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CABI Annual Report
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KNOWLEDGE FOR LIFE

CABI improves people's lives worldwide

by providing information and applying scientific expertise to solve problems in agriculture and the environment

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Front cover photo – Kate Jones surveying in Argentina for natural enemies of *Hydrocotyle ranunculoides*, floating pennywort (photo: M. Seier)

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Contents

preface

There are many significant challenges in finding sustainable solutions to the current global issues facing the agricultural and environmental sciences; not least the cross-cutting issues between these disciplines, such as invasive species. Thus it is a great pleasure to introduce the portfolio of work conducted at the CABI UK science centre at Egham in 2013, in collaboration with project partners, which makes a small, but nonetheless dynamic and frequently original, contribution to the solution of some of these problems.

Our scientists have continued to make many inroads in the field of biological control; a technology that offers clear advantages over other tools for the management of invasive species, central to which is the high benefit:cost ratio that characterizes introduction biological control. This is especially true in a day and age where many governments are anxious to meet new and tough regulations related to the reduction in herbicide and pesticide use in a number of sectors. In this context, a necessary but increasing complex subject is the demonstration of the environmental safety of biological control agents. In the case of our projects on invasive weeds for western Europe, careful research has brought the reality of biological control for Himalayan balsam (*Impatiens glandulifera*) closer for the UK and this work, along with work on other weed targets in the UK, is attracting strong interest in this technology from other European countries. Survey work in native ranges and assessment of agents has continued for other target weeds of riparian systems in the UK and opportunities now exist for looking at agents from Argentina for floating pennywort (*Hydrocotyle ranunculoides*). Host-specificity work on biological control agents is also being conducted at Egham for countries around the globe facing serious weed problems – and here an exciting development, resulting from the careful study of 'risk', is that a very promising new agent is now available for the control of the 'old chestnut' of weeds, *Lantana camera,* which will soon be used for field trials in New Zealand. A common theme in these biological control activities has been the demonstration of the huge potential of plant pathogens for weed biological control and I am pleased that CABI scientists have been at the heart of this work from the start.

On other pathology fronts at Egham, our Bioservices unit is now able to offer a full accredited service for filamentous fungal and bacterial molecular identification – the only such comprehensive service available in the UK. This follows from the success of the Bioservices team in achieving accreditation for fungal identifications in 2013, building on that achieved for bacteria in 2012. In addition, CABI has been working with partners in the UK, Australia, Brazil and sub-Saharan Africa to identify opportunities for biopesticide development to tackle major crop pests in sub-Saharan Africa.

The complex issues of pest and disease threats and climate change continue to undermine commodity production by smallholders in tropical regions. Over the last few years, CABI has been working with Papua New Guinea and Indonesia on the threat of one of the world's most serious coffee pests, the coffee berry borer (*Hypothenemus hampei*). In 2013 there was a successful workshop to conclude this project and to highlight the many outcomes; e.g. the commitment on international collaboration to monitor the future movement of the borer. Likewise, in Central and South America, CABI has been advising on the current serious epidemic of coffee leaf rust (*Hemileia vastatrix*) and, in a project also working in Africa and Southeast Asia, on mitigation of the effects of climate change, which is already causing serious problems for coffee smallholders. CABI is also helping the smallholder cocoa sector in Southeast Asia to address issues related to quality and market access.

The Plantwise team at Egham has been as busy as ever, working closely with regional teams and supporting coordination, training and other activities in half of the Plantwise countries. The team are has also been contributing to core activities – the updating of the training modules and the development of a validation methodology for Plantwise data and a handbook to accompany the Plantwise training courses, which will be made available to all plant doctors towards the end of 2014. In addition, new research on a pilot scheme for pest and disease risk assessment and forecasting was begun in collaboration with CABI's Plantwise Knowledge Bank team and UK collaborators; the pilot is taking place in Kenya with support from CABI's centre in Kenya. The objective is to add value to the information about pest and diseases shared with farmers at clinic sessions.

Finally, as always, I would like to thank, on behalf of staff based at Egham, all our partners and clients, national and international, for all their hard work and contributions, and the continuing financial support by a wide group of funding agencies.

I hope you enjoy the report!

Sean T. Murphy, Regional Director, CABI Europe – UK

highlights in International Development

Japanese knotweed biocontrol study for the Netherlands

The extensive research and approval process undertaken for the release of the Japanese psyllid *Aphalara itadori* as a biological control agent for Japanese knotweed (*Fallopia japonica*) in the UK, the first such approval for an exotic weed biological control agent in Europe, has always been seen as a model that other European countries might follow. In 2013 CABI was contracted by the Bureau for Risk Assessment and Research Programming (BuRO) of the Netherlands Food and Consumer Product Safety Authority (NVWA) to extend testing of the psyllid *Aphalara itadori,* and to a lesser extent the leaf-spot fungus *Mycosphaerella polygoni-cuspidati*, for the Netherlands (see p.11). The results confirmed the high host specificity of the psyllid for invasive knotweeds in the Netherlands.

export issue with Argentina resolved

Following a long period of uncertainties and tough negotiations conducted by our Argentinian collaborators at the Foundation for the Study of Invasive Species (FuEDEI), problems concerning the export of biological material from Argentina have now been resolved and work on affected projects can resume. The immediate impact of this development is that candidate species for the biological control of *Hydrocotyle ranunculoides* (see p.15) can now be exported for host-range testing in CABI's quarantine facility at Egham. In the longer term this will facilitate future collaborative projects with Argentina.

PRA for Himalayan balsam rust submitted and approved

Following CABI's leading role in the release of the UK's first exotic weed biological control agent against Japanese knotweed, our scientists have been pursuing another promising target, Himalayan balsam (*Impatiens glandulifera*), which invades riparian and railway habitats in particular. For this weed the best candidate proved to be a fungal rust pathogen (see p.13). In 2013 a pest risk analysis (PRA) in support of the release of the rust *Puccinia* cf. *komarovii* from the Indian Himalayas for the control of Himalayan balsam in the UK was submitted to the Food and Environment Research Agency (Fera) for consideration. The PRA was subsequently accepted, as was the external peer review that followed, opening the way for a public consultation to be held in 2014.

comprehensive host-specificity assessment of *Phakopsora arthuriana* complete

Jatropha gossypiifolia is an invasive shrub of Australia's northern rangelands that is also toxic to livestock and humans, giving rise to its common name of bellyache bush. As part of an Australian-led biological control programme, CABI has been investigating plant pathogens as prospective control agents, and in 2013 completed host-range testing of non-target species against the fungal rust *Phakopsora arthuriana* (see p.19). The results of this research highlighted the need for further specific studies to evaluate the risk potentially posed to two Australian native plant species in more detail.

renewed funding for *Hedychium gardnerianum* biocontrol

In New Zealand and Hawaii, the Himalayan plant kahili ginger (*Hedychium gardnerianum*) is an invasive weed in native forests and a major threat to delicate island ecosystems in particular. A bid for funds from the State of Hawaii's Watershed Partnership was successful and further funds from The Nature Conservancy of Hawaii (TNCH) and Landcare Research, New Zealand have been confirmed for 2014–2015. Funding has allowed the recruitment of a new team member for the project, which will enhance our capacity to conduct research: Sangay Bhutia, a student from Sikkim University in India, will carry out in-country host-specificity testing and field observations, which should greatly help progress knowledge of priority species under consideration as potential biological control agents. For more on this project, see p.20.

Lantana biocontrol agent exported to New Zealand

Biological control programmes against *Lantana camara* date back more than a century, and the potential of host-specific plant pathogens is giving renewed hope for containing the many forms of this escaped ornamental, which is a weed in many countries and climatic conditions. A damaging variety of the leaf rust pathogen *Puccinia lantanae* from Peru, identified by CABI and tested by our scientists against non-target plants for New Zealand, was approved by the country's Environmental Protection Authority in 2012 (see p.17). In 2013, the rust was shipped to a new state-of-the-art plant pathogen containment facility at Landcare Research in Auckland, in preparation for field release against the invasive weed.

Plantwise – a global programme

Plantwise works with local extension and crop protection services around the globe to provide smallholder farmers with better access to advisory services. This is achieved by providing training for the crop advisors, up-to-date information on pests and diseases, and facilitating the establishment

of a network of plant clinics that work at the grass-roots level to help farmers solve their day-to-day agronomic problems. CABI staff based in the UK have been working closely with regional teams in 15 of the 31 Plantwise countries to support training and coordination activities as well as providing diagnostic back-up services. Other activities include updating of the core training modules and the development of a validation methodology for Plantwise data that can be used by country partners. A handbook to accompany the Plantwise training courses has been drafted and this will be made available to all plant doctors towards the end of 2014.

By the end of December 2013, plant clinics were regularly collecting data in 14 countries, with over 18,000 records of visits by farmers collected in 2013 alone. Local and national engagement continues to increase, and the data collected by the clinics are building into a vital resource for informing plant health stakeholders on the current status of pests and diseases in their countries and the quality and performance of extension services

By sharing data generated at clinics and encouraging closer working relationships with strategic partners Plantwise is helping to create stronger and more integrated plant health systems.

CABI invasives blog

Eleven new in-depth posts were added to the CABI invasives blog in 2013 (cabiinvasives.wordpress.com/), reaching an audience spread across 138 countries. Total views of the blog exceeded 20,000, with close to 170 subscribers receiving every post to their inboxes and a significant number of invasives stakeholders receiving new posts via the Aliens-L Listserv email group. Blog highlights included posts on *Rhododendron ponticum* as an invasive plant, *Crassula helmsii* biocontrol prospects and a popular infographic on the impacts of Himalayan balsam (*Impatiens glandulifera*) on UK invertebrates.

Steve Edgington joins UK nematode group

Nematode advocate Steve Edgington was elected onto the Nematode Group of the UK's Association of Applied Biologists (AAB; www.aab.org.uk) in 2013 and is looking forward to working with fellow nematophiles in 2014.

highlights in Bioservices

UKAS accreditation extended and expanded

CABI's role as a key organization in microbial identification received another boost in 2013 with an expansion in the scope of Bioservices' accreditation by the UK Accreditation Service (UKAS): this year the Molecular Biology laboratory achieved UKAS accreditation for fungal identifications using molecular methods, which follows hot on the heels of the bacterial identification accreditation it attained in 2012.

The extension in scope this year means that the laboratory is accredited for both molecular identification of filamentous fungi and yeasts, and molecular identification of bacteria to ISO 17025. The accreditation covers identification of fungal and yeast isolates by ITS rDNA sequencing and bacterial isolates by partial 16S rRNA sequencing (see p.55). The service is now established as the leading authority for microbial identification in the UK: it is the only service to be UKAS accredited for the entire identification process including providing the name of the organism.

helping member countries through MIRRI

The Microbial Resource Research Infrastructure (MIRRI) is being established as a pan-European resource but CABI has a task within it to extend the lessons learned to regional activities elsewhere in the world (see p.58). This year CABI has provided the conduit to activities in Africa, South and North America and into Asia. A project 'Hands across the Atlantic' was funded by the CABI Development Fund to assist in bringing Brazilian expertise to Kenya, to join CABI in providing a better understanding of all the hurdles, capacity and resource needs to take a microorganism from the soil to the market place to contribute to the local bioeconomy. In Chile, CABI is instrumental in supporting a network of country agricultural organizations coordinating their microbial diversity activities. And in Brunei Darussalam, CABI is supporting the development of a local microbial domain Biological Resource Centre (mBRC). Thus CABI is bringing a critical mass together to help member countries conserve and utilize their microbial diversity.

student news

improving fungal conidia formulations

Formulation can make the difference between a biopesticide product succeeding or failing. Fungal conidia possess desirable properties for biopesticidal use, but the conidia of many commonly used genera are hydrophobic and hence not easily formulated in aqueous suspension, which is how most successful biopesticides are currently formulated. In January 2013, Belinda Luke was awarded a PhD by Birkbeck, University of London for her research on improving formulation methods to help overcome the hydrophobic nature of fungal conidia. She developed a novel technique using a particle size analyser to determine the hydrophobicity of fungal conidia which overcame issues that other hydrophobicity tests had. She also assessed different methods for removing hydrophobins, the proteins responsible, from the surface of *Metarhizium* and *Trichoderma* conidia. Belinda determined that fungal proteins secreted by *Metarhizium* had very unusual properties when subjected to the Langmuir trough test. She recommended tests that could be performed on formulations to determine the physical and biological properties of fungal formulations. She also demonstrated that a judicious choice of commercial surfactant will improve the surface adhesion of *Metarhizium* conidia.

training and workshops

workshop closes coffee berry borer project

A workshop on 3–6 April at the Indonesian Cocoa and Coffee Research Institute (ICCRI) in Jember on the Indonesian island of Java marked the end of a project, funded by the Australian Centre for International Agricultural Research (ACIAR), that has been addressing problems caused by the coffee berry borer (*Hypothenemus hampei*; CBB) in Indonesia and the threat it poses to neighbouring Papua New Guinea (PNG) (see p.37). Participants of the meeting, including CABI staff based in the UK, Africa and Southeast Asia, shared the successes of the project, such as farmer field schools for coffee integrated pest management (IPM) in Indonesia and the benefits of IPM practices, the establishment of a national surveillance system in PNG, and the increased awareness and policy support generated by the project for combatting the threat of CBB in the two countries. The workshop included opportunities to visit participating farmers in a coffee growing area and ICCRI's facilities for coffee research. Although this marks the end of one project, CABI is currently working on a new project proposal, which will allow it to continue working on CBB.

economic development of microbial resources in sub-Saharan agriculture

A workshop intended to help create a framework for the economic development of microbial resources in sub-Saharan Africa was held at the University of Leeds on 13-17 May. The workshop, organized by Leeds Africa College, CABI (David Smith, Bioservices and Dave Moore, International Development) and the University of Greenwich (UK) and Queensland University of Technology (Australia), sought to build on expertise in using microbes to control insect pests and in other biotechnologies, with a focus on identifying and developing microbial pesticides and biological control in sub-Saharan Africa.

The development and application of microbial resources is currently limited by the capacity to identify, evaluate and share these resources. In many countries the legislative frameworks are not well developed and legislation aimed at protecting microbial resources often severely restricts the investment and commercial input required to develop and use the resources. In sub-Saharan Africa, the vast potential of microbial resources is barely explored, there are limited facilities for curation and management, and limited legislative frameworks, all contributing to a lack of investment in the development of these resources.

The workshop included African researchers, representatives of biopesticide companies and experts on biological resource management, legislation and policy. David Smith made a presentation on the requirements of the Nagoya Protocol and access and benefit sharing. Dr Manuela da Silva (Fundação Oswoldo Cruz, Brazil) spoke on lessons from the Brazilian experience of managing and utilizing biological resources within the Brazilian legislative system.

The intention was that examples of successful exploitation of microbial resources, as in the Brazilian model, would assist African countries in planning their research, policy and legislation as positive forces for utilization of natural resources.

Bioservices training courses

Bioservices successfully delivered three training course in 2013: the first was a two-day course in 'Preserving, storing and maintaining microorganisms' (20–21 May), followed by a three-day course in 'Plant pathology techniques' (22–24 May). The third course in 'Identifying environmental fungi' took place on 12–13 November 2013. A total of 16 participants attended these courses from six countries: Chile, Ireland, Kenya, Malaysia, Nigeria and the UK. In addition, bespoke training attachments were provided during the year to scientists from Chile, Malaysia and Nigeria. Feedback was very positive, with such comments as "the training was informative and well-structured", "good theoretical and practical knowledge was provided", and "I enjoyed my training and would recommend it to others".

launching the CocoaSafe project

A new project launched in 2013 has the goal of improving global market access for smallholder cocoa producers in Southeast Asia by addressing quality along the entire cocoa supply chain. Pesticide residue build-up and introduction of other harmful substances at any point during production and processing can lead to shipments being rejected; thus the CocoaSafe project (see p.43) aims to improve quality and knowledge of food safety in different stakeholder groups along the supply chain. The project began with an inception workshop in Kuala Lumpur on 27–28 November, where 20 participants from the project countries of Indonesia, Malaysia and PNG, together with staff from CABI, the International Cocoa Organization (ICCO), the Standards and Trade Development Facility (STDF), the Food and Agriculture Organization of the United Nations (FAO) and Mars, Inc. discussed the plans for the project.

successful rubber-vine workshop in Brazil

In December 2013, 72 stakeholders from more than 20 organizations attended a workshop on rubber-vine (*Cryptostegia madagascariensis*) in northeastern Brazil, followed by a field trip to see the invasion first-hand. This invasive weed from Madagascar is impacting on not only the fragile and globally important Caatinga riverine habitat of this region, but also the US$200 million dollar carnauba palm (*Copernicia prunifera*) industry. There was general consensus that biological control offers a sustainable solution and CABI and its collaborators at the Universidade Federal de Viçosa and Universidade Estadual do Ceará were requested to produce a budgeted concept note with a view to seeking consortium funding.

CABI staff at conferences

oil palm: biosecurity and weed control

Oil palm is an important commodity in Southeast Asia, but the crop there has been dependent on a narrow genetic base. Importing germplasm from other regions is necessary for a breeding programme to improve productivity and disease resistance, but carries a risk of introducing new pests and diseases. CABI staff based in Southeast Asia are working with the Malaysian Palm Oil Board (MPOB) to strengthen biosecurity measures through emergency preparedness. As part of this initiative, in November 2013 Julie Flood presented an invited paper to the Fifth MPOB-IOPRI (Indonesian Oil Palm Research Institute) International Seminar in Kuala Lumpur, Malaysia, co-authored with CABI's Lum Keng-Yeang, on 'Quarantine tools for evading oil palm pests and diseases'. Invasive weeds are also a significant problem in plantation crops, and Carol Ellison presented a poster on the potential for the biological control of the weed *Mikania micrantha* in oil palm.

integrated approaches to basal stem rot management in oil palm

Basal stem rot caused by the fungal pathogen *Ganoderma boninense* has been a growing cause for concern in Southeast Asia where it flourishes in large-scale monoculture plantings. One strategy to minimize *Ganoderma* infection is the adoption of good sanitation practices at replanting, which reduces inoculum in the soil. The results of research into this approach was the topic of an invited paper 'Some approaches to *Ganoderma* management in Sumatra' that Julie Flood presented at the MPOB International Palm Oil Congress (PIPOC 2014) in Kuala Lumpur in November. This paper, co-authored by a researcher at CIRAD (Centre de Coopération Internationale en Recherche Agronomique pour le Développement) and colleagues from Bah Lias Research Station in southern Sumatra, outlined how breeding for resistance, cultural practices and biological control methods can be used in an integrated manner to manage *Ganoderma* basal stem rot in oil palm.

climate change features at the 50th ICO meeting in Brazil

Climate change has undergone a transformation from concept to reality in recent years. Peter Baker participated in two workshops on climate change at the 50th Anniversary Meeting of the International Coffee Organization (ICO) at Belo Horizonte in Brazil in September, but it was a presentation he co-authored with Michael Opitz (Hanns R. Neumann Stiftung) on the Coffee & Climate Initiative (see p.41) at the Council Session that illustrated how rapidly perceptions have changed. This initiative was set up to facilitate long-term planning, i.e. to help farmers adapt their practices so that they were ready to deal with the anticipated impact of climate change on coffee production. However, an unexpected but common discovery has been that climate-related problems are already affecting farmers, and consequently the project has put an emphasis on developing short-term coping activities.

coffee leaf rust sparks concern

Peter Baker was in demand as a speaker at coffee meetings this year where concern about coffee leaf rust (*Hemileia vastatrix*) had been stimulated by the severity of the current epidemic in South and Central America. He gave a 'Situation analysis' at the First International Summit on Coffee Rust in Guatemala City in April, participated in two workshops on leaf rust at the 50th Anniversary Meeting of the ICO in Brazil in September, and a keynote presentation at the Let's Talk Roya [Rust] event in El Salvador in November.

introduction

The management of invasive species is fundamental to achieving CABI's mission of 'improving people's lives worldwide by providing information and applying scientific expertise to solve problems in agriculture and the environment'. In the UK, our team's work focuses on IPM of invasive plants and insects, with a particular emphasis on applying biological control methods. We work closely with other CABI centres as well as our scientific collaborators across the globe, targeting key invasive species in many countries. Our good relationships with national governments facilitate our field survey work for natural enemies of species native to a specific region or country and invasive in other parts of the world. Our current initiative on biological control of Canada thistle (*Cirsium arvense*), which is invasive in North America but native to China, provides an example; in this case CABI is forging links between collaborators in the USA and China to help solve a globally important and intractable weed problem. Our blog (cabiinvasives.wordpress.com) provides an important platform for raising our profile and reaches an audience spread across 138 countries. In addition, we work closely with the CABI Marketing Department and directly with the media to help promote our work to an even wider audience.

