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General News

South Africa's Century of Weed Biological Control

The history and the subsequent journey to South Africa's current status as one of the world's leading countries for research and practice of weed biological control are succinctly described in a recent paper by Cliff Moran, John Hoffmann and Helmuth Zimmermann[1]. Its publication in the September/October 2013 issue of the *South African Journal of Science* coincides with the centenary of South Africa's first introduction, in September 1913, of a weed biological agent, a cochineal insect (*Dactylopius ceylonicus*) that quickly and permanently decimated dense and widespread infestations of its host, the drooping prickly pear, *Opuntia monacantha*.

Several thousand species of plants have been introduced to South Africa during its long colonial history, from the seventeenth century onwards and peaking in the nineteenth century, and about 200 species have subsequently become recognized and legally declared as 'weeds' requiring various and appropriate remedial actions. The country certainly seems to have a disproportionately large number of alien, problematically-invasive plant species: for example, far more invasive tree-species per unit area are found in South Africa than in other continental regions such as the Americas and Australia. In this context, the authors highlight some specific South African ecosystem-related problems: (i) how the impact of invasive floating waterweeds has been considerably exacerbated because the country has almost no permanent open waters, and how biological control of some of the floating waterweeds has been followed by the opportunistic-emergence of invasive, submerged aquatic weeds; (ii) how riparian habitats and the country's meagre water supplies are particularly badly affected by alien trees; (iii) how terrestrial ecosystems in higher rainfall areas harbour the most alien plant species – with the Cape Floristic Region at high risk from invasive, 'transformer' tree-species including predominantly *Acacia* and *Hakea* species from Australia, and invasive pine-tree (*Pinus*) species; and (iv) how woody invaders, notably mesquite (*Prosopis*) species, and various cacti and shrubs have invaded the drier regions.

Moran *et al.* outline the basic principles and procedures of weed biological control, aided by a table that lays out the main phases of a biological control programme and the research that has to be undertaken at each stage, together with challenges that may arise. They then review what has been achieved in South Africa, tabulating, using five-yearly intervals, the number of agents that have become established (75 species in total: predominantly phytophagous insect species) against each of 48 species of target weeds (15 cacti, ten shrubs, herbs or climbers, 18 trees and five species of waterweeds). They also record, graphically, the levels of success achieved. To date 23% of the target weed species have been completely controlled and in 38% of the cases biological control is reducing the damage inflicted by the weeds or the extent of the dependence on other controlling measures. It is important to note that these successes have been recorded 'to date', because there has been a surge in activity over the last decade with at least 15 more invasive plants as the subjects of active research, but with no agents as yet released against them, and, furthermore, new species of weeds continue to assert themselves and become increasingly problematic.

In the final section of the paper, the authors identify those aspects and attributes that they believe have contributed to the success of so many of South Africa's weed biological control programmes and that have aided its reputation for innovation and achievement in this field. The speed and degree of the first success against drooping prickly pear, 100 years ago, was something of a double-edge sword because it raised false expectations for rapid and easy results, whereas a common theme in accounting for what has been achieved is constancy of support and sustained effort. The sheer scale of the invasive plant problem in South Africa and its consequences created a strong incentive for supporting weed biological control, and this has continued more or less uninterrupted through the decades. Over 60% of the weed species targeted for biological control in South Africa, historically and currently, have not been the subjects of biological control research or implementation efforts in any other country in the world. Many of the 'novel' target species, since the late 1960s, reflect a change in policy away from agricultural/pastoral weeds to a focus on invasive plants in natural ecosystems/conservation areas, particularly those in the Fynbos Biome, which in turn led to the 'innovative expedient' of using agents that attack reproductive structures thus reducing the aggressiveness but not the usefulness of the target plants.

From the inception of weed biological control efforts in South Africa, the Agricultural Research Council–Plant Protection Research Institute has been the lead agency in the exploration, testing, release and monitoring of biological control agents that have been used against weeds. Since the early 1970s, universities became involved facilitating longer-term research, which was particularly useful for assessing the success of agent introductions. In tandem with this came the growth of annual meetings of researchers and other stakeholders and the regular publication of volumes that have provided comprehensive reviews of all of South Africa's weed biological control programmes.

A key development since 1995 has been the Department of Environmental Affairs' Working for Water (WfW) programme's political and financial support for weed biological control research and its direct involvement in its implementation. WfW's involvement helped integrate biological control into its already massive mechanical and chemical control measures against invasive plants, and paved the way for wider international collaboration, especially elsewhere in Africa. WfW also invested generously in capacity-building measures in weed biological control, notably among previously disenfranchised groups. Finally, the public and political credibility of weed biological control in South Africa has benefitted from inputs by researchers at the Council for Scientific and Industrial Research, who have been able to demonstrate the economic benefits of weed biological control.

