridge University Press (2011) 528 pp. ISBN: 9780521867856
Price: £85.00, $150.
Email: Email: directcustserve@cambridge.org
Web: www.cambridge.org

Roy, H.; De Clercq, P.; Lawson Handley, L.-J.; Sloggett, J.J.; Poland, R.L.; Wajnberg, E. (Eds) Invasive alien arthropod predators and parasitoids: an ecological approach (Progress in Biological Control Vol. 13) Springer (due October 2011), 275 pp. ISBN 9789400727083
Price: £90.00, $129.00, €109.95.
Email: orders-ny@springer.com / orders-hd-individuals@springer.com
Web: www.springer.com

Singh, A.; Parmar, N.; Kuhad, R.C. (Eds) Bioaugmentation, biostimulation and biocontrol (Soil Biology Vol. 28). Springer (2011) 364 pp. ISBN 9783642197680
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Price: £108.00, $169.95.
Email: orders@taylorandfrancis.com / international.orders@taylorandfrancis.com
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Matthews, G. Integrated vector management: controlling vectors of malaria and other insect vector borne diseases. Wiley-Blackwell (2011) 248 pp. ISBN: 9780470659663
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Web: www.wiley.com/

Bhatt, J.R.; Kohli, R.K.; Singh, J.S.; Singh, S.P.; Tripathi, R.S. (Eds) Invasive alien plants: an ecological appraisal for the Indian subcontinent (CABI Invasives Series) CABI (due December 2011) 328 pp. ISBN 9781845939076
Price: £95.00, $180.00, €135.00.
Email: orders@cabi.org
Web: http://bookshop.cabi.org

Pimentel, D. (Ed) Biological invasions: economic and environmental costs of alien plant, animal, and microbe species. 2nd edn. CRC Press (2011) 463 pp. ISBN: 9781439829905 Price: £76.99, $199.95.
Email: orders@taylorandfrancis.com / international.orders@taylorandfrancis.com
Web: www/crcpress.com

Richardson, D.M. (Ed) Fifty years of invasion ecology: the legacy of Charles Elton. Wiley-Blackwell (2011) 456 pp. ISBN 9781444335859
Price: £95.00, $180.00, €114.00.
Web: www.wiley.com/

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Price: £126.00, $189.00, €147.65.
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Newman, J.A.; Anand, M.; Henry, H.A.L.; Hunt, S.L.; Gedalof, Z. Climate change biology. CABI (2011) 304 pp. ISBN 9781845937485
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Email: orders@cabi.org
Web: http://bookshop.cabi.org