This has been an exciting year for our European biocontrol initiative, which targets weeds that threaten the ability of EU member states to meet their Water Framework Directive obligation of achieving good ecological status of waterbodies by 2015, with progress made on three target weeds in particular. We submitted a pest risk analysis (PRA) in support of the potential release of a rust pathogen for the control of Himalayan balsam (*Impatiens glandulifera*) in the UK. Following acceptance by Fera, it was undergoing external peer review at the end of the year. During 2013 our Japanese knotweed (*Fallopia japonica*) project was expanded to the Netherlands, and host-specificity testing confirmed the high specificity of the psyllid *Aphalara itadori* for invasive knotweeds found there. And following the successful resolution of export issues by our Argentine collaborators at FuEDEI, the weevils that are showing so much promise for the control of floating pennywort (*Hydrocotyle ranunculoides*) have now finally been imported from Argentina into the UK for scientific studies.

In 2012 a study funded by the UK Department for Environment, Food and Rural Affairs (Defra) to prioritize those invasive species most suitable for biological control in the South Atlantic UK Overseas Territories (UKOTs) identified the European earwig (*Forficula auricularia*) as the prime species to be targeted. The host-specificity testing of two parasitic fly species (*Triarthria setipennis* and *Ocytata pallipes*) is now underway and prospects seem good, since both species are believed to attack earwigs exclusively. Similarly, in 2012 CABI carried out a prioritization process for weed biocontrol in Brazil, and the clear leading target was found to be a species of rubber-vine weed (*Cryptostegia madagascariensis*). This climber from Madagascar is spreading rapidly in the Caatinga habitat of northern Brazil. A rust pathogen (*Maravalia cryptostegiae*) is a key candidate for release in Brazil, since a specific isolate of the same rust is already successfully controlling a close relative, *Cryptostegia grandiflora*, in Australia.

We continue to have strong collaboration with the Antipodean countries. For New Zealand (and Hawaii), work has progressed well on kahili ginger (*Hedychium gardnerianum*). This has been aided by the employment of a student in the Indian state of Sikkim (the centre of origin of ginger) to carry out open field host-specificity tests. In a new project, open field tests in the UK to determine the specificity of the bark beetle *Xylocleptes bispinus* to old man's beard (*Clematis vitalba*) have been moved to the more equable climate of the Isle of Wight, since some of the New Zealand test plants are not hardy. Surveys for natural enemies for a second new target invasive plant in New Zealand, field horsetail (*Equisetum arvense*), have been undertaken in the UK and a shipment of caterpillars of a sawfly (*Dolerus aericeps*) has been sent to our collaborators at Landcare Research. Finally, a shipment of the rust *Puccinia lantanae* was dispatched to the new Landcare Research quarantine facility in Auckland for release against lantana weed (*Lantana camara*), which is invasive on the North Island. For Australia, full host-specificity testing was completed for a Trinidadian strain of *Phakopsora arthuriana*, a potential biocontrol agent for bellyache bush (*Jatropha gossypiifolia*), and more detailed assessments of selected non-target species have commenced.

Member of the invasives team continue to develop and implement projects in Asia. Mikania weed (*Mikania micrantha*) has been a long-term CABI target there and we are continuing to investigate its impact in natural ecosystems in Nepal and the options for its biological control in Malaysia. A new and potentially very exciting regional initiative was heralded by a workshop in China at which participants from eight countries developed a proposal, potentially for EU funding, on the intra-regional technology transfer of effective control strategies for invasive plant species.

This year the Invasives team has been very active in publicizing its activities with 17 peer-reviewed publications, and many articles and project reports, as well as posters and oral presentations at conferences, meetings and workshops in the UK and around the globe. The International Conference on Biological Invasions at Qingdao in China in October was a major event on our calendar and, as co-organizers, CABI staff based in the UK and elsewhere in the world were well represented. Three out of 15 sessions were organized by CABI colleagues and CABI gave ten presentations during the main conference and three talks for the Taishan Academic Forum, alongside five posters. The conference went very smoothly and the high number and wide range of satisfied delegates were testimony to the importance of invasive species globally. The 12th International Conference on the Ecology and Management of Biological Invasions held in Pirenópolis, Brazil, in September was another significant event for our Invasives team. Thanks to the location, many more southern hemisphere delegates attended and there was a lot more exposure to biological control as a solution to serious plant invasions.

Carol Ellison and **Marion Seier**, Theme Coordinators, Invasive Species.

Kate Pollard and Sarah Thomas checking inoculated Japanese knotweed plants for leaf-spot symptoms (photo: CABI)

biological control of Japanese knotweed for the UK

Japanese knotweed, *Fallopia japonica*, is one of the few terrestrial plants to feature on the Global Invasive Species Database's list of the world's 100 worst invasive species owing to its ability to disrupt the built environment and displace native species, which reduces overall floral and faunal diversity. Since 2003, a consortium of sponsors has supported a research programme to develop biological control of this species in the UK and North America.

The Japanese psyllid *Aphalara itadori* was released as a biological control agent against Japanese knotweed at three isolated sites in the England and Wales in 2010. Adults were observed in early spring 2011 at one site, indicating that they could successfully survive the winter. Larger releases were made in late spring 2011, 2012 and 2013 at the original three sites plus five additional sites. In 2012 adults were again observed in low numbers at a number of sites, indicating that they had successfully survived the winter.

During 2013 circa 160,000 psyllids were reared for phased releases during early and late spring. These were successful despite being delayed by the cold winter of 2012/13 and the late emergence of *F. japonica*. Adults were seen at most sites after release with eggs and nymphs also present. Detectable numbers in the field declined with time but there was evidence of development with fifth instar exuviae being found. Some predation was observed and, owing to the low numbers of psyllids post-release, no impact was recorded on the knotweed. So far, attempts to establish the psyllid in large numbers in the field have not been successful.

The proposed next step for 2014 is to closely monitor the impact of an augmented population of *A. itadori* on the growth of Japanese knotweed and assess any secondary impacts on the receiving environment.

Susceptibility assessment of non-target species in a Japanese knotweed stand naturally infected with *Mycosphaerella* leaf-spot during field host-range testing in Japan (photo: CABI)

Defra-funded research into the potential of the *Mycosphaerella* leaf-spot fungus as an additional biological control agent for Japanese knotweed in the UK continued throughout 2013. Experimental work focused on completion of host-range testing and elucidation of the pathogen's life cycle under quarantine conditions. Regular shipments of infected Japanese knotweed leaf material bearing infective ascospores were received from Japan to facilitate the host-specificity assessments. Additionally, limited field host-range testing using selected UK non-target species was conducted in Japan. While studies in the UK showed that the *Mycosphaerella* leaf-spot can have some non-target effects under quarantine conditions, this was not observed during the Japanese field experiments. Inoculation studies performed using complementary leaf-spot isolates to attempt completion of the life cycle have been unsuccessful under greenhouse conditions to date. All results will be compiled in a PRA to be submitted to the relevant UK authorities for evaluation.

During 2013 evaluation of the *Mycosphaerella* leaf-spot was initiated for Canada, based on the ongoing work for the UK. Preliminary studies are focusing on assessing the susceptibility of Canadian knotweed biotypes and critical non-target species to selected isolates of the pathogen.

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biological control of Japanese knotweed in the Netherlands

In the first quarter of 2013, CABI was contracted by BuRO of the Netherlands NVWA to extend testing of the psyllid *Aphalara itadori,* and to a lesser extent the leaf-spot fungus *Mycosphaerella polygoni-cuspidati*, for the Netherlands. Rhizome samples of three knotweeds (*Fallopia japonica*, *F. sachalinensis*, *F.* × *bohemica*) taken from 11 sites spread across a wide geographical area of the Netherlands were sent to CABI in March along with ten non-target plant species selected by the sponsor for initial host-range testing.

The susceptibility of the three knotweeds to the psyllid was tested under no-choice conditions in the laboratory, where individually sleeved plants were each exposed to ten psyllids for seven days to allow egg laying. All knotweed species supported development from egg to adult, with high mean egg counts per plant of up to 131 on *F. sachalinensis*, 128 on *F. japonica* and 348 on *F.* × *bohemica*. Adult emergence was variable between sites and species but reached 100% on some replicates of *F.* × *bohemica*.

No-choice tests were also carried out for individually sleeved non-target test plants. Only three eggs in total, none of which hatched, were laid on the 60 test plants in six replicates. This compares with more than 4000 eggs counted on 18 *F. japonica* plants. Multiple-choice tests presented a more realistic situation; each replicate included one *F. japonica* and five test plants, which were exposed to 30 psyllids in a laboratory cage for one week. Again, egg numbers were minimal on non-target species: three eggs, which again failed to hatch, on 60 test plants vs more than 3500 eggs on 12 *F. japonica* plants.

Two multiple-choice tests in large field cages were used to provide an even more natural situation. The first was a multiple-choice test on plants of the three knotweed species from eight different sites with 100 psyllids released per replicate. The results confirmed all species to be susceptible to psyllid oviposition with some variation between sites. Mean egg counts per plant ranged from 39 on *F. sachalinensis* to 122 on *F. japonica* and 204 on *F.* × *bohemica*. The second test was a multiple-choice field cage trial that exposed the three knotweed species alongside three selected non-target species. Oviposition occurred on all knotweed species with a total of 3516 eggs laid, but no eggs were laid on any of the non-target plants.

The results so far confirm the high host specificity of the psyllid for invasive knotweeds in the Netherlands, revealing an apparent preference for the hybrid *F.* × *bohemica* and confirming that *F. sachalinensis* is a less-suitable host in more natural field cage tests.

Susceptibility assessments for the Dutch biotypes of the three knotweeds for the *Mycosphaerella* leaf-spot commenced in July and were undertaken using mycelial broth. Results indicate overall low levels of susceptibility in both *F. japonica* and *F.* × *bohemica* to the leaf-spot pathogen while *F. sachalinensis* appeared to be non-susceptible. However, there were also indications of seasonal changes in the susceptibility of the assessed knotweed species.

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Multiple-choice field cage (photo: K. Jones)

Rhizome pieces unpacked on arrival and placed into boxes or trays where they were kept moist to allow the first shoots to sprout (photo: S. Wood)

Multiple-choice testing cage (photo: K. Jones)

Susceptibility scoring for the *Mycosphaerella* leaf-spot (photo: K. Pollard)

Rodrigo Castro, Head of the Associação Caatinga, speaking at our workshop in Ceará state (photo: CABI)

weed biocontrol in Brazil – towards a reality

Up to now, cross-continental utilization of classical biological control (CBC) agents against weed species has, from Brazil's perspective, been largely a one-way process; South America as a whole has been the source of a large number of biological control agents yet only 5% of worldwide releases of CBC agents have been made there. To date there have been no releases at all of CBC agents against weed species in Brazil even though the country has at least 117 plant species regarded as invasive. South American countries are at high risk for invasive non-native plant species entering natural areas of high conservation potential. Brazil is one of the world's biologically megadiverse countries and is threatened by invasive species that have the potential to threaten natural biodiversity as well as infrastructure and the pasture systems that support the hugely valuable cattle industry.

In 2012 CABI carried out a prioritization process for weed biocontrol in Brazil and the clear leading target was identified to be rubber-vine (*Cryptostegia madagascariensis*). This climber from Madagascar is spreading rapidly in the Caatinga habitat of northern Brazil. The vine threatens endemic biodiversity by smothering vast areas of intact forest and forming impenetrable masses that can kill trees and prevent animal and human movement as well as depleting scarce water resources. It generates a large seed bank and the plants produce abundant amounts of toxic latex, rendering its control through standard methods extremely difficult, as well as hazardous.

Besides major environmental damage, infestations of what is now known locally as devil's claw are progressively destroying the natural stands of carnauba (*Copernicia prunifera*) and consequently threatening a valuable natural resource. For over a century, rural populations have been sustainably harvesting carnauba leaves and extracting wax for processing by local industry. Extensive areas infested with devil's claw have already been abandoned by harvesters. This industry, worth US$120 million annually, and the many industrial applications of the wax are also under threat since *C. prunifera* is its sole source.

Fortunately CABI has extensive experience with a closely related invasive rubber-vine (*Cryptostegia grandiflora*) in Australia, where our research led to the release of a rust fungus, *Maravalia cryptostegiae,* against the weed in Queensland on an area of more than 40,000 km^2; the rust is now well on the way to providing permanent control with cost:benefit ratios better than 1:100.

In order to maximize the chance of the biological control of *C. madagascariensis* in Brazil becoming a reality, CABI Development Fund finance was made available to carry out project development activities through our centres in the UK and South America, alongside partners in the region. Seventy-two stakeholders from 20 different agencies attended a very successful workshop held in the state of Ceará in December 2013 and were very supportive of the initiative, especially after a field visit allowed them to see the impact of the plant. A concept note will be further developed in the hope of securing consortium funding in 2014.

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biological control of Himalayan balsam for the UK and Canada

Himalayan balsam, *Impatiens glandulifera*, is a highly invasive annual plant that was introduced into the UK and North America in the early 1800s from its native range, the foothills of the western Himalayas. Originally introduced as a garden ornamental, Himalayan balsam has spread throughout water courses, transportation networks and waste ground to become a serious invader. It occurs throughout the UK and is present in eight provinces in Canada. As a non-native, *I. glandulifera* can have serious impacts on biodiversity, river networks and infrastructure. As an annual species, the plant dies down in autumn, and in riparian habitats this leaves dead material to be incorporated into the waterbody, increasing flood potential and bank erosion; this may in turn have a negative impact on fish spawning grounds. *Impatiens glandulifera* can invade railway banks and lines, which has serious implications for the safety of the rail network as it may obstruct the line of vision for drivers and limit access for maintenance and safety work. In all invaded habitats, it can affect native biodiversity by displacing native species and by competing for pollinators.

In 2013, we completed all of the host-range testing for the Himalayan balsam rust. We submitted a manuscript to the journal *Mycologia* in which we set out the case for renaming the rust *Puccinia komarovii* var. *glanduliferae*, based on cross-inoculation experiments with similar, closely related *Puccinia* species.

In 2013, we also submitted a PRA for the rust as a potential biocontrol agent for Himalayan balsam, which detailed all of the scientific research conducted on the project for the UK, to Fera for consideration. The PRA was subsequently accepted and sent for external peer review. Following the peer review process, the PRA was accepted by our sponsors, and in 2014 it will go to a public consultation where interested stakeholders can comment on the research and the potential for releasing the rust as a biocontrol agent against Himalayan balsam in the UK.

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Himalayan balsam monoculture on the River Torridge at Torrington in north Devon, UK (photo: R. Tanner)

Rajesh Kumar surveying Himalayan balsam in the Kullu Valley, India (photo: R. Tanner)

Puccinia komarovii var. *glanduliferae* infecting a Himalayan balsam leaf (photo: R. Tanner)

Workshop participants discussing regional invasive species problems (photo: Li H.)

intra-regional technology transfer of effective control strategies for invasive plant species in Asia

Following on from research conducted in 2012 enabling us to prioritize weed targets for biological control in China, in 2013 we participated in a workshop where invited stakeholders from neighbouring countries had an opportunity to discuss common objectives in invasive species management with a view to developing a large consortium project.

The workshop was held in Beijing on 23–26 July 2013 with the primary aim of initiating a dialogue between CABI, the Chinese Academy of Agricultural Sciences (CAAS) and representatives from Southeast Asian countries. This was seen as a precursor to developing a joint European Commission proposal for technology transfer of management techniques for invasive alien species within the region, especially from China to neighbouring Southeast Asian countries, focusing on Cambodia, the Lao People's Democratic Republic, Malaysia, Myanmar, Thailand and Vietnam.

The participants of the workshop reviewed priority weeds in each country and current management processes and measures in China, and explored the possibility of forming links for technology transfer within the region. Participants' overviews of the situation in their countries gave insights into invasive weed issues and impacts. It became clear as the workshop progressed that there are national laws and frameworks in place for invasive species, though none are comprehensive; there are gaps in legislation and capacity building and awareness raising is required in all sectors.

At the end of the workshop there was a field trip to the CAAS field station at Langfang, and visits to the CABI – Chinese Ministry of Agriculture Joint Laboratory for Bio-safety (CABI-MoA Joint Laboratory) and the Institute of Plant Protection (IPP-CAAS) buildings in Beijing.

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Group photo of workshop participants (photo: Li H.)

biological control of floating pennywort, *Hydrocotyle ranunculoides*

This four-year Defra-funded project to determine the potential for biological control of one the UK's worst aquatic weeds, floating pennywort, began in 2011 but export of candidate biocontrol agents to our UK quarantine facilities and hence progress have been stalled until this year by access and benefit sharing issues in South America.

In April 2013, the export issues were resolved and a shipment of adult *Listronotus elongatus* weevils was received from FuEDEI, our collaborators in Argentina, which allowed host-range testing to begin and progress apace. In the second half of the year, a small shipment of the same weevil species was received from Brazil through collaboration with the Universidade Estadual Paulista/Fundação de Estudos e Pesquisas Agrícolas e Florestais (UNESP/FEPAF).

The majority of plants for testing have been sourced, with particular emphasis placed on obtaining all priority 1 and 2 plants, i.e. those most closely related to the target weed and native to the UK and Europe. Kew's Millennium Seed Bank has proved a great source of rare or hard-to-obtain species. Of the 79 species on the test plant list, 30 have been subjected to cut-leaf, no-choice testing with the weevil from Argentina, with follow-up no-choice tests on functional plants if and when any damage was sustained. The weevil from Argentina continues to show a high degree of host specificity and initial tests with the Brazilian strain suggest the same.

Work on the stem-mining fly *Eugaurax floridensis* from North America, which had been ongoing in parallel, was terminated when both adult oviposition and larval choice tests indicated that development could be supported by the European native *Hydrocotyle vulgaris*.

Unfortunately, the steady progress made with the host-range testing was curtailed in the second half of the year by a phoretic mite infestation, and despite a number of attempts to curb their impact and clean up the weevil cultures, it proved difficult to rear sufficient numbers of 'uninfected' weevils to undertake valid specificity tests. A survey in Argentina in December by CABI scientists from the UK allowed a further shipment of weevils to be hand-carried back to replenish our culture, as well as a rust, *Puccinia hydrocotyles*, which is rarely found on *H. ranunculoides* in its native range. Host-specificity testing of another stem-mining *Eugaurax* sp., this time from Argentina, will begin in Argentina to assess whether it should be prioritized for export to the UK, while the host specificity of the rust will be studied in our UK quarantine facility.