The story is not entirely rosy, however. Since the 1980s support for biological control suffered a hiatus in South Africa – as in many other countries – with the growth of risk-averse attitudes and restrictive processes, which slowed weed biological control research and almost halted the release of new agents. Auspiciously, in this centenary year, the protracted stalemate has been lifted by the Directorate of Plant Health (Department of Agriculture, Fisheries and Forestry) and the Department of Environmental Affairs who, assisted by the South African National Biodiversity Institute, have reinvigorated a peer-review process for assessing applications to release weed biological control agents in South Africa.

In international terms, South Africa is considered a 'big hitter' in weed biological control. It hosted the IX International Symposium on Biological Control of Weeds in 1996. In March 2014, as part of its centenary celebrations, it will host the fourteenth meeting in this series in the Kruger National Park (www.isbcw2014.uct.ac.za/).

[1]Moran, V.C., Hoffmann, J.H. and Zimmermann, H.G. (2013) 100 years of biological control of invasive alien plants in South Africa: history, practice and achievements. *South African Journal of Science* 109(9/10), 5–10.

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South African Weed Biocontrol: Fielding New Players

As indicated in the article above, this spring in South Africa saw the deployment of new weed biological control agents. During a meeting in late January 2013, representatives from the Department of Agriculture, Forestry and Fisheries (DAFF), Department of Environmental Affairs (DEA), the Agricultural Research Council–Plant Protection Research Institute (ARC-PPRI) and Rhodes University agreed on an interim procedure for processing the accumulated applications. A biocontrol review committee, chaired by Philip Ivey of the South African National Biodiversity Institute (SANBI), a public entity under the DEA, was also formed to assess comments from the expert reviewers, issue recommendations to DAFF, and assist in developing relevant protocols for future applications. As a result DAFF has issued permits for the release of seven host-specific insects as biological control agents against six invasive alien plants in South Africa, six developed by ARC-PPRI and one by Rhodes University. All of the agents have proved exciting in one way or another during testing, and the scientists involved are both relieved and grateful to all concerned in the process described above that they are now able to see how they fare in the field.

A leaf-feeding ladybird beetle (*Mada polluta*) from Mexico is the first biological control agent to be introduced against yellow bells (*Tecoma stans*), a weedy shrub or tree in the family Bignoniaceae that has spread to seven provinces since 1995. Both larvae and adults of the ladybird feed extensively on the weed, and rapid population increase in the field is anticipated because of *M. polluta*'s short life cycle (= multiple generations per year) and high fecundity.

Another 'first' is the release of a stem- and leaf-deforming thrips (*Liothrips tractabilis*) against pompom weed (*Campuloclinium macrocephalum*), an aggressive perennial invader of grasslands, savannas and wetlands whose showy pink flowers give rise to numerous wind-dispersed seeds that have facilitated a dramatic expansion in range by the weed in the last two decades. The thrips will reduce the ability of pompom plants to produce flowers, so reducing seed production and spread.

After ten years of research, the first biological control agent for balloon vine (*Cardiospermum grandiflorum*) has been finally approved for release in South Africa. Based on field and laboratory studies, a seed-feeding weevil (*Cissoanthonomus tuberculipennis*) was found to be suitable for release, and since the release approval the weevil has been released at nine sites located in KwaZulu-Natal (KZN), Gauteng and Limpopo provinces.

Two of the approved agents represent the first to be released on the African continent against parthenium (*Parthenium hysterophorus*), a severe global invader which has primarily infested regions with a sub-tropical climate in KZN, Mpumalanga and North-West provinces in South Africa, as well as neighbouring Swaziland, Mozambique, Zimbabwe and further north in East Africa. A stem-boring weevil (*Listronotus setosipennis*), previously introduced to Australia during the 1980s, was released in South Africa in July 2013. This weevil is considered a promising biological control agent for regions with prolonged dry periods and erratic rainfall patterns. Simultaneously, the leaf-feeding beetle *Zygogramma bicolorata*, which can cause extensive defoliation of parthenium and has been utilised effectively in Australia and India, has also been released in South Africa.

A moth with shoot-tip boring larvae (*Dichrorampha odorata*), the latest biological control agent to be released against chromolaena (*Chromolaena odorata*) in South Africa, has excited interest for two reasons: it is the first shoot-tip feeding agent to be introduced, and it originates from Jamaica, within what is now thought to be the area of origin of the South African biotype of chromolaena. The moth occurs widely in Jamaica, including at high altitudes, and may thus adapt to cooler South African conditions. It has a short lifecycle, a high rate of increase, and is easy to rear. The two agents already established have given disappointing results, partly because they are leaf feeders which do not do well in seasonally dry inland infestations of chromolaena. Releases of the moth commenced in June 2013 and to date have been made at three sites in KZN, with larval damage observed at one of the sites.

Host-specificity testing for a sap-sucking bug (*Megamelus scutellaris*) for water hyacinth (*Eichhornia crassipes*) biological control was completed in 2001; studies since, which have focused on impact, indicate that it could be particularly effective in eutrophic systems with high levels of nitrates and phosphates – a niche unfilled by the suite of seven agents released so far. The delphacid was first released in the USA in 2010 by the United States Department of Agriculture, while its release in Cape Town, South Africa, in October 2013 marked a first for this biological control agent in Africa. It is anticipated that *M. scutellaris* will help the long-term management of water hyacinth, which relies on the reduction of nutrients entering aquatic ecosystems, and the implementation of an integrated control programme combining herbicidal and biological control.

Three further release applications submitted by ARC-PPRI covering four insect biological control agents targeting yellow bells, mesquite (*Prosopis* spp.) and a new target weed, red sunflower (*Tithonia rotundifolia*) are currently being processed.

Main source: Zachariades, C. (2013) Release of biological control agents approved by DAFF. *Plant Protection News* 96, p.11. Newsletter of ARC-PPRI, South Africa.

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Can a Genetic Rescue Help Heather Beetles?

Perseverance is the name of the game in the long-running biological control programme against heather, *Calluna vulgaris*, on the Central Plateau of New Zealand's North Island. Heather was deliberately introduced into Tongariro National Park (TNP) in a failed attempt to create a grouse moor in the early twentieth century – the grouse were never released in the park but the heather thrived and spread. TNP is now a dual World Heritage Site, recognizing its importance to Maori culture and for its volcanic features. As reported in past *BNI*s (most recently *BNI* 33(2), June 2012), scientists have put a lot of effort into finding out why the apparently promising heather beetle, *Lochmaea suturalis*, introduced in 1996 from the UK, has not been more successful. That it has potential is evident from some impressive outbreaks in recent years where beetles achieved high densities and inflicted significant damage, but such outbreaks have been slow to grow and spread and establishment in new areas is sporadic. An article in the latest *What's New in Biological Control of Weeds?*[1] reports on a novel approach being taken with *L. suturalis* to explore whether the performance of this already established biological control agent can be enhanced so it can better adapt to local conditions and more effectively control the target weed, an approach described as a 'genetic rescue mission'.

Comparisons with UK populations indicated that genetic diversity in the New Zealand population is low and beetles are smaller than in the UK, including those at the site where the successfully established population came from at Oakworth in northern England. Lack of diversity is partly attributable to an early hiatus in the programme, before releases into the wild were made, when microsporidian infection was identified in the quarantine culture and infected lines were culled in order to produce an infection-free stock for mass rearing and release. Although many lines were still released, establishment rates were so poor that only one line, derived mostly from one field-collected female, established. All heather beetle in the field in New Zealand are the offspring from this one line, and may be the offspring of just one Oakworth female. The option of bringing in more heather beetle has always raised the issue of whether that might accidentally introduce the microsporidian disease. However, by bringing in just new males to mate individually with New Zealand females, and using molecular techniques to detect any disease, it was considered that a 'genetic rescue mission' was now feasible. In terms of what would be optimal to introduce, climate matching suggested that Scotland was a better match for the harsh conditions of New Zealand's Central Plateau[2], while investigations into beetle overwintering demonstrated that fat reserves were an important factor – and these are proportionately larger in larger beetles. Importantly, Scottish beetles are on average bigger than heather beetles from the climatically less-challenged, more-southerly English populations. Furthermore, previous surveys suggested that Scottish beetles were less-often infected with microsporidia than populations further south.

Thus Paul Peterson (Landcare Research) and Paul Barrett (Massey University) made the long trip to Scotland in May 2013 and collected suitably large Scottish male beetles from eight field sites, which survived the long trip back for subsequent quarantine investigations to check they were free from infection and for mating with local females. Progeny will be checked, once more, that they are free of disease before they are released into the field in New Zealand – after which time will tell whether the approach has worked.

[1]Evans, A. (2013) Scottish 'laddies' flown in for genetic rescue. *What's New in Biological Control of Weeds* No. 65, p. 3. Landcare Research New Zealand 2013.

[2]Emberson, R.M. (1988) Biology of the heather beetle in Europe. Heather control workshop, Whakapapa, Mount Ruapehu, Tongariro National Park, 1–2 May 1986. Turangi, Department of Conservation Tongariro District Office, pp. 26–30.