Outlines for potential research projects were submitted to local universities (Imperial College London and Royal Holloway, University of London) with the aim of attracting MSc and undergraduate students to undertake degree-related research in 2014; this should allow us to address some of the outstanding questions about the weevil's life cycle under temperate conditions as well as its potential levels of impact on the plant.

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Kate Jones surveying in Argentina (photo: M. Seier)

Looking for *Listronotus* larvae in *Hydrocotyle ranunculoides* petioles, Argentina (photo: K. Jones)

Puccinia hydrocotyles rust in the field in Argentina (photo: M. Seier)

Norbert Maczey checking a sweep net for natural enemies of *Crassula helmsii* in Australia (photo: S. Varia)

biological control of *Crassula helmsii* in the UK

Crassula helmsii or Australian swamp stonecrop is an invasive, aquatic weed from Australia and New Zealand. It was introduced to the UK in the early 1900s as a garden pond plant and has since spread throughout the country. The weed can dominate still and slow-moving waterbodies, smothering native species and potentially depleting the water of oxygen. Its control is a problem owing to restrictions on the use of chemicals near waterbodies and manual control spreading viable fragments.

The introduction of the EU Water Framework Directive requires European waterways to reach a 'good ecological status'. Therefore the UK government commissioned CABI to investigate the potential of controlling *C. helmsii* using biological control. Since 2011, we have been conducting exploratory surveys to identify potential biological control agents for the weed.

In 2013, we returned to Australia to survey new areas to see whether we could find natural enemies of *C. helmsii* that we had not found during previous surveys. Three previously undocumented fungal pathogen species were collected – a *Stemphylium* species and two *Alternaria* species – and exported to CABI for identification. Meanwhile, studies in quarantine continued with a stem-infecting *Colletotrichum* species collected in 2011.

A promising species of eriophyid mite, *Aculus* sp., was also collected and exported to our quarantine facility in the UK. Culturing techniques were developed and host-specificity testing with the most closely related plant species has been initiated.

Host-specificity testing with a stem-mining ephydrid fly, *Hydrellia perplexa,* that was collected late in 2011 also continued in 2013. No-choice oviposition and development tests were carried out, which indicated that it had minimal non-target impact.

Several protected test plants were sourced with the help of colleagues throughout the UK, including the vulnerable *Crassula aquatica* and the endangered *Damasonium alisma.*

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Crassula helmsii stem infected with *Aculus* sp. mites (right) next to a healthy uninfected stem (left) (photo: S. Varia)

Alternaria-infected *Crassula helmsii* patch in Australia (photo: S. Varia)

assessment of the rust *Puccinia lantanae* for the control of *Lantana camara* in Australia and New Zealand

Lantana camara, or lantana weed, is a woody, thicket-forming shrub native to tropical and subtropical America. Bred by man, it was spread around the world as an ornamental plant in many genetically different forms. It has become a major invasive pantropical weed, predominantly of pastures, plantation crops and natural ecosystems. In Australia, lantana is considered a serious weed along a wide coastal strip from Cairns in Queensland to Sydney in New South Wales. In New Zealand it has been established in the wild since 1890, but has only become an aggressive invader in the upper Northland region of the North Island since the 1980s. Twenty-nine forms of the species are invasive in Australia and two in New Zealand.

Lantana camara plants infected with *Puccinia lantanae* for shipment to New Zealand (photo: S.E. Thomas)

Biological control methods that utilize natural enemies from the native range of *L. camara* have been implemented in 29 countries since 1902. Around 40 species of natural enemies have been released to date. However, the biological control agents that have established have been limited in their impact, mainly because they have a more restricted climatic tolerance than lantana. In addition, each agent can usually infect only a few of the lantana forms. In order to achieve effective control over its entire weedy range, more agents are being considered for release.

A leaf rust pathogen, *Puccinia lantanae*, is widely found infecting lantana in its native range. However, a specific isolate found in Peru causes significantly more damage than previously observed isolates. As well as infecting the leaves, it damages the petioles and stems and causes systemic infections that lead to whole shoots dying. This Peruvian strain of the rust is being considered for introduction into Australia and has been imported by New Zealand this year.

Shipment box and permits for the transfer of the rust to New Zealand

Screening work for Australia was completed in 2010 and the dossier prepared was externally evaluated during 2011 and 2012. The rust was found to cause mild infection symptoms on the purported Australian native species *Verbena officinalis*, and further discussions with Queensland's Department of Agriculture, Fisheries and Forestry (DAFF) have continued to decide on a way forward for the rust in Australia.

Following the successful completion of host-range screening of non-target plants for New Zealand, permission was granted to import the rust in 2012. In March 2013, CABI prepared a shipment of *P. lantanae* for import into the newly constructed quarantine containment facility at Landcare Research in Auckland.

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Systemic infection of *Puccinia lantanae* on *Lantana camara* (photo: C.E. Ellison)

Puccinia spegazzinii infecting *Mikania micrantha* (photo: C.A. Ellison)

implementing a classical biocontrol strategy for mikania weed in Asia

Mikania micrantha (mile-a-minute weed, mikania weed or South American climber) is a major invasive alien plant in many of the tropical humid forest regions of the Asia–Pacific region. This fast-growing Neotropical vine is able to smother plants in agricultural ecosystems, agroforestry and natural habitats, reducing productivity and biodiversity. Fungal pathogens were first investigated for CBC of this weed in 1996. The highly host specific and damaging rust pathogen *Puccinia spegazzinii* was selected and screened. It was first released in India and China in 2005–2006, although it is not believed to have established. Since then, four successful releases have been made in Taiwan, PNG, Fiji and most recently Vanuatu. In these countries, the rust has established and is spreading rapidly, after applying lessons learned from the first releases on improving rust pathotype selection and the release strategy. In PNG, monitoring and evaluation studies have demonstrated that the rust is having a significant impact on *M. micrantha*, with no unpredicted non-target impacts.

Despite this, the authorities in many affected countries remain cautious about releasing the rust. This project focused on identifying the barriers to implementing CBC of mikania weed, and developing appropriate approaches to help overcome them. In Western Samoa, introduction of the rust has not been pursued because of a conflict of interests and the perception that mikania suppresses even worse weeds. For some, 'pathophobia' is still a major obstacle; in Indonesia, where insects for weed CBC have been introduced, pathogens will currently not be considered. In other countries such as Bhutan and Myanmar, there is no baseline data on the presence and impact of invasive alien plants and, with no history of CBC, no institutional framework for implementing this approach. Malaysia has a well-developed framework, but capacity building is needed to develop in-country capabilities. Overall, it remains critical to have champions at decision-making levels. Hence, even with an effective 'off-the-shelf' agent available, implementation of mikania weed CBC still requires significant inputs tailored to the countries' specific needs.

Since Malaysia has good capacity for implementing CBC, and a history of doing so, a stakeholder meeting was held at the Plant Biosecurity Division of the Department of Agriculture, Kuala Lumpur, to discuss introducing the rust into Malaysia. This will be followed up with an in-country CBC training workshop in 2014.

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Mikania micrantha invading young oil palm, United Plantations, Malaysia (photo: C.A. Ellison)

assessment of the rust *Phakopsora arthuriana* as a potential biocontrol agent for *Jatropha gossypiifolia*

Jatropha gossypiifolia, commonly called bellyache bush, is a perennial shrub belonging to the family Euphorbiaceae. Native to the Caribbean rim and islands, this species was introduced into Australia in the late 19th century for medicinal and ornamental purposes. The plant has now become a serious and expanding invader in northern Australia's rangeland. Forming dense thickets, bellyache bush poses a major threat to native biodiversity and the productivity of invaded land. Furthermore, all parts of the plant, and in particular the seeds, are toxic to livestock and humans. *Jatropha gossypiifolia* is a declared noxious weed in many parts of Australia and since 1996 has been the target of a biological control programme that initially focused on insect agents. Evaluation of fungal pathogens as potential biocontrol agents commenced in 2008 when CABI was tasked to research the biology, pathogenicity and host specificity of the rust fungus *Phakopsora arthuriana* (formerly *P. jatrophicola*), which is associated with the invasive shrub and other *Jatropha* species in its native range.

Bellyache bush *(Jatropha gossypiifolia)* in Queensland (photo: K. Dhileepan, DAFF)

Preliminary screening of a Mexican strain of *P. arthuriana* ex *J. gossypiifolia* under quarantine greenhouse conditions showed the rust to be specific to the genus *Jatropha*. Furthermore, there were indications for the existence of specialized strains of the rust adapted to specific hosts within this plant genus. Subsequent screening of additional *P. jatrophicola* strains ex *J. gossypiifolia* from different geographic areas and regions was aimed at finding isolates with infectivity and high virulence towards all major Australian biotypes of the target *J. gossypiifolia*, but low virulence towards the non-target biofuel crop species *J. curcas*. This work led to the selection of a Trinidadian isolate for full host-range testing.

Jatropha gossypiifolia infected with *Phakopsora arthuriana* in the field in Puerto Lobos, Mexico (photo: M. Seier)

During 2013 host-specificity testing of this isolate was completed for 38 non-target species. Based on macroscopic and microscopic examination of inoculated leaf material, the majority of test plant species were classed as either immune or resistant to the isolate as they did not support disease development or sporulation of the pathogen. Five non-target species, however, including three species in the genus *Jatropha* (*J. curcas*, *J. multifida* and *J. integerrima*) and two further species belonging to other genera within the same tribe, Crotonoideae (*Aleurites moluccana* and *Beyeria viscosa*) proved to be susceptible and supported sporulation of the rust, although to varying degrees.

Funding has been secured for a fourth phase of this project in 2014, during which the susceptibility of additional non-target species within the genera *Aleurites* and *Beyeria* will be assessed. Furthermore, dose–response inoculation studies using a range of spore concentrations will be conducted for *J. curcas*, *A. moluccana* and *B. viscosa* to help evaluate the potential risk to these non-target species. Experiments to elucidate the full life cycle of *P. arthuriana* will also continue.

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Non-target species *Beyeria viscosa* showing strong plant defence responses to *Phakopsora arthuriana* during host-specificity testing (photo: K. Pollard)

biological control of kahili ginger, *Hedychium gardnerianum*

Student Sangay Bhutia in the field in Sikkim (photo: C. Pratt)

In its introduced range in Hawaii and New Zealand, kahili ginger (*Hedychium gardnerianum*) is a serious weed in native forests and a major threat to delicate island ecosystems. Now entering its sixth phase, the project this year aimed to progress the host-range testing of the two prioritized agents, namely the shoot-mining fly *Merochlorops dimorphus* and the large weevil *Tetrotopus* sp., for a New Zealand and Hawaiian consortium of funders.

Because of the rearing challenges posed by these two species, host-range testing is still heavily reliant on shipments from their centre of origin. To this end, two surveys were undertaken to Sikkim, India, in May–June and September–October, which allowed further collections to be made and hand-carried or couriered back to the UK.

Collaborations with ICAR and NBPGR continued in 2013 but an ICAR office order to restore individual responsibilities for microbes, plants and insect genetic resources to their respective national bureaux was issued and is likely to come into effect in 2014, meaning we will need to establish new relationships with these authorities.

Importantly, official collaboration with Sikkim University was initiated and an MSc student, Sangay Bhutia, was appointed to the project with a remit to undertake observational research and host-range testing in the field, starting with hispine beetles. Sangay had the opportunity to accompany CABI scientists on both surveys as part of his training.

Merochlorops dimorphus egg cases on *Hedychium gardnerianum* (photo: D. Djeddour)

Host-range studies in quarantine are ongoing. Laboratory choice test results in the UK support earlier indications that *M. dimorphus* flies will only complete their development in *H. gardnerianum*, and that, while *Tetratopus* weevil adults feed on a wide number of species in the Zingiberaceae, host plant specialization at the clade level is apparent for oviposition and developmental stages. The specificity of the weevil will be further assessed in caged host-range studies in India and additional efforts to develop an artificial diet for the weevil will be made in the UK alongside host-range studies in 2014. Hispine beetles were found to cause significant damage to *Hedychium* species in the field and these were deposited for identification and subsequent export approval at NBPGR.

Opportunities to promote the project and solicit funds from potential stakeholders from South Africa and Brazil were investigated at various international meetings and conferences and new funding was secured from the US Government (State of Hawaii), TNCH and Landcare Research, New Zealand for 2014–2015.

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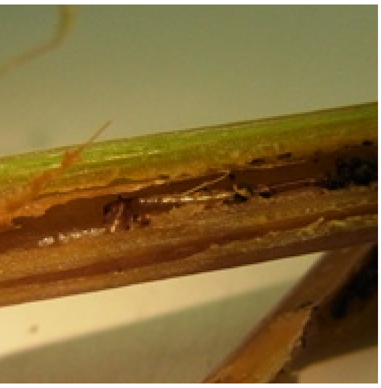


Larval tunnelling and pupa of *Merochlorops dimorphus* on New Zealand *Hedychium gardnerianum* (photo: C. Pratt)

searching for specific pathogens to control Canada thistle, *Cirsium arvense,* in the USA

Cirsium arvense, Canada thistle, is among the most important invasive plants in the world. To date, five biological control agents have been released against this weed in North America and several other natural enemies have been accidentally introduced. Thus far, however, none appears to have been able to halt the spread or reduce the impact of Canada thistle. Coevolved fungal pathogens can be more host specific than insects at the plant species level. Since host specificity is the main hurdle to introducing additional biological control agents of *C. arvense* into North America, we are now focusing on the potential of pathogens.

We selected China as a survey area because a large number of *Cirsium* species are recorded from there, and some areas show a good eco-climatic match with infested areas in North America. Because CABI's fungal expertise lies with CABI staff based in the UK, the CABI centre in Switzerland, which leads the project, is collaborating with staff based in the UK and at the MoA-CABI Joint Laboratory in Beijing.

During surveys in 2010, different pathogens had been collected on *C. arvense*, and a white blister 'rust', *Pustula spinulosa*, was identified as the most promising agent. The blister 'rust' proved to be difficult to work with, and the first successful infection of *C. arvense* under laboratory conditions was achieved only in 2012. In 2013, inoculations were attempted with oospores – purported to be able to survive for several years in dried plant parts – but no infection occurred. At the end of July 2013, fresh material of *C. arvense* infected with zoosporangia of the blister 'rust' was collected at Urumqi, in Xinjiang Province in northeastern China, and used for simultaneous inoculation tests in the UK and China. Both tests showed that single populations of *C. arvense* from China, the USA and Canada were fully susceptible, while two other US populations were only moderately to weakly susceptible. Three native North American *Cirsium* species that were inoculated proved to be resistant or only weakly susceptible. In addition, a mycoparasite (*Lecanicillium* sp.) was found on the *P. spinulosa* culture, which is probably responsible for our previous difficulties in maintaining a laboratory culture of the blister 'rust' and in developing a consistent inoculation method. Zoosporangia of *P. spinulosa* were found to survive well in liquid nitrogen.

Plans for 2014 include trying to obtain a mycoparasite-free culture of *P. spinulosa*, continuing host-specificity tests in our quarantine facility in the UK, and conducting an open-field test in China.

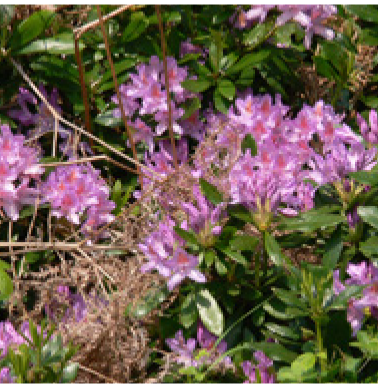
C.A. Ellison (c.ellison@cabi.org), **Wan H.**, **Li H.M.**, **Zhang F.** and **H.L. Hinz.** Joint project with the MoA-CABI Joint Laboratory. Funded by the US Department of Agriculture – Animal and Plant Health Inspection Service – Center for Plant Health Science and Technology (USDA-APHIS-CPHST), USA, and the MoA-CABI Joint Laboratory, China.

Native North American *Cirsium tracyi* 40 days after inoculation with white blister 'rust': a single tiny (c. 1-mm) pustule (arrow) is evident on the lower leaf surface (photo: C.A. Ellison)

Cirsium arvense nine days after being inoculated with white blister 'rust'; many newly developing pustules are present (photo: C.A. Ellison)

Wan Huanhuan collecting blister 'rust'-infected *Cirsium arvense* in Xinjiang Province (photo: C.A. Ellison)

evaluation of *Chondrostereum purpureum* as a cut-stump treatment to control re-sprouting of *Rhododendron ponticum* in the UK



Rhododendron ponticum invading natural woodland (photo: N. Maczey)

Introduced to the British Isles from the Iberian Peninsula in the late 18th century, *Rhododendron ponticum* has spread invasively through most of the western parts of the UK and Ireland. The species poses a threat to native biodiversity and impacts on commercial forestry operations. Crucially, *R. ponticum* is also one of the main sporulating hosts of the damaging introduced plant pathogens *Phytophthora kernoviae* and *P. ramorum*, both of which threaten trees and native heathland species by causing foliage dieback and sap-seeping lesions known as 'bleeding cankers' on the trunks. By harbouring these pathogens without being killed, *R. ponticum* populations act as a prolific source of spore inoculum. Therefore, their management has become vital, not only because of their invasive properties, but even more so from a plant health perspective.

The current project, entitled 'Determining best methods for the clearance and disposal of key host plants, especially invasive *Rhododendron*, for the control of the quarantine plant pathogens *Phytophthora ramorum* and *Phytophthora kernoviae*', commenced in April 2010. It is part of a five-year disease management programme funded by Defra. Led by Forest Research in collaboration with CABI, one remit of the project is to assess the efficacy of specified chemical, biological and physical treatments to cut-stumps of *R. ponticum* with the aim of finding improved methods to prevent re-sprouting, and kill stump and root material, in order to reduce infection and spore levels of the two *Phytophthora* species. CABI's role in this research is to evaluate the potential of a UK-native strain of the wood-rotting basidiomycete fungus *Chondrostereum purpureum* as a cut-stump bioherbicide. This pathogen has neither been trialled against *Rhododendron* species nor tested in the UK, although it has been successfully used in parts of Europe and North America to control re-sprouting in various woody species.

Sampling fungal growth on the cut surface of a treated *Rhododendron ponticum* stump (photo: S. Varia)

Field trials were established at an experimental site in southwest England in the summer and winter of 2010. Treatments comprised three herbicides and a selected strain of *C. purpureum*, with the latter being applied either as the sole agent or in combination with the herbicide glyphosate to freshly cut *R. ponticum* stumps. The effect of each treatment date on regrowth was assessed after 25 months. Stumps treated with *C. purpureum* were further examined for the presence of fruiting bodies, and samples of cambium/xylem tissue were removed to confirm colonization of the *Rhododendron* stumps through successful re-isolation of the pathogen.

The final results showed that the application of *C. purpureum* had no significant impact on the assessed regrowth parameters of *R. ponticum* stumps. However, successful re-isolation of *C. purpureum* and observations of basidiocarp formation on *R. ponticum* in the field indicated that infection and colonization of some cut stumps had taken place. The results also indicated a potential synergistic effect of *C. purpureum* with glyphosate. The project finished in March 2013 with submission of the final project report to Defra.

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Chondrostereum purpureum bodies present on the cut surface of a treated *Rhododendron* stump (photo: M. Seier)

Sarah Thomas and Sonal Varia assessing the experimental field site in southwest England (photo: M. Seier)

biological control of water fern, *Azolla filiculoides*, using the North American weevil *Stenopelmus rufinasus*

Water fern, *Azolla filiculoides*, is an aquatic plant with delicate fern-like foliage. It originates in the New World, but was introduced into the UK in around 1840 as an ornamental aquatic. The plant soon escaped the confines of ponds and is now considered to be one of the UK's most invasive aquatic plants. In mainland UK, *A. filiculoides* is commonly found in static or slow-moving waterbodies throughout the lowland regions of southern England and the English midlands, with sporadic occurrences in low-lying areas of the north. The plant is generally absent from high-elevation sites (over 450 metres above mean sea level).

Azolla filiculoides is able to rapidly colonize the water's surface through vegetative reproduction, each frond elongating and fragmenting to form new plants. The mats that form on the water's surface can be 20 cm thick and during hot weather can double in size every 7–10 days. The plant also reproduces sexually and in autumn millions of sporocarps are released, each capable of growing into a new plant in subsequent years. *Azolla* infestations reduce the light level beneath the water's surface causing submerged plants to die back. This can lead to serious deoxygenation resulting in the death of fish and a reduction in the invertebrate fauna. The mats can also impede water-based recreation, such as boating and angling, and can be drawn into water intakes, blocking pumps and filters. Dense infestations, which completely cover the water's surface, are a danger to children, pets and livestock who may mistake the weed-covered water for land.

Despite warnings about *Azolla*'s 'weedy' tendencies and a Royal Horticultural Society ban on the plant at its flower shows, it continues to be sold directly by some garden and aquatic centres or acquired indirectly as a contaminant. Fragmentation of the fronds makes control by mechanical means virtually impossible. Chemical control is limited to herbicides containing the active ingredient glyphosate, which is not practical to use in areas of conservation interest owing to its non-selective action.

In 2002 CABI began investigating the possibility of using the host-specific North American weevil *Stenopelmus rufinasus* as a biological control agent. The weevil had proven very successful in South Africa where, following extensive host-range testing, it was deliberately released. *Stenopelmus rufinasus* was already present in the UK (probably through 'hitching a ride' on imported *Azolla* plants) and is considered by Defra to be ordinarily resident.

The weevil was collected from several sites in the south of England for further investigations into its biology and life history. Through field observations and laboratory experimentation it soon became apparent that it was very efficient at controlling UK populations of *Azolla*. There is an increasing demand for effective, alternative strategies for managing environmental weeds, and after reviewing the current management options the decision was taken to commercialize the sale of *S. rufinasus* as a biological control agent. The weevil is currently mass produced and supplied on demand to private individuals and water managers within the UK, controlling *Azolla* at all scales; from small ponds to lakes and canals.

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Stenopelmus rufinasus adult (photo: C. Pratt)

Azolla filiculoides (photo: C. Pratt)

Field horsetail, *Equisetum arvense* (photo: N. Maczey)

survey of biological control agents of field horsetail, *Equisetum arvense*, for New Zealand

Field horsetail (*Equisetum arvense*) is a rhizomatous perennial plant that grows up to 80 cm high and has distinctive stems with whorls of branches. In New Zealand it is an invasive species and is listed on the National Pest Plant Accord. In the British Isles it is abundant but not invasive, as it is native to the temperate and Arctic regions of the northern hemisphere.

CABI is working with Landcare Research, New Zealand to identify sites within the UK that support populations of insects associated with field horsetail, with the aim of finding insects that specifically feed on it. The insects are being collected, identified and shipped to New Zealand for further studies on their host range and to assess their suitability as biological control agents of field horsetail.

During 2013, CABI identified field sites supporting populations of the flea beetle *Hippuriphila modeeri* and two sawfly species, *Dolerus aericeps* and *Dolerus* sp. Larvae of *D. aericeps* were sent for further assessments to New Zealand and surveys are set to continue in 2014.

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Survey site for *Equisetum arvense* in Surrey, UK (photo: N. Maczey)

Sawfly larva in an *Equisetum* stem (photo: N. Maczey)

understanding and addressing the impact of invasive non-native species in the UK Overseas Territories in the South Atlantic: a review of the potential for biocontrol

This Defra-funded project to evaluate the potential for CBC of invasive alien species in the UKOTs of the South Atlantic finished in March 2013. The project was administered through the Joint Nature Conservation Committee (JNCC) and built on previous work, notably the South Atlantic Invasive Species (SAIS) project led by the Royal Society for the Protection of Birds (RSPB).

CABI's assessment of the potential for CBC of introduced invasive species in the South Atlantic UKOTs was based on a tool developed for prioritization of Australian weeds, which was adapted for the South Atlantic and also for invertebrate targets. Invertebrate species prioritized by the SAIS project were reviewed using the insect biocontrol database BIOCAT held by CABI.

The Falkland Islands, South Georgia and Ascension Island were then the focus for detailed case studies of priority invasive weeds and invertebrates for which CBC could be feasible. These assessments were based on a review of literature and reports from publicly available sources, and additional information provided by stakeholders involved in conservation on the islands. Preliminary results were refined through stakeholder workshops and field site visits to the Falklands and Ascension Island, which also allowed stakeholder attitudes to CBC to be assessed in more detail.

A major output of the project was the identification of highest-priority species on the Falklands and Ascension Island for which CBC is likely to provide a cost-effective and sustainable management option, and further detailed assessments of these are recommended.

For the Falklands, high-priority targets include the weeds *Berberis microphylla*, *Pilosella officinarum* and *Ulex europaeus* plus the European earwig *Forficula auricularia*. On Ascension Island, high-priority targets are the weeds *Prosopis juliflora*, *Nicotiana glauca*, *Argemone mexicana* and *Lantana camara*, and good potential for CBC of the scale insect *Icerya purchasi* was also recognized. In contrast, no priority species suitable for CBC were identified for South Georgia.

Extending the work to St Helena and Tristan da Cunha, a preliminary evaluation of priorities for non-native plants and terrestrial invertebrates was made, although without the benefit of field site visits or detailed stakeholder consultations. Only tentative recommendations can be made, therefore, but CBC is provisionally highly recommended on St Helena for the fast-spreading weed *Asparagus densiflorus* and the scale insect *Pseudococcus viburni*, which is currently threatening endemic gumwood trees.

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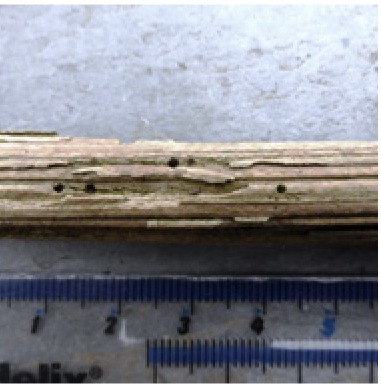
The European earwig (*Forficula auricularia*), an aggressive invasive alien in Port Stanley on East Falkland (photo: N. Maczey)

Mouse-eared hawkweed (*Pilosella officinarum*) spreading on West Falkland (photo: N. Maczey)

Spreading Mexican thorn (*Prosopis juliflora*) on Ascension Island (photo: N. Maczey)

Calafate (*Berberis microphylla*) spreading at Port Sussex on East Falkland (photo: N. Maczey)



Emergence holes of *Xylocleptes bispinus* in *Clematis vitalba* on the Isle of Wight (photo: N. Maczey)

Xylocleptes bispinus collected on the Isle of Wight (photo: N. Maczey)

host-range testing of *Xylocleptes bispinus* for the control of old man's beard, *Clematis vitalba*

Old man's beard (*Clematis vitalba*) was introduced into New Zealand as an ornamental in gardens and parks sometime before 1922. In its introduced range it often forms extensive vigorous thickets that threaten native biodiversity. In New Zealand it is a particular threat to remnants of native forests, where it can kill even mature trees through its sheer weight and by shading out the vegetation.

During preliminary surveys and host-range testing experiments, the bark beetle *Xylocleptes bispinus*, native to large parts of Europe, emerged as a promising agent for biological control of old man's beard in New Zealand. However, tests regarding its host specificity conducted under laboratory conditions are so far inconclusive.

In an experiment aiming to collect more detailed information about its host specificity, Landcare Research, New Zealand, in collaboration with CABI and the Ventnor Botanical Gardens on the Isle of Wight, is currently exposing *Clematis* species native to New Zealand under semi-natural conditions to naturally occurring populations of the bark beetle. The Isle of Wight was specifically chosen as a suitable UK location for this experiment as a number of the test species from New Zealand are only semi-hardy and the largely frost-free environment of the Isle of Wight will support the development of healthy mature specimens.

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RINSE: reducing the impact of invasive non-native species in Europe

The RINSE (Reducing the impact of invasive non-native species in Europe) project is funded by the EU Interreg IVA 2 Seas programme and aims to raise awareness of invasive species and demonstrate effective techniques for their management. The RINSE region includes coastal areas of England, France, Belgium and the Netherlands. CABI is working alongside project partners, providing invasive species expertise for several activities.

Our main input comes under the project's Work Package 3, which aims to inform best practice through a series of invasive species management trials. CABI is conducting demonstrations of the efficacy of the azolla weevil, *Stenopelmus rufinasus*, which can be mass reared and released to control outbreaks of the invasive aquatic weed *Azolla filiculoides*. The azolla weevil has proven a highly successful biocontrol agent in South Africa since its release in 1997 and has more recently been successfully deployed in the UK (see p.23).

Both the weed and the weevil are naturalized in western Europe, including the RINSE region, so this study aims to demonstrate the potential of weed biological control in Europe using an already-established agent against a widespread weed. Clarification of the regulatory framework and permission for operating in each RINSE country have been secured, and field surveys are now being carried out to locate and identify weevil populations in each RINSE country with the aim of mass rearing separate cultures of weevils from material collected in each country. This means that future releases on *Azolla* sites can be made of weevils reared from parent stock that was collected in-country.

To assist with field studies and to educate RINSE collaborators on the theory and application of biological control, CABI hosted a successful training workshop in April 2013 attended by representatives from all RINSE partner organizations.

This project, utilizing a highly effective, off-the-shelf biocontrol agent already resident in the RINSE countries, is a first step in demonstrating the potential of weed biological control in mainland Europe.

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Funded by the EU.

The CABI training workshop (photo: C. Pratt)

Dave Moore and Suzy Wood recording in the field, south Devon (photo: A. Brook)

Lenient grazing of agricultural grassland: promoting in-field structural heterogeneity, invertebrates and bird foraging

This project (BD5206 and BD5207) was an extension of a previous project, BD1454 (2006–2009). The main aim of the projects was to enhance vegetation structure and the availability of invertebrate food to support populations of priority farmland birds (buntings, finches and skylarks). In 2010, grassland fields were selected in southwest England with the specific objectives of: (i) assessing the biodiversity benefits and agronomic costs of continuous and intermittent lenient cattle grazing of agricultural grassland, and (ii) recommending lenient grazing options suitable for inclusion in Natural England's Entry Level agri-environment schemes. In 2013 the final report came to the main conclusions summarized below.

- Lenient grazing was associated with changes in structural heterogeneity, increasing the number of short and tall patches. However, over time short patches declined and there was an increase in dominance by grasses such as Yorkshire fog, and also reduced clover cover.
- Lenient grazing doubled the densities of bird-food invertebrate taxa. However, over the course of the project invertebrate numbers as a whole declined, resulting in no clear benefit between grazing regimes in the last year that data were gathered (2012). Forb- and grass-feeding invertebrates (chrysomelid beetles and Auchenorrhyncha) were the main beneficiaries of lenient grazing.
- Lenient grazing increased the frequency of foraging visits by buntings and skylarks, but only skylarks responded behaviourally to higher invertebrate densities, selecting paddocks with higher densities of large-bodied invertebrates (caterpillars and Orthoptera).
- Weather had a strong influence on the results (2010 and 2011 were dry and 2012 was very wet). Because 2012 was so wet, grass growth was pronounced, particularly in the control fields where it more closely resembled that of the lenient grazed treatments than of control fields in previous years.
- The seven years of combined data from the two studies showed that high rainfall generally depressed grassland invertebrate populations (particularly Coleoptera and Auchenorrhyncha) and this masked any benefits of lenient grazing in 2012.
- Economic costs of lenient grazing measures instituted in the second study were substantially lower than those from the first study, but because of the highly variable weather it was not possible to assess whether yields fell with time.

Norbert Maczey prepares for field work in south Devon (photo: A. Brook)

Based on the results from this second study, the project consortium made a recommendation to Natural England and Defra which met the study objectives: enhancing the utility of grass swards to foraging birds (particularly buntings) and reducing costs relative to measures recommended previously at the end of the first study (BD1454).

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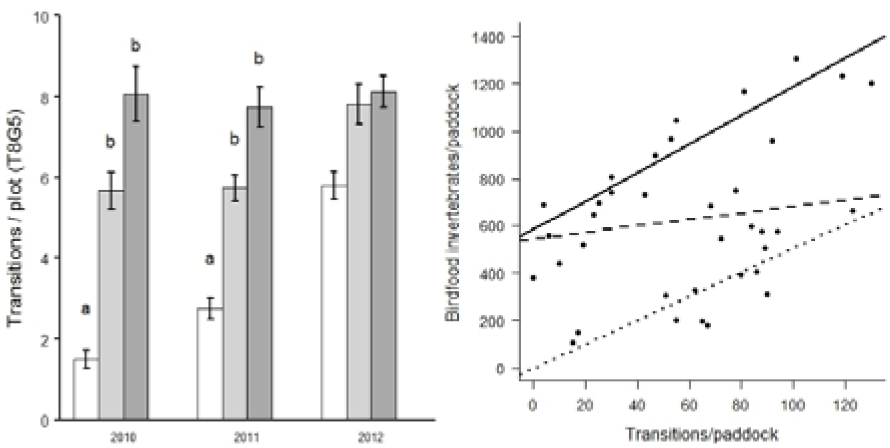
Potential bird food in a field in south Devon (photo: A. Brook)



Left: treatment effects on sward structural heterogeneity ('transitions') in July 2010–2012. White, light grey and dark grey bars indicate means (± 1 SE) for control, intermittent lenient and continuous lenient treatments, respectively. Letters indicate significant ($P < 0.05$) within-year differences between treatments in post-hoc tests. Right: the relationship between sward structural heterogeneity ('transitions/paddock') and total birdfood invertebrates (per paddock). Solid, dashed and dotted lines indicate the relationships for 2010, 2011 and 2012, respectively. The relationship for 2011 was not significant ($P = 0.370$).

reducing the vulnerability of livelihoods and biodiversity to invasive plants in Nepal

Invasive alien plants affect many national parks in Nepal and the problem is escalating. In particular, during the last 10–15 years, they have become a critical issue in the grassland–forest ecosystems of Chitwan National Park, which is located in southern Nepal. Here the South American species *Mikania micrantha* (mikania) and *Chromolaena odorata* currently dominate; the former in wetter grassland areas and the latter in drier areas. The extensive natural sal (*Shorea robusta*) forests and buffer-zone community forests used by local people are also affected by both species. As a result, the harvesting efficiency of natural resources (e.g. fuel wood, fodder) by local communities has been reduced. In addition, invasive alien plants have had a negative impact on large herbivores of conservation significance such as the one-horned rhinoceros (*Rhinoceros unicornis*). Previous studies strongly suggest that these plant invasions are being greatly exacerbated by human factors such as inadvertent spread through cutting and harvesting and through the now extensive burning of Chitwan National Park each year for grass regeneration; the invasive plants are fire-adapted and fare better under regular and intense burning regimes.

This project, which started in late 2012 and is managed by the Zoological Society of London (ZSL), UK, is scientifically assessing the efficacy of low-technology cultural and mechanical controls. These include reduced burning regimes, and improved cutting, uprooting and dispersal methods; cutting is the main method used by local people to control invasive alien plants. Early in 2013, the local partners in the project, the National Trust for Nature Conservation (NTNC) and the Department of National Parks and Wildlife Conservation, with scientific advice and support from CABI's Sean Murphy and ZSL, established replicated experimental plots in the core area of Chitwan National Park to measure the effects of various treatments comprising reduced burning and the cutting/uprooting of mikania on the frequency of native indicator plants and invasive alien plants in the plots. The first assessment of the plots was made in March, with a follow-up assessment in September. It is anticipated that the effects of the treatments on the plant communities within the plots will not be detected until after a year or so.

More general permanent 25-km^2 sampling plots have been set up in the core area of the park to allow the monitoring of changes in invasive alien plant distribution and abundance.

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Experimental plot for the mikania management trials (photo: B.R. Lamichhane, NTNC)

Fire break between experimental plots (photo: B.R. Lamichhane, NTNC)

Counting indicator plants in a quadrat placed at random within one of the plots (photo: B.R. Lamichhane, NTNC)

host-range testing of two tachinid flies for earwig control in the Falklands

European earwigs (*Forficula auricularia*) are a nuisance pest in Port Stanley (photo: N. Maczey)

The European earwig (*Forficula auricularia*) was only recently introduced to the Falkland Islands but has rapidly become a considerable domestic and public nuisance, especially around Port Stanley and Mount Pleasant Airport. The earwigs are causing significant problems for local horticulture by decimating many garden vegetable crops. This population explosion is due to the absence of natural enemies that would normally keep them under control. In contrast, earwigs in the UK are attacked by many generalist predators including spiders, beetles, frogs, toads and also specific parasitic insects (or parasitoids).

To try and find a solution to this problem, CABI is investigating the potential for controlling the earwigs using CBC. This decision came after a workshop held in Port Stanley in 2012, where the European earwig was identified as a well-suited target for this type of control. We are focusing on using two parasitic fly species, *Triarthria setipennis* and *Ocytata pallipes*, which are both believed to be highly specialized and to attack earwigs exclusively. To bring these parasitoids into culture, CABI scientists have been trapping earwigs in a number of orchards throughout England. By placing the traps in fruit trees, the team were able to collect more than 20,000 earwigs during 2013. Back in the laboratory, they collected parasitoids as they emerged from parasitized earwigs, and used them to establish breeding cultures at CABI, thus providing the material for host-range tests.

Eggs of *Ocytata pallipes* on a piece of carrot previously exposed to earwigs (photo: N. Maczey)

The host specificity of both parasitoids is relatively unknown and to date no risk assessments or laboratory host-range studies have been conducted. CABI is therefore conducting a host-range testing programme with them, although the absence of native Dermaptera from the Falklands and near islands means testing can be restricted to related insects with a similar ecology to earwigs. Currently, crickets and cockroaches are being tested for their susceptibility to attack by the potential control agents.

So far, more than a thousand parasitoids have been bred in CABI's cultures. Some of these are being used for host-range testing, while the remainder are being stored in a dormant phase, ready to be used for mass rearing flies for release on the Falklands Islands if and when host-range testing is finalized successfully.

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Funded by the Falkland Islands Government.

Houses in Port Stanley, the centre of the earwig infestation on the Falkland Islands (photo: N. Maczey)

The tachinid fly *Ocytata pallipes*, a promising control agent for the European earwig on the Falklands (photo: N. Maczey)

introduction

The goal of the Commodities theme aims to enable smallholder commodity producers (especially those in coffee, cocoa, oil palm, cotton and high-value horticulture) to be better able to compete in global markets and improve their livelihoods. Specifically, we aim to:

1. Promote sustainable production methods, especially raising productivity.
2. Improve post-harvest processing and market access for producers to earn better incomes.
3. Improve capacity building through knowledge dissemination.

Projects conducted by CABI's staff based in the UK fit within these priority areas, with much of our work being conducted in collaboration with CABI's other centres.