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First Biocontrol Agents Released against Swallow-worts

The first introduction of a biological control agent against swallow-worts, *Vincetoxicum* spp., to North America was made in September 2013 when the leaf-feeding noctuid *Hypena opulenta* was released in Canada on *V. rossicum* at a site near Ottawa.

Two European species of swallow-worts, *V. nigrum* (black swallow-wort) and *V. rossicum* (pale swallow-wort), were introduced into eastern North America around 1850 as ornamental vines and have since spread throughout north-eastern North America and into the Midwest. These aggressive, perennial, toxic vines have become major pasture pests and serious weeds in many agricultural, ornamental and forest environments, forming dense clumps that smother/outcompete native species. They may have negative impacts on monarch butterflies (*Danaus plexippus*), as they are related to some of the monarch's preferred native host plants (milkweeds – *Asclepias* spp.); monarchs readily lay eggs on swallow-worts but hatching larvae do not survive.

A biological control project involving CABI in Switzerland, the University of Rhode Island (URI) in the USA, and Agriculture and Agri-Food Canada (AAFC) that began in 2006 identified five potential species for swallow-wort biological control. Research on the biology, impact and host range of these insects, conducted at the URI Insect Quarantine Laboratory, progressed most rapidly with two defoliating caterpillars, *Abrostola asclepiadis* and *H. opulenta*. Host-specificity tests conducted with some 80 test plant species showed that both species are very host specific: successful larval development occurred only on *Vincetoxicum* spp., so they pose no threat to North American native plant species or species of economic importance. *Hypena opulenta* was petitioned first for release because it has multiple generations per year and thus is expected to have more impact on the target weeds.

A petition for the release of *H. opulenta* in North America was submitted to the Canadian Biological Control Review Committee–CFIA (Canadian Food Inspection Agency) and USDA-APHIS TAG (United States Department of Agriculture–Animal and Plant Health Inspection Service, Technical Advisory Group) for Biological Control of Weeds in November 2011. Based on positive scientific reviews from both Canadian and US panels, CFIA granted a release permit in September 2013. APHIS TAG has additional steps in its approval process which are currently underway and it is hoped that the agent will be released in the USA next spring. Insects used in this initial release in Canada were collected by CABI, reared at URI and released by AAFC. This first release in Canada provides an opportunity for the entire international team to see whether this moth from southern Ukraine will, as hoped, be hardy enough to survive the Canadian winter.

Research on two other potential agents is continuing: host-range testing has been completed at URI for the leaf-feeding noctuid *A. asclepiadis*, while work is continuing on the seed-feeding tephritid *Euphranta connexa* at CABI in Switzerland.

Further information: Hazelhurst, A.M., Weed A.S., Tewksbury, L. and Casagrande R.A. (2012) Host specificity of *Hypena opulenta*; a potential biological control agent of *Vincetoxicum* in North America. *Environmental Entomology* 41, 841–848.

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NBAII's Broader Remit Brings New Focus to Research

India's National Bureau of Agriculturally Important Insects (NBAII) in Bangalore succeeded the Project Directorate of Biological Control in 2009 as the Indian Council of Agricultural Research's nodal institute for research and development on all aspects of crop and veterinary pests. Its new Director, Dr Abraham Verghese, who took up his post in April 2013, describes in its latest newsletter[1] how the transition to the new Bureau has been achieved through a shift in mindset from a focus on biological control to a broader one encompassing 'the entire gamut of agriculturally important insects'. Work on biodiversity, bioinformatics and biological control functions 'in harmony with the mandate of collecting, characterizing and utilizing insects'. Paradoxically, Dr Verghese says, this broadening of NBAII's remit has led to greater involvement in biological control, notably the supply of live agents across the country as well as managing the AICRP (All-India Coordinated Research Project) on Biological Control. To raise the profile of NBAII's contribution to agriculture, a trademark logo carrying the word 'Shatpada' (Sanskrit for six-legged) has been provisionally registered with the Indian authorities and it is anticipated that this will be used for all products resulting from research efforts at NBAII.

NBAII's facilities received a boost in March 2013 with the opening of a new campus at Yelahanka in Bangalore by Dr S. Ayyappan, Secretary, Department of Agricultural Research and Education (Ministry of Agriculture). In May 2013, the new campus was host to the XXII Biocontrol Workers' Group Meeting, when research progress on biological control of insect pests, plant diseases and nematodes of crop plants using parasitoids, predators, pathogens and antagonists at the various centres participating in the AICRP on Biological Control was reviewed by some 80 participants and plans for 2013/14 and 2014/15 were finalized.