Under sustainable production methods, our staff work on reducing pest constraints in coffee, e.g. coffee green scales (*Coccus* spp.; CGS). By the end of 2013, collection of data had been completed in one of two coffee projects funded by ACIAR and preliminary analysis suggested that coffee tree flowering and the number of cherry-bearing nodes are negatively associated with increased levels of CGS, thus allowing impact on yield to be measured. Data collection will continue until mid-2014 when final analyses will be conducted. The second ACIAR-funded project, on coffee berry borer (*Hypothenemus hampei*; CBB), conducted in PNG and Indonesia, has been implementing awareness, surveillance, IPM and training to manage the pest, as well as capacity building in quarantine, early detection and emergency response. The final meeting for the project was held in Java in April 2013 and a new proposal will be developed to continue this work. A further coffee project being implemented by staff based at Egham is part of a public–private partnership with the Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (BMZ) in Germany, the Sustainable Trade Initiative (IDH) in the Netherlands, and several coffee companies. The project aims to develop practical tools to help farmers adapt to climate change. Two studies on climatic histories (in parts of Brazil and Vietnam) were produced in 2013 with detailed information on how climate has changed in coffee producing zones over the last 30 years.

In addition to our coffee work, we continue to provide third-country quarantine for oil palm materials being transported from West Africa to Southeast Asia. Pollen is now being screened to detect *Fusarium oxysporum*, and in further work on palms, a project on the management of red palm mite (*Raoiella indica*; RPM) continued in 2013. This mite has devastated coconut production in the Caribbean and beyond. This year, surveys were conducted to assess the impacts of RPM on native palms in Trinidad in the dry season and we are also investigating biological control of the mite. In East Africa, the CABI Development Fund helped our biological control expertise to develop a larger project to enhance infection rates of an entomopathogenic fungus against sugarcane white grubs, which are a serious constraint to sugarcane production. Another CABI Development Fund project sought to enhance sustainable production of large cardamom (*Amomum subulatum*) in Asia. For many rural communities in Bhutan, Nepal and Sikkim, this cash crop is their only source of income. However, yields are declining rapidly owing to poor farming practices plus the emergence of new diseases. In 2013, CABI assessed the current crisis and developed a concept to understand more about the causes of the decline and to develop farmer training methods. Also as part of priority area 1, CABI led an EU-funded project to investigate the impacts on farmer livelihoods and the environment of growing jatropha (*Jatropha curcas*) on land previously used for other purposes. The project ended in 2013 with the overall conclusion that jatropha has potential to contribute to sustainable rural development but is not currently sufficiently productive and profitable to play that role.

Under priority area 2, we have continued our research on *Beauveria bassiana* as a control measure for stored product pests in the UK and Europe and have also started to adapt the technology to Africa. Using Bill and Melinda Gates Foundation (BMGF) funding, we have shown that our product is effective at killing the larger grain borer (*Prostephanus truncatus*; LGB), which is the main cause of losses in stored maize in sub-Saharan Africa, as well as the maize weevil (*Sitophilus zeamais*), the second most damaging storage pest. Another new project under priority 2 involves improving the quality and knowledge of food safety in different stakeholder groups along the cocoa supply chain in Malaysia and Indonesia. A project inception meeting was held in Kuala Lumpur in November 2013, and training of master facilitators will begin in Malaysia in 2014 in conjunction with the Malaysian Cocoa Board (MCB).

With regard to priority 3, our capacity building activities in cocoa have been expanded in the Pacific with ACIAR funding, which has enabled us to help rehabilitate cocoa production in Vanuatu. During 2013, training visits were made to more farmer groups including groups in southern Malekula and Efate, where field demonstrations were used to demonstrate rat and disease management.

Julie Flood, Senior Global Director, Commodities

Aerial view of an oil palm plantation (photo: B.J. Ritchie)

helping to protect oil palm production in Southeast Asia and the Pacific

For more than four decades, CABI has been a centre for intermediate quarantine of oil palm in the UK for organizations in Southeast Asia. Until 2011, this involved detection of the wilt fungus *Fusarium oxysporum* f. sp. *elaeidis* in oil palm seed, which was how germplasm was traditionally moved between countries. Nowadays, however, pollen is also being used as a germplasm source, and in 2012 CABI developed and introduced a new technique to allow detection of the disease in pollen. This technique has been used successfully on pollen in 2013 to determine whether *F. oxysporum* is present.

Oil palm production is a multi-billion dollar industry in Malaysia, Indonesia and PNG. The crop is grown not only in large plantations but also by smallholder farmers for whom it is a major source of cash income. Worldwide, palm oil is used extensively in the manufacture of soaps and detergents as well as in the food and cosmetic industries. *Fusarium* wilt disease is present in West Africa and some parts of South America and can cause considerable yield loss if not managed. It is not present in Southeast Asia and the Pacific but could cause significant losses to the industry if it reached the region.

For many decades, oil palm breeders have sought to improve productivity from each individual palm and to breed for various agronomic characteristics, such as a dwarf growth habit to make harvesting easier and more efficient. Equally, improving oil yield from the fruit bunches increases palm oil production and more can be produced from existing plantings. Moving germplasm in the form of seeds is a bulky and expensive operation, which underlies the preference for pollen germplasm sources by some organizations. Although transmission of *Fusarium* wilt fungus by pollen is not a common occurrence, testing still needs to be undertaken as a quarantine precaution. CABI's molecular method for detecting the wilt fungus in oil palm pollen allows this to be done. Unlike seeds, there is no method for treating pollen, so contaminated pollen accessions are disposed of in the UK to minimize the risk of infected germplasm materials entering Southeast Asian oil palm production systems.

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control of stored product pests using the entomopathogenic fungus *Beauveria bassiana*

Control options in UK grainstores have become increasingly restricted over recent years with the onset of insecticide resistance and the withdrawal of approval of use of certain insecticidal compounds at the EU level. In 2008, just under 29 million tonnes of cereals were stored in UK farm and commercial grain stores; to these approximately seven tonnes of pesticides were applied as fabric treatments to control a complex of insect pests which infest the grain. The development of new control methods is vital to reduce the use of potentially harmful chemicals and to give options within IPM systems.

Entomopathogenic fungi such as *Beauveria bassiana* provide one option for use against these grainstore pests. Several strains of *B. bassiana* were isolated from pests within UK grainstores during previous projects, and one was selected for development as a potential control option based on both its efficacy against target pests and its capability for producing large numbers of high-quality conidia during mass production, which may be stored without losing viability over a prolonged period of time. Building on the success of these previous projects, in October 2010, CABI received further funding from the UK's Technology Strategy Board (TSB) as part of a larger consortium (with Exosect Ltd, Fera, Sylvan Bio and Check Services) to make further improvements to the formulation and application of *B. bassiana* and to generate data to support the registration of a product suitable for treatment of grainstores across the EU.

Assessing product deposition during a field trial in a grainstore (photo: E. Thompson)

In 2013, we worked with the consortium to run two more full-scale field trials within grain silos to provide more information on the efficacy of the formulation developed during the project. New application equipment was adopted for the trials this year, and CABI scientists were responsible for assessing application methods and ensuring that the correct dose was applied. Product viability was assessed over time and the reliability of a qPCR (quantitative polymerase chain reaction) method for examining the transfer of formulation onto grain was tested. Trials again gave extremely promising results, with more than 90% mortality within 14 days of the saw-toothed grain beetle, *Oryzaephilus surinamensis*, and the rusty grain beetle, *Cryptolestes ferrugineus*, attributed to the formulation. In addition to trial work, CABI continued to investigate the storage of the formulated compared with unformulated conidia, and ran experiments to assess the ideal moisture content at which conidia should be stored. Quality control methods were also assessed and new protocols were developed for the formulated conidia.

Grain damaged by stored product pests (photo: B. Taylor)

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Sponsored by: TSB, UK.

feeding more by wasting less

Following on from the successful project, 'Control of stored product pests using the entomopathogenic fungus *Beauveria bassiana*' based in the UK (see p.33), in 2013 BMGF funded our consortium to trial this technology in sub-Saharan Africa for control of LGB (*Prostephanus truncatus*) in maize.

Maize accounts for 25% of staple starch consumption in Africa, representing the largest single source of calories for the population (36% of daily calorific intake). Subsistence farmers are particularly affected by LGB as a high proportion of their disposable income and agricultural output is devoted to staple food production and storage. Significant losses in the food supply chain take place during post-harvest handling and storage, with LGB the most significant pest of stored maize. Protecting food from post-harvest losses is a critical issue in addressing the challenges of food security.

The aim of this project is to take our *Beauveria bassiana* product, which has been shown to be effective in the UK, and adapt the technology in Africa. Working through CABI's centres in Kenya (for work in Tanzania) and Ghana, we obtained import and experimental use permits to test the *B. bassiana* product in both Tanzania and Ghana. Prior to any practical work, we held successful in-country workshops attended by staff of local institutes and government bodies relevant to biopesticide registration. CABI also carried out in-country training courses to pass on the basic and specialist insect pathology skills required for the project.

Early results indicate that our *B. bassiana* product is effective in killing LGB and also the maize weevil (*Sitophilus zeamais*), the second most damaging storage pest in sub-Saharan Africa. However, infectivity to the introduced predator *Teretrius nigrescens* is very low. We plan to carry out further laboratory and semi-field trials in 2014.

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Funded by BMGF.

Participants of the 'Feeding More by Wasting Less' workshop, Accra, Ghana, April 2013 (photo: A. Koomson)

rehabilitating cocoa for improving livelihoods in the South Pacific

A decade of low world cocoa prices led smallholder farmers in South Pacific island nations to neglect their cocoa trees, which has resulted in a decline in cocoa production. However, with market prices forecast to rise during the next decade, the time is ripe for a significant rehabilitation effort in the South Pacific. The emergence of higher-value certified organic or single-origin cocoa markets provides an additional incentive for farmers to intensify management and improve production as they possess fine-flavour varieties of cocoa and benefit from favourable climatic conditions for producing premium cocoa.

Cocoa production in Vanuatu is currently constrained by pests and diseases. Black pod disease (*Phytophthora palmivora*) and damage caused by rats are two major problems. Cocoa production could be significantly increased through integrated pest and disease management (IPDM), while cocoa bean quality could be enhanced through improved drying and fermentation processes.

Since 2011, CABI and Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) have carried out IPDM training with several farmer groups on two islands, Epi and the northern part of Malekula. Owing to the success of this training, news has spread through lead farmers to more remote cocoa growing areas. In 2013, two new groups in southern Malekula and one in northern Efate were visited by CABI's scientists who provided training on cocoa IPDM. Field demonstrations were held on black pod disease and rat management, and the advantages of good pruning techniques to remove dead branches and diseased pods were explained and encouraged, because reducing the overall height of the trees increases sunlight and airflow in the cocoa tree canopy.

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Healthy cocoa pods (photo: S.E. Thomas)

Cocoa farmers in South West Bay, Malekula (photo: S.E. Thomas)

A chocolate bar produced in Vanuatu (photo: S.E. Thomas)

Cocoa bean drier at Lorlow in South West Bay, Malekula (photo: S.E. Thomas)

coffee green scales in Papua New Guinea: highland arabica coffee and yield loss

Group of smallholders in Jiwaka Province (photo: A. Brook)

PNG's smallholders grow coffee as one of their cash crops, which accounts for approximately 88% of the country's coffee production and the foreign exchange income from it is the second largest in the agricultural sector at approximately 5% of GDP. Currently CGS, a complex of two scale insect species (*Coccus* spp.), is described as the most serious pest. Although much is known about CGS in other countries and from studies in PNG, little is known about yield loss in the context of the highland smallholders of PNG. There is a need to understand the impact of CGS on smallholder yield and its economic consequences.

In this project we aim to capture information from multiple sources, i.e. smallholders, larger growers/processors and experiments, to try and obtain estimates of both yield and yield loss due to CGS. The project has developed relations with smallholders, larger-scale coffee farmers and processors, and established research station field experiments. Ecological and socio-economic survey methods are being employed at smallholder farms in Eastern Highlands Province. The impact of CGS on yield will be estimated as part of overall yield loss, and also by comparing smallholder farms with and without CGS.

CGS-infested coffee leaf and coffee diseases in PNG: clockwise from top left: CGS, sooty mould, coffee leaf rust and pink disease (photo: A. Brook)

By the end of 2013 the collection of the first year's data from smallholder and experimental farms had been completed. Preliminary analysis suggests that coffee tree flowering and the number of cherries are negatively associated with increasing levels of CGS. This emerging trend suggests that a link can be found that will allow the impact of CGS on yield to be estimated, and therefore estimates of yield loss to be produced. The collection of data for the second coffee growing season was started in the last quarter of 2013 and will continue until mid-2014.

The team also conducted the first round of spot-surveys on smallholder farms in Eastern Highlands, Western Highlands, Jiwaka and Simbu provinces to gather data in order to estimate the economic impact of CGS across the provinces. This involved visiting over 60 smallholders, and travelling many thousands of kilometres over mountainous terrain and countless bridges. As well as CGS, coffee diseases were recorded (e.g. pink disease and coffee leaf rust). The farms were mapped using GPS, and other factors such as altitude, total number of trees, soil type, shade level and age of trees were recorded. The survey will be repeated in 2014 to take account of seasonal variation.

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Crossing a bridge in PNG (photo: A. Brook)

Mountainous terrain makes for spectacular scenery in Simbu Province (photo: A. Brook)

Google Earth™ map showing spot-surveyed smallholder farms in PNG

incursion prevention and management of coffee berry borer in Papua New Guinea and Indonesia's South Sulawesi and Papua provinces

This ACIAR-funded project was set up to address the problem of CBB (*Hypothenemus hampei*) in Indonesia and Papua New Guinea. CBB is a very serious pest of coffee worldwide, causing premature fruit-fall and reduced bean weight and quality. It is present in Indonesia's South Sulawesi and Papua provinces where it is causing an annual production loss of 15–20% and it also threatens PNG because it has been confirmed at sites in Indonesia's Papua Province close to the border with PNG. Most coffee in these regions is produced by smallholders, so CBB is a particular threat to the livelihoods of these farmers. The project has been implementing awareness, surveillance, IPM and training to control CBB, and capacity building in quarantine, early detection and emergency responses.

The year 2013 marked the end of the project and a final meeting involving all project partners was held on 3–6 April at ICCRI in Jember, Java. Project representatives included senior staff from CIC and the National Agricultural Quarantine Inspection Authority (NAQIA) in PNG, senior staff from ICCRI and the Directorate of Estates Crops Protection, Ministry of Agriculture in Indonesia, and CABI staff based at our centres in Southeast Asia, Africa and the UK. The ACIAR Programme Manager and two independent project reviewers also attended the meeting.

Presentations were given on the main activities, experiences, outputs and outcomes of the project. Examples of highlights in the presentations included: the success of farmer field schools for delivering IPM in Indonesia, where farmers have benefited from using new methods such as stripping out-of-season coffee and deploying traps; the establishment of a national surveillance scheme for PNG; the increased awareness of stakeholders across the region (farmers, extension, policy makers, etc.) as a result of information material produced by the project; and policy support from the governments of PNG and Indonesia to address the threat of CBB to the economies of the two countries.

The meeting concluded with a visit to a local coffee growing area to meet and talk to farmers, and a visit to see ICCRI's facilities.

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Field visit to a coffee farm in Bondowoso where the farmer is under the supervision of ICCRI (photo: S.S. Soetikno)

Participants from the project meeting with members of a coffee farmers' cooperative in Bondowoso (photo: S.S. Soetikno)

Participants of the ACIAR CBB end of project meeting being shown the mass-production facilities for coffee somatic embryos at ICCRI in Jember (photo: S.S. Soetikno)

Participants of the ACIAR CBB end of project meeting in Java (photo: S.S. Soetikno)

Coconut palms adjacent to the Nariva Swamp in Trinidad displaying signs of red palm mite infestation (photo: B. Taylor)

red palm mite and associated natural enemies on coconut and native palms of the Nariva Swamp, Trinidad

Raoiella indica or RPM is an invasive mite first reported from the New World in 2004 in Martinique. It has since spread through the Caribbean and south Florida and has now been detected in several countries in South and Central America. The mite feeds through stomata on the underside of leaves of selected plants found within the orders Arecales and Zingiberales, with the most economically important hosts being coconut (*Cocos nucifera*) and banana (*Musa* spp.). Populations of up to c. 7000 mites per leaflet on coconut have been reported in Trinidad and severe infestations may cause extensive yellowing of leaflets and a reduction in transpiration efficiency of host plants.

A project to assess the impact of this invasive mite on native palms in the protected Nariva Swamp in Trinidad was initiated in 2012 as part of the Global Environment Facility (GEF) funded 'Mitigating the threats of invasive alien species in the insular Caribbean' programme with co-financing from the Government of Trinidad and Tobago Ministry of Food Production. The objectives were to design and implement a sampling programme to estimate RPM population densities on coconuts and native palms, in addition to identifying and estimating densities of native entomopathogenic fungi and natural enemies associated with RPM, in the swamp during one wet and one dry season. An additional objective was to screen native and exotic pathogens from the CABI Genetic Resources Collection (GRC) against RPM to find isolates with the potential to be developed as a biopesticide.

Behind these trees in the Nariva Swamp, sunlight highlights the yellowed leaflets of coconut palms – a sign of red palm mite infestations (photo: B. Taylor)

Surveys were conducted in April 2013, with support from the Forestry Division, Ministry of the Environment and Water Resources, to assess the impacts of RPM on coconut and native palms in the dry season, based on the protocols developed for the 2012 wet season surveys. RPM populations were found to be much higher in this season compared to the wet season on coconut palms, with *Amblyseius largoensis* the predator most frequently associated with RPM on this palm. In addition, RPM was found established in breeding colonies on moriche palms (*Mauritia flexuosa*) in the protected 'Bush Bush' area of the Nariva Swamp, also with higher population densities than in the wet season. No RPM were found on the other palms surveyed (royal palm, *Roystonea oleracea*; manac palm, *Euterpe oleracea;* cocorite palm, *Attalea maripa*). *Amblyseius largoensis* was not found on palms other than coconut in the swamp, but other species of phytoseiid mites not previously reported in association with RPM were found on several occasions with this mite on moriche palms, and these warrant further study as there was evidence that they responded numerically to RPM populations.

Isolates from the GRC and one *Hirsutella* sp. found on tetranychid mite populations in the Nariva Swamp were tested for efficacy against RPM in laboratory based bioassays. Mixed results were obtained but one isolate showed promising results and merits further research.

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Red palm mite viewed down a microscope

Sampling red palm mite on moriche palm in the Nariva Swamp in Trinidad (photo: B. Taylor)

addressing the cardamom crisis in the eastern Himalayas

Large cardamom (*Amomum subulatum*), the most important cash crop for many communities throughout the Himalayas, is progressively coming under threat from devastating diseases and unsustainable production. Many rural communities in Bhutan, Nepal and Sikkim grow the native large cardamom as their major and often only source of income. Increasingly, more communities in the region are depending on this crop because mandarin (*Citrus reticulata*), the only other important cash crop, is in rapid decline after widespread devastation due to citrus greening disease. Traditionally, large cardamom is grown in a form of agroforestry, an arrangement that preserves high levels of biodiversity and provides protection from soil erosion and landslides on steep slopes.

A combination of bad farming practices and the emergence of as yet unidentified diseases threatens the sustainability of cardamom agroforestry throughout the eastern Himalayas. Yields have declined significantly and, despite rising market prices, exports have significantly lost real value. Although some new management practices have been developed, the improved cultivation methods have not been adequately implemented. A number of diseases have been problematic for cardamom production for some time but, more recently, a new disease, sometimes referred to as 'cardamom blight' has accelerated the decline of cardamom in a dramatic way. *Colletotrichum gloeosporioides* has been tentatively identified as the causal agent of the blight, but other pathogens are likely to be involved and the full picture requires elucidating.

A number of other parameters are crucial for successful and sustainable cardamom farming, such as the right amount of shading, fertilizer and irrigation. Field trials to determine the best farming practices covering these factors are urgently needed. In addition, the impact of climate change is becoming increasingly pronounced and it is anticipated that the altitudinal belt suitable for cardamom growing will shift to higher altitudes, where less suitable land is available. Any efforts towards a more sustainable production system need to take long-term climatic forecasting into account and aim for more climate-proof production.

During 2013 CABI has used its own resources (the CABI Development Fund) to assess the current crisis and estimate the scope for improved and more sustainable production of large cardamom. In collaboration with local stakeholders in Bhutan and Sikkim and backed up through interviews with smallholder farmers, we developed a strategy for addressing the crisis through a combination of urgently needed scientific research and farmer participatory education. This includes closing remaining knowledge gaps with regards to the identity, ecology and life cycle of diseases. It is considered likely that once the problem is fully understood, modifications to farming practices will reduce or prevent devastation by the pathogen. However, once improved farming methods have successfully been trialled, they need to be implemented, which will require extensive efforts in knowledge dissemination and farmer training. Consortia involving major stakeholders in Bhutan and Sikkim have been established and funding opportunities for further work are currently being explored.

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Freshly harvested large cardamom in Sikkim (photo: N. Maczey)

Pods of large cardamom (photo: N. Maczey)

Monitoring a preliminary cardamom trial at Darla in Bhutan (photo: N. Maczey)

Diseased cardamom plantation near Rabongla in Sikkim (photo: N. Maczey)

Ophiocordyceps barnesii growing on sugarcane white grubs (photo: N. Maczey)

controlling white grub in sugarcane in East Africa

Sugarcane is a widely grown and important crop in Tanzania and Kenya, bringing much needed income to smallholder farmers and helping support the countries' economies. The grubs of chafer beetles (Scarabaeidae) seriously constrain sugarcane production and frequently cause severe yield losses. One way of controlling these beetles is by releasing the entomopathogenic fungus *Ophiocordyceps barnesii* as a biological control agent. The fungus infects the last larval stage of the beetle and kills the pest before it develops into an adult.

Recognizing the beneficial role that *O. barnesii* plays in pest control, some farmers collect the fruiting bodies of the fungus and scatter them on their sugarcane fields to help protect their crop. However, little is known about the efficacy of such traditional methods. So far, there has been no systematic exploitation of the fungus as a natural enemy, nor has any research been conducted on application methods. Owing to the nature of its life cycle, *O. barnesii* is very probably not suitable for inundative, large-scale application of fungal spores. However, we believe we can help boost naturally occurring infection through careful crop management, which will reduce yield losses. We used the CABI Development Fund to support the development of a new research project to examine the possibility of artificially enhancing infection rates of sugarcane white grubs. At present, little is known about the host range of the fungus or pathways of infection. It is likely that factors such as timing of cropping, rotational cropping, irrigation and weed management have a major effect on infection rates. Better knowledge of the underlying biology would allow adjustments to crop management practices, which would boost biological control by *O. barnesii.*

White grub damage in sugarcane at Moshi in Tanzania (photo: N. Maczey)

During 2013, we conducted a literature review and identified potential collaborators in Tanzania and Kenya. We also identified suitable sugarcane plantations in these countries and visited them during a field survey in June 2013. In contrast to Kenya, where the majority of sugarcane is produced by smallholder farmers, production of sugar in Tanzania is dominated by just four large estates. We therefore currently see more scope in advancing our work on *O. barnesii* in Kenya, where the mandate for relevant research is much larger owing to the high percentage of cane grown by smallholder farmers. Based on discussions with scientists from the Kenya Sugar Research Foundation (KESREF) and the Kenya Agricultural Research Institute (KARI) at meetings in Kibos near Kisumu in Western Kenya, options for further joint collaboration on this issue are currently being explored.

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Funded by the CABI Development Fund.

Surveying for sugarcane white grubs at Mtibwa in Tanzania (photo: N. Maczey)

Sugarcane growing in the foothills of Mount Kilimanjaro (photo: N. Maczey)

adapting to climate change

The Coffee & Climate Initiative (www.coffeeandclimate.org) is a public–private partnership funded by the BMZ programme develoPPP, the Swedish International Cooperation Development Agency (SIDA), the IDH Sustainable Coffee Partnership and a number of coffee companies including Tchibo, Lavazza, Tim Hortons and Paulig. CABI, along with Hanns R. Neumann Stiftung and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), is implementing the project. The objective is to provide smallholder farmers with very practical tools to help them adapt to climate change.

CABI's specific tasks for 2013 were to evaluate how climate change is affecting coffee production in the Mbeya region of Tanzania; advise on pilot adaptation activities in farmers' fields in the four project zones of Minas Gerais (Brazil), Trifinio (Central America), Central Highlands (Vietnam) and Tanzania; coordinate scientific studies to validate tools and a strategic approach; and develop promotional and planning activities for a phase two of the initiative.

In Tanzania the evaluation involved a triangulation process whereby field data were collected from farmers and extension workers and then compared with available meteorological data and scientific studies. Coffee plots visited were characterized by a very wide range of production problems, including disease, lack of funds for inputs and climate-related influences. It proved difficult to establish the relative importance of these various factors, but very clearly coffee farming in a substantial proportion of the zone must be regarded as marginal, with annual rainfall of around 850 mm, a long and intense dry season, and a late and sometimes stuttering start to the wet season. In 2013 there was widespread flower abortion due to a combination of high maximum temperatures and soil moisture deficit, which will lead to very low yields for many farmers in 2014. Ongoing participatory field activities include mulching trials to increase soil cover to maintain moisture and reduce erosion, infiltration pits to encourage rainfall to soak into the soil instead of running off, as well as establishment of shade nurseries and a package of good agricultural practices.

In other project countries where pilot farm trials are more established, first results are promising, including enhanced survival of out-planted seedlings and improved soil moisture retention under mulch and ground cover plants. In Central America the severe outbreak of coffee leaf rust (*Hemileia vastatrix*) has led to a number of emergency measures including trials with low-cost protective sprays for farmers unable to afford commercial products.

Two studies on the recent climatic histories of Minas Gerais (Brazil) and Central Highlands (Vietnam) were produced for the project in 2013 and give detailed information on how the climate has changed over the past 30 years in these intensive coffee producing zones.

A common experience of this initiative, which had planned to develop long-term adaptive tools for farmers, is that climate-related problems are in reality more severe and pressing than had been imagined. This has led to more emphasis on short-term coping activities to address these emergencies.

CABI: **P. Baker** (p.baker@cabi.org), in collaboration with Hanns R. Neumann Stiftung and GIZ. Funded by BMZ's develoPPP programme, SIDA, IDH and the following European coffee companies: Gustav Paulig Ltd, Joh. Johannson Kaffe AS, Löfbergs Lila AB, Neumann Gruppe GmbH, Tchibo GmbH, Fondazione Giuseppe e Pericle Lavazza, Franck Coffee (Croatia) and Tim Hortons.

Farmer in Guatemala examining coffee leaf rust (photo: P. Ruiz, Neumann Stiftung, Guatemala)

Technicians studying robusta coffee as a more climate-resilient alternative to arabica (photo: P. Ruiz, Neumann Stiftung, Guatemala)

Comparing *Trichoderma* vs mycorrhizal treatments to improve coffee seedling root systems for combatting water stress (photo: P. Ruiz, Neumann Stiftung, Guatemala)

Farmer field school group in Mbeya District, Tanzania, inspecting a new coffee variety (photo: P. Baker)


Jatropha facts

Jatropha growth and oilseed production in Africa

Policy message

assessing the impacts of the biofuel crop *Jatropha curcas*

Jatropha curcas (jatropha), a member of the Euphorbiaceae, is grown as a multi-stemmed small tree for its oil-rich seeds. They contain 27–40% oil that can be easily extracted and requires minimal processing to produce biodiesel. CABI has been the lead partner in an EU-funded project, ‘Jatrophability’, which has been investigating the impacts on farmer livelihoods and the environment of growing jatropha on land that has previously been used for other purposes. The other project partners are from Belgium, Burkina Faso, India, Mali, Mexico and Spain. The project started in June 2009 and work concluded in the first quarter of 2013. CABI staff based in the UK looked at the impacts of pathogens on *J. curcas* plant growth and fruit production, and developed management plans to control the key diseases. CABI staff based in Switzerland, in tandem, undertook a similar study for the pests.

The overall conclusion of the project is that jatropha has potential to contribute to sustainable rural development, but is currently not sufficiently productive and profitable to play that role. Current oil prices are well above the theoretical threshold predicted to make jatropha production economically viable; however, no economically viable jatropha systems are known. To minimize risks for farmers, at present jatropha should only be grown as a supplement to current farming systems, preferably as living fences or in wide intercropping systems. Reliable agricultural practices must be developed and plant breeding undertaken to provide farmers with germplasm that gives consistent and higher yields. In addition, the price for the harvested seed needs to be more competitive, which is likely to become a reality with increasing global demand for non-fossil fuel sources.

The final months of the project were devoted to ensuring results and reports were finalized, together with writing opinion papers and other publications. Scientists in the UK produced a paper on a new disease of jatropha in West Africa (caused by the pathogen *Colletotrichum truncatum*), which included a management plan for farmers. In conjunction with two other projects in the European Research Area - Agricultural Research for Development (ERA-ARD) jatropha bioenergy programme, a series of five policy briefs were produced that give research insights into important issues surrounding the crop, with particular emphasis on Africa. Each policy brief addresses a specific aspect: growth and oilseed production; potential for climate change mitigation; potential for rural energy supply; economic feasibility of biofuels; and food security implications.

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CocoaSafe: helping Southeast Asia's smallholder cocoa farmers to access markets

Ensuring smallholder cocoa production meets international regulations and legislation is essential if farmers are to access global markets. Cocoa is an important source of income for thousands of smallholder farmers in Indonesia, Malaysia and PNG, but pesticide residue build-up and the introduction of other harmful substances can occur in the field and during processing; such an event at any one of the many stages involved in the cocoa supply chain can lead to shipments being rejected, which is why the new CocoaSafe project is taking a supply chain approach to managing cocoa quality.

The CocoaSafe project, which began in late 2013, has a remit for 'capacity building and knowledge sharing in sanitary and phytosanitary measures in cocoa in South East Asia'. It aims to help people working in all parts of the cocoa supply chain ensure that cocoa is produced safely, and meets international food and plant health standards, with the goal of improving smallholders' access to global markets. CABI is leading the project, in collaboration with STDF and ICCO, and with project partners from the MCB in Malaysia, ICCRI in Indonesia, the Cocoa Coconut Institute (CCI) in PNG and Mars, Inc.

Above and below:
Breaking cocoa pods in Sumatra, Indonesia (photo: J. Flood)

The project was launched at an inception workshop held in Kuala Lumpur, Malaysia, on 27–28 November 2013, which brought representatives from CABI, FAO, ICCO, Mars, Inc. and STDF together with our in-country partners. The meeting was an opportunity to share information on the cocoa economies and current practices in the participating project countries, hear about lessons learnt from previous projects, and discuss methods to be used during the CocoaSafe project. A Project Steering Committee was set up and held its first meeting, and a workplan was initiated to detail activities planned for the initial part of the project, together with indicators to track progress.

The project will focus on improving stakeholder knowledge of food safety through the application of good agricultural practices at all points along the supply chain. In 2014, it will begin to train master facilitators, who will then promote and embed these practices throughout the cocoa value chain – from production, through to processing and export. Project staff will also be working to facilitate knowledge sharing among participating stakeholders and raise their awareness of food safety issues and how to address them through the creation of a knowledge sharing hub. The hope is that these messages will spread not only among project partners but beyond, and ultimately reach many more cocoa chain workers in the region.

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knowledge for development

introduction

Plantwise continues to be a flagship programme for CABI and delivers against the Knowledge for Development outcome related to strengthening the capacity of plant health systems to identify and respond to plant health problems. Plantwise works with local extension and crop protection services, non-governmental organizations (NGOs) and other key actors in plant health to provide smallholder farmers with better access to advisory services and at the same time provide a system of vigilance for emerging plant health problems. CABI supports countries to develop a network of plant clinics that are the starting point for developing and reinforcing the links that help create a functioning plant health system. Better communication and stakeholder linkages in the areas of extension, research, regulation and input supply enable national plant health systems to be more effective, ultimately benefiting the farmers that depend on the services they provide. The clinics are reinforced by the Plantwise Knowledge Bank that provides online and off-line resources for advisory services and a platform for plant clinic data management and use. CABI staff based in the UK are part of a global team supporting work in Africa, Asia, Latin America and the Caribbean.

In 2013 Plantwise was operating in 31 countries, with CABI's UK-based staff working closely with regional staff in 15 countries as well as contributing to coordination activities, development of training modules and materials, improving the diagnostic back-up services, and development of a validation method for Plantwise data that can be used by country partners. Also in 2013, plant doctor training modules were improved and a manual drafted, which will be published in 2014 and provided to plant doctors that complete training. UK-based staff also contribute to the programme of monitoring and evaluation – learning lessons about what works well and what does not – that feeds into further development and improvement of the Plantwise approach.

Plantwise emerged from an original concept developed by CABI staff based in the UK and partners in Latin America under the Global Plant Clinic and the UK centre continues to make essential contributions to ensuring its success.

Dannie Romney, Global Director, Knowledge for Development

Plantwise supporting the development of plant health systems

The Plantwise initiative expanded its reach in 2013, welcoming another seven countries to the fold, making a total of 31 participating countries. The length of engagement with the programme influences the activities that take place; however, for most countries the general focus was on training and mentoring, and identifying mechanisms for creating and strengthening the linkages among plant health system stakeholders. The role of CABI's UK-based staff in this process is to develop the supporting training materials for the programme and to provide assistance to CABI's country coordinators as they implement the activities.

The Plantwise training modules underwent further revision throughout the year with the development of two of new modules: 'Extension messages' and 'Data management' (for more information on these, see p.50). In order to become a plant doctor you must have completed Modules 1 and 2 training on 'How to become a plant doctor'. Throughout this training the plant doctors receive a variety of hand-outs expanding on the key points. This year, considerable effort was put into consolidating these materials into a single training manual that expands on the concepts taught and includes additional information on the biology of the organisms and how this affects their management. The training manual should be made available towards the end of 2014.

To support plant doctors with the challenging task of field diagnostics, Plantwise has been compiling a directory of diagnostic services (DODS) for each member country or region. These directories are made available through the Plantwise website and should help plant doctors to identify relevant national/regional facilities that can help when farmers bring plants with unusual symptoms to a clinic. In circumstances where there is no national or regional capacity to identify a pest or disease problem, then the problem can be referred on to the Plantwise Diagnostic and Advisory Service (DAS) based at Egham. DAS offers authoritative identifications of bacteria, nematodes and fungi and gives practical management advice. Other pest groups such as viruses, phytoplasmas and arthropod pests can also be identified through our links to partner organizations in the UK. These services are provided free-of-charge to Plantwise and member countries. Please see our website for more details and restrictions: www.plantwise.org/

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Plant doctor examines fruit samples brought into a plant clinic in southern Vietnam (photo: R. Reeder)

Ugandan plant doctor shows farmers how to identify the symptoms of cassava brown streak virus (photo: R. Reeder)

CABI scientist examines a specimen sent to the Plantwise Diagnostic and Advisory Service (photo: R. Reeder)

Plant clinic session running in a market in Atwima Nwabiagya District, Ghana (photo: J. Crozier)

supporting plant health systems in Africa, Asia and the Americas

During 2013 CABI's UK-based Plantwise support team has worked closely with the CABI country coordinators in many different countries to train new plant doctors, give diagnostic support to new and existing plant clinics and assist in developing relationships with in-country partners.

Africa

The UK support team participated in activities in five of the 12 African Plantwise countries: the Democratic Republic of the Congo (DR Congo), Ghana, Malawi, Rwanda and Uganda. During 2013, a total of 268 plant doctors were trained and 86 new clinics were established across these countries. Training in the production of extension messages resulted in the development of 59 factsheets for farmers and 38 Pest Management Decision Guides (PMDGs) written in both English and local languages. Highlights for 2013 include bringing the central government in Kinshasa on-board as the main coordinator for clinics in DR Congo. In Uganda local government and university staff participated in the first training of trainers' session. This was an important first step for the scaling-up of the plant clinic programme within the country and trainers went on to conduct three training sessions for Modules 1 and 2 for 99 students from the College of Agricultural and Environmental Services at Makerere University. Elsewhere, plant doctors and CABI staff held a demonstration clinic to raise awareness of Plantwise at the annually held National Farmers Day event in the Volta Region of Ghana.

Validating factsheets with farmers in Malawi (photo: J. Crozier)

Country	Plant doctors trained 2013	Total plant doctors trained	Plant clinics opened in 2013	Total plant clinics opened	Factsheets written	PMDGs produced
DR Congo	54	101	5	27	5	0
Ghana	28	57	14	25	0	0
Malawi	34	34	13	13	15	0
Rwanda	46	96	18	26	15	19
Uganda	106	147	36	110	24	19

Asia

During 2013 Plantwise activities supported by UK-based staff continued in Afghanistan, Bangladesh, Cambodia, Nepal, Pakistan and Vietnam. A total of 106 new plant doctors were trained across these countries and a further 49 new clinics were established. Training in extension messages resulted in the development of 132 factsheets for farmers and 94 PMDGs for use by plant doctors in the clinics. Highlights from Afghanistan were the establishment of clinics in three new provinces (Kabul, Baghlan and Parwan) and commitment from government partners to expand into other regions of the country. In Pakistan, Sheikhupura district in Punjab Province became the latest district to implement Plantwise by establishing 26 new clinics in 2013. Cambodia and Vietnam improved links for plant diagnostic support systems with the production of the first edition of their national DODS and facilitated the delivery of specimens for laboratory diagnosis. Nepal also drafted the first edition of a national DODS and formed of a multi-stakeholder consultative group that will guide Plantwise implementation.

Training data managers for Plantwise scale-up in Pakistan's Punjab Province (photo: J. Lamontagne-Godwin)

Plant doctors in Nepal pose for a group photograph after successfully completing a Plantwise training module (photo: S. Edgington)

Country	Plant doctors trained 2013	Total plant doctors trained	Plant clinics opened in 2013	Total plant clinics opened	Factsheets written	PMDGs produced
Afghanistan	33	52	13	27	18	8
Bangladesh	0	30	0	11	25	0
Cambodia	0	25	0	10	30	30
Nepal	0	71	0	18	10	0
Pakistan	51	103	26	52	25	36
Vietnam	22	42	10	20	24	20

Senior ministry official Bret Taylor (standing) assists a newly trained plant doctor in plant diagnosis at a plant clinic in St Georges, Barbados (photo: P. Taylor)

Caribbean and Latin America

UK-based staff supported CABI country coordinators in three Caribbean countries (Barbados, Grenada & Cariacou and Trinidad & Tobago). A total of 43 new plant doctors were trained and nine new clinics were established in the region. The first clinics were opened in Barbados and Grenada & Cariacou while training in how to write extension messages was carried out in each of the three countries, producing a total of 19 factsheets and nine PMDGs. The first edition of a DODS was drafted for the region including laboratory services for each of the three countries.