Cooperation between taxonomic and biological control research is evidence of the harmonization of NBAII's work: in the past year staff have collected and identified many new records and new species for insects of agricultural importance, and often potential biological control significance, including platygastrids, trichogrammatids and anthocorids. Recent publications include a review of Indian *Microplitis* species, and a well-received co-authored catalogue of Microgastrinae of Réunion. Similar synergy is clear from bioinformatics work, where a significant research area is bar-coding key pest species; this has been achieved to date for 24 species in the Coleoptera (one), Diptera (nine), Hemiptera (two) and Lepidoptera (12) using the mitochondrial cytochrome c oxidase subunit 1 gene.

During the reporting year 2012/13, live cultures of 113 insect species were maintained at the Bureau, and 887 consignments were supplied to customers. In addition, technology for the *in vivo* production, processing, formulation and field application of the entomopathogenic nematode *Heterorhabditis indica* was sold to a Bangalore company. NBAII's biopesticide work received another boost by the award of an 'Amulya 2012' by Karnataka's Department of Industries and Commerce and State Innovation Council for a patent on development of formulations for the nematode pathogen *Paecilomyces lilacinus* PL55.

One key biopesticide research area at NBAII is insect baculoviruses, which have potential in species-specific/narrow-spectrum pest control and have already been used in a number of crops in India and elsewhere. Work at NBAII has led to the sequencing of viral genes important for infection in three lepidopteran pests (*Spodoptera litura, Amsacta albistriga* and *Helicoverpa armigera*) and efforts are now focused on sequencing the entire *Ha*NPV genome, which would be a first for India.

Biological control work at NBAII received unplanned but welcome recognition when an award-winning progressive farmer visited a display of biological control agents and technologies put on by NBAII staff at the 'Krishi Vigyan Mela' (agricultural science fair) organized by the Indian Agricultural Research Institute (IARI) in New Delhi in March 2013. The farmer, who was subsequently presented with the IARI Fellow Award by the Minister of Agriculture and Food Processing Industries, Mr Sharad Pawar, proved a vocal advocate for biological control, saying that it had the potential to revolutionize crop pest management in India and calling for more publicity and extension.

One example of farmer-focused research by NBAII biological control scientists is the development of a biologically based pest control strategy in brinjal (eggplant/aubergine) – a popular and versatile vegetable crop in India. The brinjal ash weevil, *Myllocerus subfasciatus*, is a widespread pest that inflicts substantial damage to brinjal and to a lesser extent potato. Adults are leaf feeders, while larvae feed on roots, causing wilting of mature brinjal plants and up to 100% crop loss. Application of a formulation of the entomopathogenic nematodes *Heterorhabditis indica* (see above) and *Steinernema abbasi* was able to reduce the incidence of *M. subfasciatus* larvae by 44–68% and increased crop yield by 18–24%. Combining the nematodes with the entomopathogen *Metarhizium anisopliae* increased control to 73%.

[1]NBAII (2013) *NBAII Newsletter* V(2), June 2013. National Bureau of Agriculturally Important Insects, Indian Council of Agricultural Research, Bangalore, India, 4 pp.
Web: www.nbaii.res.in/newsletters/

Also see: *NBAII Newsletter* V(1), March 2013, listed on the same webpage.

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Revisiting Peach Aphid Biocontrol in Yemen

The publication of CABI's Working Paper No. 5[1] is a reminder that some very successful classical biological control programmes have never been sufficiently documented and are thus little known.

As CABI's Chief Scientist Matthew Cock explains in the introduction, the working paper puts the original dossier that led to the introduction of *Pauesia antennata* against the brown peach aphid, *Pterochloroides persicae*, in Yemen in 1997 into the public domain. This has been done firstly as a historical example of a biological control agent dossier from the first days of ISPM3 (International Standards for Phytosanitary Measures No. 3: 'Code of conduct for the import and release of exotic biological control agents'; since revised in 1995). Secondly, the publication of the dossier helps to document a little known but very successful biological control programme. This *BNI* news item is based on CABI Working Paper No. 5, a 1995 review[2], and additional unpublished information kindly supplied by scientists involved in the programme.

In 1993 an aphid attacking fruit trees, particularly peach and almond, was first reported in Yemen and was identified as *P. persicae*. This aphid probably originates from East-Central Asia and dispersed westwards along traditional trade routes in past centuries, along with its host trees. In recent decades it has spread westwards and southwards into Europe and the Middle East. By the mid-1990s it had spread through Yemen and was inflicting severe losses on the country's 70,000 farmers who grew fruit tree crops for sale and home consumption. Yields and fruit quality were affected and in some areas the aphids were causing tree decline. Chemical control meant spraying every two weeks which was costly and had environmental/health implications. An FAO (Food and Agriculture Organization of the United Nations) emergency response project was set up with the General Department of Plant Protection (GDPP), Republic of Yemen, in collaboration with the Yemeni–German Plant Protection Project.