Country	Plant doctors trained 2013	Total plant doctors trained	Plant clinics opened in 2013	Total plant clinics opened	Factsheets written	PMDGs produced
Barbados	19	21	2	2	0	0
Grenada & Cariacou	0	15	5	5	13	0
Trinidad & Tobago	24	48	2	10	6	9

Plant doctors interviewing a farmer while researching and considering the cause of unusual symptoms on citrus leaves brought to a clinic in St Georges, Barbados (photo: P. Taylor)

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Farmer at a clinic in the vegetable market at Gujranwala, Pakistan (photo: J. Lamontagne-Godwin)

Plant doctors diagnosing plant health problems at a clinic in southern Vietnam (photo: M. Rutherford)

Training Plantwise personnel in Cambodia in best practice for collection, packaging and transfer of samples and specimens to diagnostic laboratories (photo: J. Ngim)

Plantwise diagnostic activities

Within the broader plant health system, diagnosis and provision of information and advice on plant health problems is essential to ensure that pest and disease outbreaks can be tackled appropriately, effectively and sustainably. Within Plantwise this is being achieved principally through the establishment of local plant clinics supported by laboratories and organizations that can provide diagnostic services. During 2013, CABI's UK-based staff built on the excellent progress made in 2012 by consolidating and expanding existing diagnostic activities and also by initiating a number of new activities. With their assistance, 742 in-country personnel were fully trained as plant doctors across 22 countries by the Plantwise programme as a whole, and more than 350 newly established local plant clinics were operated by plant doctors. Plant clinics provide farmers with an accessible and vital source of information and advice on their plant health problems. More than 350 new plant health problem factsheets were prepared and published to help farmers, plant doctors and others to better understand problems they are likely to be confronted with and how best these should be managed.

Efforts to identify, characterize and link plant clinics with diagnostic support services have also moved forward significantly, with the preparation and publication of first edition DODS for 18 countries across Africa, Asia and Latin America. By providing detailed information on each diagnostic service and the type of assistance they can offer, the DODS constitute an important resource for plant doctors and others seeking help within their country or beyond. Work also continued in 2013 – partly through national internships – to investigate the extent to which such services are already accessed by plant clinics and to identify factors that limit access, thereby highlighting mechanisms by which improved access may be facilitated. In parallel, efforts have continued in Southeast Asia in consultation with national Plantwise partners, diagnostic services and national plant protection organizations (NPPOs) to enhance access to diagnostic support through the establishment and development of national diagnostic networks and by linking these with regional and international diagnostic expertise. Regional expertise includes that available through the Association of Southeast Asian Nations (ASEAN) Regional Diagnostic Network (ARDN), while international assistance can be provided free of charge by Plantwise's DAS, based at CABI's centre in the UK. During 2013 DAS has undergone modification to enable provision of an improved and more efficient service. This encompassed addition of new expertise to the DAS team, improving linkages with the CABI Microbial Identification Service (MIS) and increased promotion of DAS, including through the Plantwise website. As a consequence, the number of queries and diagnoses dealt with by DAS increased markedly on preceding years.

In order to facilitate access by Plantwise countries to diagnostic services and help ensure international standards are adhered to, a Plantwise policy on the 'International transfer of biological specimens for identification' was prepared in 2013. The policy is available at: www.plantwise.org/uploads/file/Plantwise_Policy.pdf

For further information on Plantwise diagnostic activities, see the Plantwise website: www.plantwise.org/

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Farmers acquiring information on how to recognize and manage white dot disease of dragon fruit at a plant health rally in Vietnam (photo: M. Rutherford)

developing data validation protocols for the Plantwise programme

The plant clinic prescription form is an important document that captures information about a farmer and the diagnosis and recommendations given during the farmer's visit to a clinic. From this it is possible to map the frequency and distribution of pests and diseases within a country and to assess the quality of the advice being given.

The basis of any recommendation is an accurate diagnosis of the problem. The prescription form records the observed symptoms using a common set of symptom check boxes and a written description. The Plantwise validation process compares the diagnosis and symptoms against a set of standard criteria to assess its accuracy. The recommendations are treated in a similar manner except the criteria are based on how effective, safe and practical the advice is.

The validation criteria and methodology have been produced and validators trained in a pilot trial undertaken in Kenya. In the future, validation will take place in each country using expert validators who are familiar with local inputs and farming practices. Integrating the validation process within the existing plant health institutions is an important step towards creating ownership and ensuring the sustainability of the process.

Identifying where problems exist is only the start of the process. The next and essential step is to feed back this information to the plant doctors so that improvements can be made. Work has begun to identify the best feedback mechanisms and to identify the key personnel who will oversee the process. In Kenya this is likely to be through a series of regular 'cluster meetings', where staff from several clinics in a region will gather to discuss progress and problems they have encountered. The feedback process may differ for each country in the Plantwise programme and the exact requirements will need to be agreed in discussion with key stakeholders.

As the number of plant clinics expands so will the volume of data that needs to validated. In order to assist the validators an Excel® data entry sheet has been created to simplify the process. Work has also started to investigate the possibility of semi-automating the validation of the diagnosis by making use of the symptom check boxes. These could be used to flag up obvious anomalies where the symptoms do not match the diagnosis. This is still under development and considerably more work needs to be undertaken before a working prototype is available for field testing.

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Above and below:
Trainee data validators get to grips with the Kenyan plant clinic data at the national validation workshop (photo: R. Reeder)

development of Plantwise training material

Access to the Plantwise training material is now available to all CABI staff through SharePoint® and this is now being used as a development platform for producing more material. It complements an existing web-based portal access system.

Plantwise is now relying to a much greater extent than ever before on locally trained people to provide training for plant doctors, and so we are training trainers to provide this. This means that the training needs to be robust so that it is not misinterpreted and can be given by people without higher degrees in crop production.

To achieve this the training material has been revised. Module 1 – 'Field diagnostics and plant clinic operation' and Module 2 – 'Giving good recommendations' have remained largely unchanged whereas Module 3 and the PMDG courses have recently been fused into a new module called 'Extension messages'. For this training, Green and Yellow lists are produced which guide extension workers and farmers through a process of pest prevention, pest monitoring and pest control. Control measures are subdivided into those which can be applied without restrictions and those which have restrictions imposed on them. The Green and Yellow lists are limited to one side of A4 paper and they may be lacking detail in some cases, which is where the modified factsheets come in. Whereas the factsheets were formerly written on a specific host/pest combination in simple farmer-friendly language they are now written on a technology (identified in the Green and Yellow lists) and are used by extension workers to advise farmers.

Data management training has also been developed and is currently being rolled out to the Plantwise countries. This shows how to use the data generated by the clinics and also how the power of the computer can be used to identify features of the data that are not immediately obvious. This training is not usually provided for plant doctors but for those who are making policy decisions on behalf of governments.

The quality of recommendations provided to farmers and the accuracy of diagnoses need to be as high as possible for the sake of both the farmer and the Knowledge Bank. Validation protocols for assessing these have been developed and are being trialled around the world.

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Plant doctors listen intently to training being provided by a local trainer following a successful training of trainers course in Malawi (photo: P. Taylor

introduction

CABI's Knowledge Management theme improves access to reputable and verified information and supports the transformation of scientific and technical information into easily accessible formats for use by those who seek improvements in the natural environment, farming and the livelihoods of the poor.

Knowledge management is growing in importance in research and development programmes as policy makers and researchers are increasingly asked for evidence that research has had an impact and has been used. Policy change can be more evidence-based if policy makers are helped to understand the science and use insights from research. There is now a growing movement to make all data open and linked, and CABI is proud to be a signatory of the Global Open Data in Agriculture and Nutrition initiative www.godan.info/

Those who fund research also want to know that research is communicated more widely to improve greater understanding of the science and the issues addressed. Good communication improves the reach of funded research and broadens its potential application. In particular, approaches that facilitate research uptake and the scaling-up of research outputs are key components of Knowledge Management activities carried out by our staff based in the UK.

Elizabeth Dodsworth, Global Director, Knowledge Management

compilation of folders for CTA's Knowledge for Development bilingual website

The ACP-EU Technical Centre for Agriculture and Rural Cooperation's (CTA's) Knowledge for Development website supports the policy dialogue on science and technology for agricultural and rural development in African, Caribbean and Pacific (ACP) countries. It enables the ACP scientific community – primarily agricultural research and development scientists and technologists, policy makers, farmers and other stakeholders and actors – to share and review results of national and regional efforts and collaborate to harness science and technology for the development of agriculture in their countries. CABI is developing dossiers for this website.

In 2013, this involved commissioning scientists to write lead articles on topics such as 'Research collaboration in a globalised world', 'What are global priority nutrition and food-related issues?', 'The changing face of EU science and technology cooperation' and finally 'Technologies for small scale dairy processing'. It involved the expertise of CABI and CTA in identifying key scientists, particularly with knowledge relevant to ACP countries. The articles may be written in French or in English. After review and editing, they are translated before posting on the website so that they are available in both languages to be of maximum use to the ACP community.

In addition to commissioning the lead articles, the project involves the identification of key documents and links relevant to particular topics. In the third phase of this project, links and documents for 'Research collaboration', 'Nutrition and agriculture' and 'Technology in dairy' have been identified and made available with descriptions in French and English. The folders are available at: knowledge.cta.int/index.php/en/Dossiers/

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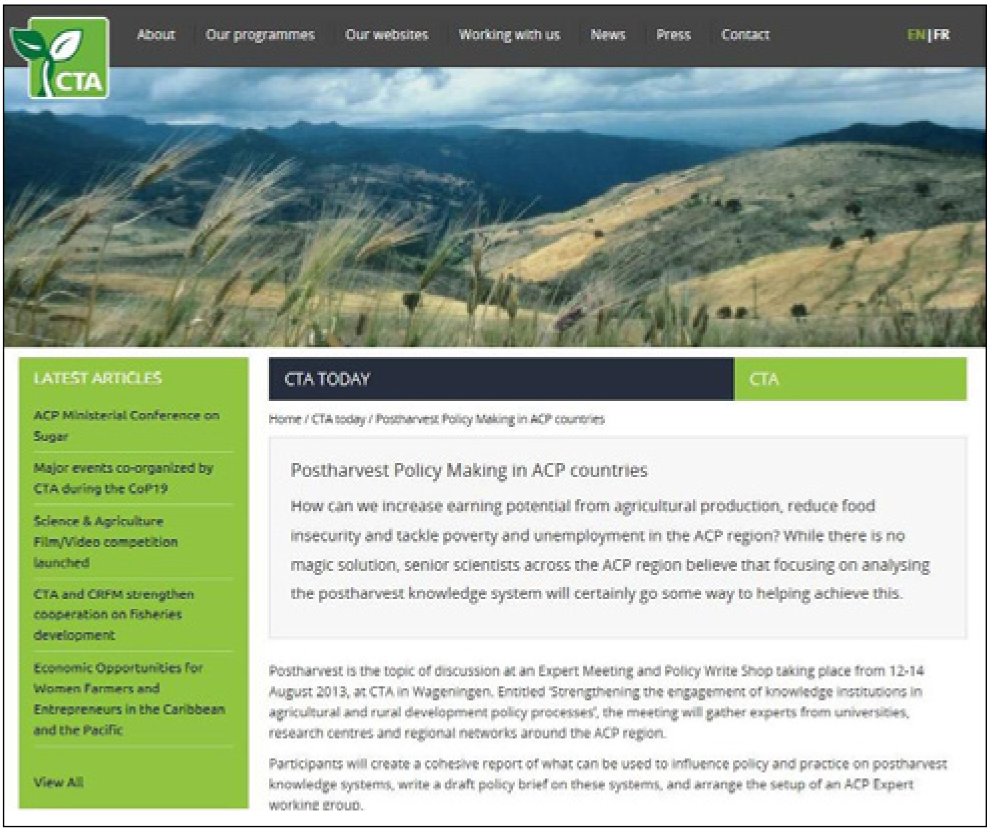


introduction

Bioservices is one of the four science themes in CABI's International Development strategy. Based in Egham, UK, Bioservices provides a number of services and/or biological resources to CABI projects and commercial customers. We specialize in six main activities:

- DNA sequence-based identification of microorganisms
- Environmental and industrial services
- Supply, preservation and safe storage of microorganisms
- Contract research
- Training courses
- Publications

Typical areas in which we work with our customers include:

- Agriculture – crop pathogen identifications
- Environmental – air/building surveys for fungal contamination
- Pharmaceuticals – production environmental monitoring
- Food and drink – product contaminant identifications
- Biotechnology – patent deposits and safe deposits
- Electronics – resistance to mould growth testing
- Transport – microbial contaminant assays for fuels
- Drug discovery – culture and extract provision
- Academia – identifications, culture supply and training
- Biological Resource Collections – culture supply and training
- Publishing – specialist mycology publications

DNA sequence-based identification of microorganisms

Microbial identification services now accredited to ISO 17025 by UKAS include:

- Bacterial identification by partial 16S ribosomal DNA (rDNA) sequencing
- Fungal and yeast identification by internal transcribed spacer (ITS) sequencing

This is the only UKAS-accredited service for the entire identification process to species-level naming. In 2013, we provided a total of 1206 identifications to 49 organizations from 17 countries.

environmental and industrial services

Environmental monitoring and testing services accredited to ISO 17025 by UKAS include:

- Resistance to mould growth testing of materials and components
- Assessment of microbial contamination of fuels and lubricants
- Sampling of air and bulk materials from constructed environments that are suspected to contain fungi
- Isolation and enumeration of environmentally sampled fungi

microbial resources

Bioservices hosts a collection of ~28,000 living cultures. These are primarily fungi but some bacteria are included. We also host a number of smaller non-CABI collections. Preserved formats include oil immersion, freeze drying and liquid nitrogen cryopreservation. We supply cultures and extracts (including validated reference cultures), and patent and other safe deposit services are also available.

contract research

This includes R&D work for Conidia* fuel contamination testing kits, strain fingerprinting and authentication, contract preservation of microorganisms, and aflatoxin detection in foodstuffs.

*Conidia is a spin-off company from CABI Bioservices that specializes in immunoassay-based kits for the detection of fungal and bacterial contamination of aviation and shipping fuels

training courses

These are generally 2- to 5-day Egham-based courses, and topics include:

- DNA sequence-based identification of microorganisms
- Morphology-based fungal identification
- Environmentally important fungi
- Isolation methods for microorganisms
- Microbial preservation
- Plant pathology

publications

CABI publications produced through or in association with Bioservices include:

- *Dictionary of the Fungi*
- *Index of Fungi*
- *The Bibliography of Systematic Mycology*
- *Descriptions of Fungi and Bacteria* series

The year 2013 saw a number of significant developments for Bioservices. Yeast and fungal identifications achieved accreditation to ISO 17025, industrial consultancy grew significantly during the year, and Bioservices increased activity in establishing and developing genetic resource centre networks. Further details of our provision of services and resources during 2013 are presented below. I hope you enjoy reading about our progress in developing the services and resources that we offer to CABI projects and to commercial customers.

Mike Reeve, Head of Bioservices

the Microbial Identification Service

The MIS provides a worldwide service for the identification of filamentous fungi, yeasts and bacteria. Our customers are in a range of industries, mainly the pharmaceutical, food and manufacturing sectors, as well as plant pathologists, plant health authorities and researchers working in agriculture, horticulture, forestry, quarantine, biodiversity assessment and biological control. The service also provides identifications to support CABI businesses and projects including Plantwise, the Environmental and Industrial Biology (EIB) laboratory and the GRC.

For the commercial sector, accurate identifications are essential to support environmental monitoring programmes as well as for sterility testing of products and validation of reference organisms, and to establish the identity of microorganisms associated with the development of novel products.

The MIS offers DNA fingerprinting analysis, which provides detailed characterization to assess the genetic similarity of strains. This analysis is also used to obtain reference profiles of proprietary strains to comply with the requirements of regulatory authorities for purposes such as strain release.

In 2013, Bioservices successfully achieved an extension to the scope of its UKAS accreditation to include molecular identification of filamentous fungi and yeasts – molecular identification of bacteria to ISO 17025 having been gained in 2012. This establishes the MIS as the leading provider of identifications in the UK, because it is the only service to be UKAS accredited for the entire identification process including providing the name of the organism.

Regulatory authorities recommend genotypic identifications as preferable to those based on phenotype. Standard methods used by the MIS are sequencing of part of the 16S rRNA gene subunit for bacteria and sequencing of the ITS region of rDNA for filamentous fungi and yeasts. The latter locus encompasses ITS1-5.8S-ITS2, the region considered to be the *de facto* 'DNA barcode' for fungi. Results from each sample are matched against global databases of sequenced organisms, and the data interpreted by our specialists to establish identity. In cases where determination of fungi to species level cannot be resolved using ITS sequencing, alternative loci are sequenced. For example, for identifications in the genus *Fusarium*, which contains many significant plant pathogens, part of the translation elongation factor 1α (TEF) gene is sequenced to provide definitive identification. In 2013, a total of 1206 identifications were provided to 49 organizations from 17 countries.

As part of CABI's member country benefits, the MIS, in conjunction with Plantwise, provides a free service to member countries in bands 1–4. This provides for identification of bacteria and fungi of agricultural importance in relation to food security or plant health, including quarantine organisms, and is available to national and regional agricultural research centres, government institutions responsible for agriculture, and university departments whose studies relate to agricultural research. In 2013, use of this service increased by 34% compared with the previous year.

CABI: **T. Caine**, MIS Operations Manager (t.caine@cabi.org) and **A. Buddie**, Molecular Biology Operations Manager (a.buddie@cabi.org).

Fungal samples being prepared for DNA extraction (photo: T. Caine)

Examination of a *Penicillium* sample (photo: T. Caine)

The Stirling cycle controlled-rate cooler allows for optimal cryopreservation of important cultures (photo A. Kermode)

CABI utilizes freeze drying as one of its methods of choice for the preservation of cultures (photo A. Kermode)

the Genetic Resources Collection

With a particular focus on agricultural biotechnology, the GRC holds over 28,000 living microbial strains, making the collection one of the most significant in the world with respect to agriculture and the environment. Its activities and services form part of the wider Bioservices business offering and are accessible to scientists from around the world.

The majority of our holdings are of filamentous fungi and yeasts but we also hold a significant collection of plant pathogenic bacteria. CABI scientists travel the world through their research work and add strains from remote locations to the collection, making it very diverse and therefore particularly interesting for novel product discovery. The unique properties and capabilities of microorganisms can be utilized for drug and active molecule discovery and as part of the research, testing and quality-control programmes linked with production and manufacturing.

In addition to supplying active or freeze-dried cultures to scientists in CABI and the wider scientific community, we can supply DNA and culture extracts for ease of use or where containment facilities for the living culture are more demanding. We supply authenticated reference, type and test strains to business. We maintain ISO 846, BS2011 Part II j and MIL810F test strains for the European, UK and US testing standards, and hold many other test and challenge strains. We hold production strains for enzymes, metabolites, active biomolecules and novel products.

We also have expertise in developing cryopreservation regimes for recalcitrant microorganisms using cutting edge technologies such as 'Stirling cycle' controlled-rate freezing. Bioservices offers preservation services such as safe deposit and contract preservation and provides consultancy services in these areas particularly related to the stability of production strains. Culture collection staff contributed to a highly successful training course 'Preserving, storing and maintaining microorganisms' held in May 2013 and hosted several students and visitors throughout the year.