Pterochloroides persicae had not previously been the subject of a biological control programme, so CABI (as the International Institute of Biological Control) was tasked to survey for *P. persicae* and research potential biological control agents. Literature searches indicated that *Pauesia antennata* was the most commonly recorded and predominant natural enemy of *Pterochloroides persicae* in Central Asia. Extensive surveys in Pakistan indicated that it was the only parasitoid of late instars/adults there. As it also had similar biological attributes to other aphid parasitoids that have been successful in classical biological control programmes, it was prioritized for further study.

Cultures of both the aphid and the parasitoid were established at CABI in Pakistan and the CABI quarantine facility in the UK, and research conducted on their biology, ecology and rearing, and the host specificity, other potential risks and likely impact of *Pauesia antennata*, in line with ISPM3. Particularly in countries lacking specific legislation, this standard provided a mechanism to help countries implement classical biological control safely. A key step in the regulatory process set out in ISPM3 is the preparation of a dossier on the proposed biological control agent, on the basis of which the risks associated with its proposed introduction can be assessed by the regulatory authorities. A dossier was prepared and submitted via FAO to the Government of Yemen. Clearance for introduction of the parasitoid was received in December 1996.

During this time, an MSc student at Sana'a University in Yemen, Ahmed Saif Abdul-Hak, was also conducting research, which included studying the population dynamics of *Pterochloroides persicae* in Yemen and later the effects of the introduced parasitoid on aphid populations[3]. His results indicated that before *Pauesia antennata* was released, *Pterochloroides persicae* was present throughout the year, reproducing parthenogenetically at all surveyed sites. Populations increased from mid-September through to the end of July with peak populations recorded from the beginning of May to mid-July. Female alates produced at the end of April/beginning of May dispersed to other orchards. Abdul-Hak's studies also indicated that indigenous natural enemies were limited to generalist predators which were clearly not keeping the exotic aphid in check.

Pauesia antennata was imported to the GDPP laboratories in Sana'a at the end of January 1997 and a rearing colony established. By July the GDPP had reared more than 65,000 parasitoids, and over 50,000 of these were released in the field. At the peak of production 1000 parasitoids a day were being released. Releases were concentrated at three main sites around Sana'a and within two months the aphid populations in these areas, and beyond, had completely collapsed as a result of parasitoid attack: within two months, Abdul-Hak was finding parasitism rates of approximately 40–90% in orchards within 25 km of Sana'a. The parasitoid was found at farms more than 50 km from release sites two months after release, and 120 km away four months later. The release programme was extended to the south and south-east to increase dispersal, and successful country-wide control was achieved as the parasitoid spread and established in Yemen. Just under 350,000 parasitoids were released in all.

Abdul-Hak's data indicated that after parasitoids were released, *Pterochloroides persicae* populations decreased dramatically, except in orchards where farmers continued to use chemicals. He also cited a fall in pesticide use in stone- and pome-fruit orchards country-wide from 22 to 2.5 tonnes between 1995, at the height of the outbreak, and 1998, by which time *Pauesia antennata* had controlled the pest; the cost of pest control also fell nine-fold in the same period. However, he reported a potential hyperparasitoid problem: two pteromalid species newly recorded for Yemen were identified from *P. antennata*. Although hyperparasitism was less than 30% in 1997 and caused no problems in that year, in 1998 it exceeded 75% and even 80% in places and thus became a problem. The approach was to treat trees in affected areas with pesticide and release fewer *P. antennata*; hyerparasitism subsequently fell back to around 30%.

The classical biological control programme was proclaimed a success in Yemen: the front page of the *Yemen Times* for 6–12 October 1997 carried the headline, 'Over 7.6 million trees saved: a biological enemy for the peach stem aphid introduced in Yemen'. Later, the GDPP shared the Edouard Saouma Award 1998–1999 which recognizes particular efficiency in implementation of a project funded by the Technical Cooperation Programme.

[1]Cross, A.E. and Poswal, M.A. (2013) Dossier on *Pauesia antennata*: biological control agent for the brown peach aphid, *Pterochloroides persicae*, in Yemen. CABI Working Paper No. 5. CABI, Wallingford, UK. Web: www.cabi.org/uploads/cabi/expertise/CABI-WP5-Pauesia-antennata.pdf

[2]Kairo, M.T.K. and Poswal, M.A. (1995) The brown peach aphid, *Pterochloroides persicae* (Lachninae: Aphididae): prospects for IPM with particular emphasis on classical biological control. *Biocontrol News and Information* 16(3), 41N–47N.

[3]Abdul-Hak, A.S. (2000) The biological control of giant brown bark aphid *Pterochloroides persicae* (Cholodk.) on stone-fruit trees in the Republic of

Yemen. MSc thesis, Department of Plant Protection, Faculty of Agriculture, Sana'a University, Yemen.

Other sources: various CABI/IIBC Pakistan and UK annual reports, 1996 and 1997.

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If readers know of other 'neglected' classical biological control successes that are worthy of an article in BNI's news section, please get in touch (bni@cabi.org).

Evaluation of *Rodolia* in the Galapagos Islands

The November 2013 issue of *Biological Control* includes a paper[1] on a two-year study assessing the long-term impact of *Rodolia cardinalis* in the Galapagos Islands, the first classical biological control programme to be undertaken in this UNESCO World Heritage Site and one that the authors conclude has been a success. The study began in 2009, seven years after the biological control agent was introduced during a classical biological control programme for *Icerya purchasi.*

Icerya purchasi was first reported in the islands in 1982, probably introduced on plant material from mainland South America, and subsequently spread to at least 15 of the archipelago's 18 main islands. Populations reached damaging, high densities that restricted plant growth and were killing plants among 62 native or endemic species; over a quarter of these species were listed as threatened in the IUCN Red List of Threatened Species, with six also classified as Endangered or Critically Endangered. A Technical Advisory Committee assembled to manage the crisis recognized that insecticides would not mitigate the problem and suggested classical biological control. However, the idea of deliberately importing and releasing another exotic species was controversial: the biological control agent would probably also be invasive and be able to spread unassisted throughout the Galapagos archipelago. A secure quarantine facility was built at the Charles Darwin Research Station in Puerto Ayora, Santa Cruz, and an *R. cardinalis* culture established from material supplied by CSIRO Entomology in Brisbane, Australia. Legitimate concerns about the potential threat from the exotic coccinellid to non-target insects, especially native and endemic species, were addressed through host-specificity and competition experiments. Upon completion of testing, permission was granted for the release of *R. cardinalis* in 2002, and these began in identified priority areas on 11 islands. The beetle established easily on the abundant *I. purchasi* and brought about swift reductions in pest densities, even reaching islands where releases had not been made.

The November 2013 paper reports that pest population densities have been reduced by some 60–98% by the biological control agent and persistent population suppression has been achieved. Most endemic and native plants that were suffering heavy infestations and disfiguring honeydew contamination have recovered. A few species still suffer fluctuating and sometimes substantial, but temporary, *I. purchasi* infestations, and biological control may be less effective in urban areas, probably because of invasive ants tending *I. purchasi*. No non-target impacts were recorded during the post-release studies, which included direct field cage observations and sticky trap monitoring among host and non-host plants.

[1]Hoddle, M.S., Crespo-Ramírez, C., Hoddle, C.D., Loayza, J., Lincango, M.P., Van Driesche, R.G. and Causton, C.E. (2013) Post release evaluation of *Rodolia cardinalis* (Coleoptera: Coccinellidae) for control of *Icerya purchasi* (Hemiptera: Monophlebidae) in the Galápagos Islands. *Biological Control* 67(2), 262–274.

Further information: http://biocontrol.ucr.edu/rodolia/rodolia_icerya_biocontrol_galapagos.html

Elephants Scared of Tigers at Night

Indian elephants are more afraid of tigers than leopards growling during the night – that is the finding of a recent article in *Biology Letters*[1]. But whether or not this fear could be exploited in a control strategy to safeguard villagers and their crops from marauding elephants is open to debate, according to a recent article in SciDevNet[2].

The authors of the paper in *Biology Letters* describe it as the first study of anti-predator night-time behaviour in any elephants. In villages bordering two wildlife reserves in southern India, infra-red beams were positioned on paths that elephants were using to reach crops. When the beams were interrupted (by elephants passing), this tripped the playback of a recording of either a tiger or a leopard growling. Tiger sounds instigated an immediate and silent retreat by the elephants, while leopard noises prompted a response but not immediate retreat. The paper suggests that the approach has practical potential for protecting crops and villagers. SciDevNet quotes representatives of two organizations working with Indian elephants as saying that elephants learn to recognize such recordings, although the *Biology Letters'* authors say that research showing this has been done mostly with African elephants and during the day.

[1]Thuppil, V. and Coss, R.G. (2013) Wild Asian elephants distinguish aggressive tiger and leopard growls according to perceived danger. *Biology Letters* 9(5), 20130518. doi:10.1098/rsbl.2013.0518.

[2]Bhatta, A. (2013) Tiger growl recordings deter crop-raiding elephants. SciDevNet, 1 October 2013.
Web: www.scidev.net/

Emerald Ash Borer in North America and Europe

A timely chapter in the forthcoming 2014 *Annual Review of Entomology* deals with emerald ash borer (*Agrilus planipennis*; EAB) in North America[1], reviewing the substantial information generated on *A. planipennis* history, biology, ecology, impacts and management since it was first discovered in North America in 2002. It describes how early eradication efforts for this exotic buprestid pest were abandoned, largely because of the difficulty of detecting and delineating infestations, and discusses current management measures which focus on biological control, insecticide-based protection of high-value trees, and integrated efforts to slow tree mortality. Substantial effort has been devoted to developing survey methods for EAB, whose stratified dispersal results from natural and human-assisted spread. The authors also suggest that future management efforts may be aided by tree breeding: ash species indigenous to China are generally resistant to EAB and may be a source of resistance genes for introgression into North American species.

There is also a chapter devoted to this pest in the latest volume in the series that documents biological control in Canada[2]. The author reviews studies on exotic and native biological control agents of EAB, and the use of exotic agents in the US biological control programme (none has yet been approved for Canada; petitions are being prepared). He also identifies future needs in research and implementation activities.

Europe will be grateful to draw on this body of knowledge if the predictions in a recent paper in *Forestry*[3] prove accurate. The authors of this paper warn that on top of the ash dieback that now has a strong footing in Europe, ash trees face a new threat from EAB which could 'spread unhindered' through the continent. First recorded in Russia around Moscow in 2007, EAB has become established in surrounding broadleaved woodlands where ash is a major component, becoming abundant and achieving an almost continuous distribution; many of the ash trees in the infested areas have suffered severe dieback and tree mortality is reported. It is spreading at an estimated 30–40 km per year to the west and south of Moscow; within four years of first being recorded it was found some 220 km to the south and 235 km to the west of the city.

[1]Herms, D.A. and McCullough, D.G. (2014) Emerald ash borer invasion of North America: history, biology, ecology, impacts, and management. *Annual Review of Entomology* 59.

[2]Lyons, D.B. (2013) *Agrilus planipennis* Fairmaire, emerald ash borer (Coleoptera: Buprestidae). In: Mason, P.G. and Gillespie, D.R. (eds) *Biological Control Programmes in Canada, 2001–2012*. CABI, Wallingford, UK.

[3]Straw, N.A., Williams, D.T., Kulinich, O. and Gninenko, Y.I. (2013) Distribution, impact and rate of spread of emerald ash borer *Agrilus planipennis* (Coleoptera: Buprestidae) in the Moscow region of Russia. *Forestry* 86(5): 515–522.

Latest in Canada Biological Control Book Series

As indicated above, *Biological Control Programmes in Canada, 2001–2012*, edited by Peter G. Mason and David R. Gillespie, the latest in this series documenting the history of biological control in Canada, has been published by CABI. The 544-page, 71-chapter book devotes a chapter to each of 64 biological control targets, and has chapters discussing biological control in relation to regulation, access and benefit sharing and climate change, as well new approaches and tools, and potential new target species.
For further information see:
Web: http://bookshop.cabi.org/?page=2633&pid=2583&site=191

Integrated Management for Insect Pests of Chickpea in Asia

A paper in the *Pakistan Journal of Zoology*[1] reviews significant efforts made at research institutions in South and South-east Asia to combat the major insect pests of chickpea (*Cicer arietium*) by developing integrated pest and/or crop management strategies. The evolution of integrated strategies in chickpea is described, and extensive research conducted on integrating crop resistance, cultural controls, plant-derived products, and biological control using viruses, bacteria, parasitoids and predators, with safe use of chemicals is appraised from over 150 references. Insect pest management (IPM) options are reviewed from a systems perspective, and examples of successful IPM approaches operating in farmers' fields are identified for possible extrapolation to other situations. The authors found few examples of direct farmer involvement in the development of IPM packages for chickpea or indeed other legume food crops, and highlight the need for involving farmers in the evolution and evaluation of such strategies. They state the wish that the 'assembly of information [in this review] relating to IPM of chickpea will facilitate increased farmer-participatory IPM activities.'

[1]Ahmed, K. and Awan, M.S. (2013) Integrated management of insect pests of chickpea *Cicer arietinum* (L. Walp) in South Asian countries: present status and future strategies – a review. *Pakistan Journal of Zoology* 45(4), 1125–1145.