Information about CABI's culture collection:

- We have managed the UK National Collection of Fungus Cultures since 1947.
- The collection houses the National Collection of Wood Rotting Fungi (NCWRF), the British Antarctic Survey (BAS) Collection, and the Aquatic Phycomycetes Culture Collection (APCC).
- The collection is a member of the United Kingdom National Culture Collection (UKNCC) and the European Culture Collections' Organisation (ECCO), and is a World Federation for Culture Collections (WFCC) affiliated collection, a UNESCO (United Nations Educational, Scientific and Cultural Organization) Microbial Resource Centre (MIRCEN) and an International Depository Authority (IDA) under the Budapest Treaty (1977).

Our culture collection operates:

- To the WFCC guidelines for culture collections;
- To the UKNCC Quality Management System;
- To the Common Access to Biotechnology Resources Information (CABRI) Guidelines;
- Within the spirit of the Convention on Biological Diversity (CBD), ensuring our microbial resources are acquired and supplied according to this international convention with terms and conditions of supply being compatible with the ECCO material transfer agreement core text (see www.eccosite.org).

See also the MIRRI project, p.58.

CABI: **M. Ryan,** Curator (m.ryan@cabi.org) and **A. Kermode** (a.kermode@cabi.org).

GRC: low temperature mycoinsecticides from Antarctic fungi

Bioservices is working in partnership with BAS and the Natural Environment Research Council (NERC) in maintaining and developing the BAS collection of Antarctic microbes. This collection of fungi and bacteria has been collected by BAS scientists from sites in the Antarctic and is maintained by Bioservices in the GRC.

The Antarctic is the most isolated continent on Earth, and it is the coldest, windiest and driest. The region ranges from the ice-covered inland continental areas to the milder, tussock grass-dominated sub-Antarctic islands. Most biological research in the region has taken place in the maritime Antarctic region of the continental coastline and the associated islands. Microbial diversity here is thought to be very restricted, but despite this the microbes are possibly the most diverse group of organisms in the region, with over 1000 fungal species reported. While many of the microbes in the Antarctic are likely to be present only as transient visitors, others have been shown to occupy specific niches in the local ecology. These include specific associations with the only two vascular plant species present, and with mosses and liverworts.

Scientists in Bioservices have been working with colleagues at BAS and other collaborators to screen the BAS cultures for potentially commercial properties related to their unique ecology and environmental capabilities. Physiological and chemical screening programmes during 2012–13 identified a number of potential leads within the fungal cultures and these are now being developed and assessed in further research in Bioservices and at BAS, funded by the NERC Innovation Programme.

CABI: **S. Edgington** (s.edgington@cabi.org), **E. Thompson** (e.thompson@cabi.org), **D. Moore** (d.moore@cabi.org) and **P. Bridge** (p.bridge@cabi.org), in collaboration with **K. Hughes** (BAS).
Funded by NERC.

Chinstrap penguins, Signy Island, South Orkneys (photo: P. Bridge)

Field transport, Adelaide Island (photo: P. Bridge)

Aerial view of sea-ice and coastline, northern Antarctic peninsula (photo: P. Bridge)

Biology laboratory, British Antarctic Survey, Rothera Research Station, Adelaide Island (photo: P. Bridge)

CABI shares MIRRI developments with its member countries, for example with the Brunei Biological Resource Centre at the Tropical Forest Bureau in Andulau, Labi. (photo: CABI)

the Microbial Resource Research Infrastructure: improving access to microbial resources, services and data

For more than a century, microbial resources have been recognized as the essential raw material for the advancement of health, and more recently for biotechnology, agriculture and food technology, and for research in the life sciences. Microbial domain Biological Resource Centres (mBRCs) including the GRC at CABI, have been established to provide live cultures to foster and support the development of basic and applied science. The pan-European Microbial Resource Research Infrastructure (MIRRI) was placed on the European Strategy Forum for Research Infrastructures (ESFRI) roadmap in 2012. Better managed resources will lead to further discovery in all areas of the life sciences. Influenced and directed by user needs, the MIRRI partners will coordinate national nodes with unparalleled depth and breadth of microbial resources; the infrastructure will improve access to high-quality microorganisms within an appropriate legal framework and to resource-associated data. MIRRI will fundamentally change operations of microbial resource collections (MRCs) so that they can underpin and improve the microbiological sciences more effectively and efficiently and thus have an impact on the global bioeconomies, providing integrated solutions to the grand challenges and to the generation of knowledge from data. The key areas where MIRRI will make a difference are:

- Connecting microbial strain data to other relevant data sets to facilitate the generation of knowledge, ensuring interoperability to facilitate accelerated discovery and innovation;
- Cooperation with resource providers, policy makers and users to provide a legally-compliant operational framework that gives legal clarity of rights in use of microbial resources and delivers transparency to engender trust;
- Making available coordinated platforms of resources, tools, data and expertise through controlled and confidential business models;
- Working with journal editors, research funders and scientists to ensure microorganisms in publications are available for the furtherance of science and impact on global challenges;
- Improving the quality of scientific research, to remove fragmentation in resource and service availability with a focus on the fundamental needs and challenges.

The project brings together 16 public mBRCs in Belgium, France, Germany, Italy, the Netherlands, Poland, Portugal, the Russian Federation, Spain and Sweden supported by 17 European and several non-European collaborating partners to build this pan-European coordinated research infrastructure dedicated to microbial diversity. MIRRI's national nodes will allow users to gain access to state-of-the-art technologies and expertise for education and research, directed against the declining basic taxonomic expertise in the academic world. MIRRI provides coherence in the application of quality standards, homogeneity in data storage and management and sharing of the workload to help to release the hidden potential of microorganisms. With its anticipated intense dialogue with users and stakeholders, MIRRI has the potential to add value to research innovation, also by bringing into contact and fostering separate research projects. MIRRI reaches beyond European boundaries with links to the Americas, Asia and Africa, facilitating CABI to support its regional activities particularly in Brunei Darussalam, Chile, Kenya and Malaysia to improve the understanding and use of microbial diversity.

CABI: **D. Smith**, Project Manager (d.smith@cabi.org), in collaboration with many partners within the MIRRI consortium.

Participants of the Brunei Biological Resource Centre training course held at the Tropical Forest Bureau in October 2012 (photo: CABI)

Environmental and Industrial Biology

The EIB laboratory at CABI has been UKAS accredited since 1984. This accreditation entails an annual assessment against the requirements of ISO/IEC 17025:2005 to demonstrate our competence, impartiality and performance capability. The management system requirements in this standard also meet ISO 9001:2000.

Our confidential services are available to both commercial and domestic customers from the UK and overseas with the scope of our accreditation covering:

- *Mould growth testing*: we specialize in assessing mould growth on customers' items to any recognized published standard or to their own specifications. These tests give an indication of an item's susceptibility to fungal growth and thus allow an evaluation of its performance in the environmental conditions under which it could be employed.
- *On-site sampling*: we are the only UK laboratory accredited by UKAS for on-site mould contamination testing. We investigate fungal contamination problems found in a wide range of domestic and workplace environments. Our customers include insurance companies, building companies, hospital trusts, composters, food manufacturing plants, and archives and museums.
- *Fuel testing*: based on a method produced by the Institute of Petroleum, these tests quantify fungal and bacterial contamination of aviation and diesel fuels. This aspect of our work involves a close working relationship with Conidia Bioscience Ltd, based on-site at Egham.

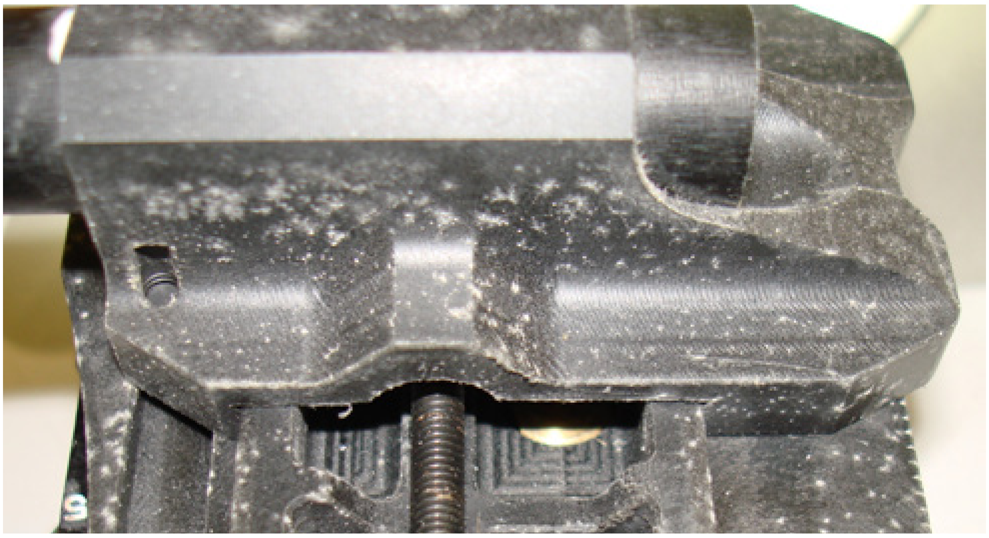
In addition, we offer an isolation and identification service to which customers submit contaminated samples for analysis.

The emphasis in 2013 was on mould growth tests, with a large number of samples passing through the EIB laboratory during the year. Each test lasts 28 days and also requires the services of the GRC to provide the correct strains of fungi. After some preparation, the fungal spores are sprayed onto the test item (this could be anything from a piece of material to a pilot's communication system) which is then kept for 28 days at a specific temperature and humidity. At the end of this period the item is assessed for mould growth according to a grading system, from which the customer can make decisions as to whether the materials used in the test item are suitable for its intended use.

CABI: **S. Lawrence** (s.lawrence@cabi.org) and **G. Godwin-Keene** (g.godwin-keene@cabi.org).

Flooding can cause potentially harmful fungi to thrive on the interior walls of buildings (photo: G. Godwin-Keene)

Lack of basic hygiene in food assembly areas is a recipe for disaster (photo: G. Godwin-Keene)



After 28 days, items undergoing mould growth tests are assessed for susceptibility to fungal growth (photo: G. Godwin-Keene)

Microbial DNA sample handling for molecular identification by PCR (photo: L. Tymo)

Molecular Biology

The Molecular Biology group continues to play a central role within Bioservices by generating DNA sequence-based identification information for the benefit of:

- Member country agricultural scientists;
- CABI projects;
- The Plantwise DAS;
- Commercial identifications customers from the pharmaceutical and biotechnology industries;
- EIB laboratory customers;
- The GRC.

Uniquely within the UK, we are accredited to ISO 17025 by UKAS for DNA sequence-based identification of bacteria to species level by partial 16S rRNA gene sequencing and, in 2013, successfully extended accreditation to identification of yeasts and filamentous fungi to species level by partial ITS (and genus-specific additional gene) sequencing (see p.55). Also during 2013, we have built the foundations required to be able to extend the scope of our UKAS accreditation further to include bacterial and fungal identifications by reference to higher-quality (i.e. validated) DNA sequence databases assembled and curated within Bioservices.

Other activities engaged in by the Molecular Biology group include:

- The characterization of mixed microbial populations by PCR amplification, library synthesis and clone sequencing;
- The analysis of post-preservation genomic stability for organisms in the GRC (both for GRC holdings and for GRC preservation consultancies);
- The development of DNA barcoding methodology for arthropods;
- Further development of our real-time PCR methodology for tracking specific biocontrol fungi in stored products for CABI colleagues for an externally funded project (see p.33);
- Support for Conidia Biosciences Ltd – including the provision of sulphate-reducing bacterial consortia for immunoassay antibody generation;
- Contract research.

In addition, we have maintained our links with Royal Holloway, University of London during 2013 and have continued a study of the fungal biodiversity of green roofs with Professor Alan Gange as part of a jointly supervised PhD programme. This is in addition to our long-standing commitment to offer a final year undergraduate BSc project each year, with one student each year now since 2008.

Looking to the future, we are keen to develop our repertoire of molecular-based methodologies. The fact that nucleic acids define the genetic identity of all living creatures on earth, combined with the rapidly falling costs of DNA sequencing, opens up countless possibilities for future activities in this exciting area.

CABI: **A. Buddie**, Molecular Biology Operations Manager (a.buddie@cabi.org).

Lukasz Tymo collecting samples on the green roof at Royal Holloway, University of London (photo: L. Tymo)

formulating hydrophobic fungal conidia in water: overcoming problems of hydrophobicity by examining hydrophobin-like proteins and the use of commercial adjuvants

Fungal formulations are vital for effective biopesticide development. Good formulations help to optimize field efficacy while poor formulations result in product failure. Most biopesticide applications are water-based but commonly used genera, such as *Metarhizium* and *Beauveria*, have hydrophobic conidia which suspend poorly in water. This study tried to improve such fungal formulations by looking at hydrophobin-like proteins and commercial adjuvants.

Hydrophobins are relatively small proteins secreted by filamentous fungi that, at air–water interfaces, confer hydrophobicity on fungal structures. Particle size analysis was developed in this project and proved to be a useful method for determining the hydrophobicity of conidia; it was used to show that *Metarhizium* conidia had more hydrophobin-like proteins than *Trichoderma* conidia. Attempts to alter the surface properties of conidia, using physical and chemical means, to make them less hydrophobic indicated that *Metarhizium* surface proteins were the harder to remove, and that conidia of both *Trichoderma and Metarhizium* were killed by these processes.

The hydrophobin-like proteins were further studied by extracting proteins from fungal broth, determining surface characteristics by using a Langmuir trough and assessing wetting agent and surfactant effects. The conidial proteins showed reverse hysteresis when subjected to repeated compression–expansion cycles. Yet while fungal broth was shown to have potential as a wetting agent, it did not help to suspend hydrophobic conidia in water.

It was possible to produce an emulsifiable concentrate of *Metarhizium* conidia using commercial surfactants. Standard tests developed to compare fungal formulations indicated that the choice of emulsifier influences the adhesion of conidia to surfaces with differing hydrophobic and hydrophilic properties. The physical and biological stability of the emulsion concentrates was tested using models developed for the purpose.

The results achieved during this study should help researchers to develop better formulated products and achieve greater field efficacy, and regulators to choose tests suitable for biopesticides, which will ultimately provide end-users with simpler and more effective biopesticide formulations.

PhD student: **Belinda Luke**; University: Birkbeck, University of London, UK. Supervisors: **Dr Jane Nicklin** (Birkbeck), **Dr Dave Moore** (CABI) and **Dr Roy Bateman** (ex-CABI). Date awarded: January 2013.

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staff

Murphy Sean, Regional Director

Anderson Kath, PA to Regional Director

Invasive Species

Ellison Carol, Theme Coordinator Invasive Species

Brook Alex, Higher Scientific Officer – Ecologist

Djeddour Djami, Weed Biocontrol Scientist

Edgington Steve, Insect Pathologist (& KFD)

Hill Lynn, Glasshouse/Laboratory Technician (Bioservices from 5 August)

Jones Kate, Project Scientist

Luke Belinda, Principal Scientist – Insect Pathologist (& Commodities)

Maczey Norbert, Senior Ecologist/Entomologist

Pollard Kate, Project Scientist

Pratt Corin, Project Scientist

Seier Marion, Project Coordinator (Weed Pathology) and Acting Theme Coordinator Invasive Species

Shaw Dick, Deputy Director (Development) and Regional Coordinator Invasive Species

Tanner Rob, Project Manager

Taylor Bryony, Insect Pathologist (& Commodities)

Varia Sonal, Project Scientist

Wood Suzy, Project Scientist

Commodities

Moore Dave, Theme Coordinator Commodities

Crozier Jayne, Plant Pathologist

Ritchie Barbara, Plant Health Specialist

Rutherford Mike, Project Manager, Commodities

Thomas Sarah, Plant Pathologist

Thompson Emma, Project Scientist (& Centre Project Manager)

Knowledge for Development[1]

Reeder Rob, Plantwise Data Manager

Taylor Philip, Plant Health Systems Coordinator

Knowledge Management

Lamontagne-Godwin Julien, Project Scientist (& KFD)

Bioservices

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Dorsett Allison, Group Administrator and Office Manager

Buddie Alan, Molecular Biology Operations Manager

Caine Thelma, Identification Operations Manager

Clayton Teresa, Prep Room Manager

Godwin-Keene Georgina, Environmental and Industrial Microbiologist

Hill Lynn, Support Technician (5 August – 6 November)

Hudson Ken, Mycology Publications Coordinator

Kasulyte Daiva, Molecular Microbiologist

Kermode Anthony, Preservation Technician, Bioservices

[1]Knowledge for Development, KFD.

Lawrence Sharon, Senior Environmental and Industrial Microbiologist

Madden Esther, Database Administrator

Minter Dave, Mycology Consultant

Offord Lisa, Yeast and Bacteria Specialist

Ross Milena, Microbial Identification Service and GRC Sales Administrator

Ryan Matthew, Curator

San Shwe Phue, Screening Technician (to 9 May)

Smith David, Director, Biological Resources

Stewart Helen, Senior Technician

Tymo Lukasz, Molecular Microbiologist

other International Development staff based at Egham

Baker Peter, Senior Scientist, Commodities and Climate Change

Blench Cindy, PA to Executive Director Global Operations (from 16 October, maternity cover)

Cock Matthew, Chief Scientist

Flood Julie, Senior Global Director, Commodities

Kelley Joan, Executive Director, Global Operations

Pearce Trinity, PA to Executive Director Global Operations (to 16 October 2013, maternity leave)

White Gretel, Project Development Officer

library

Ragab Lesley, Librarian

support staff

Cross Tony, Facilities Manager

Fell Bill, Finance Manager, International Development

Hussain Saika, Finance Officer (maternity leave)

Mays Steve, HR Operations Manager

Muiruri Alice, Finance Officer (maternity cover)

O'Sullivan Kevin, Site Maintenance Officer

Prickett Carol, Finance Officer

Roll Michael, IT Technical Support Engineer (from 19 August)

Viney Ann, Receptionist and Administrator

Wall Louise, Receptionist and Facilities Administrator

Emeritus Research Fellow

Evans Harry C.

CABI Europe UK Associates

Bentley Jeffery, Agricultural Anthropologist

Harling Rob, Plantwise Country Coordinator

temporary staff

Borley Helen, Technician, Bioservices (16–31 December)

Clewley Gary, Field Assistant, Invasive Species (1–24 May)

Kiss Boroka, Field Assistant, Invasive Species (10 June – 12 August)

Pollard Tom, Field Assistant, Invasive Species (18 June –13 September)

Savill Katie, Intern, Bioservices (22 July – 28 August)

Sivagurunathan Menaka, Plant Technician, Invasive Species (from 1 August)

what does CABI do?

CAB International (CABI – www.cabi.org), originally established in 1910, is a not-for-profit science-based development organization. It operates under an international treaty agreement amongst its, currently 49, member countries, that is registered with the United Nations. It has a Headquarters Agreement with the Government of the UK and operates through a network of centres located around the world. CABI's mission is to improve people's lives worldwide by providing information and applying scientific expertise to solve problems in agriculture and the environment. CABI has over 400 staff operating from bases in ten countries and working in more than 70. Our activities include:

publishing

We produce key scientific publications including CAB Abstracts, the world-leading database covering agriculture and the environment, and Global Health, the definitive bibliographic database for public health information. We also publish multimedia compendia, books, eBooks and full text electronic resources which support the practical application of the results of research.

international development

Our staff research and find solutions to agricultural and environmental problems. We use science, information and communication tools to help solve issues of global concern. Our work is arranged around four core themes:

Commodities: we work to enable smallholder commodity farmers to compete in global markets. We diagnose and control plant pests and diseases, and help farmers get a better price for their crops. We work on crops such as coffee, cocoa, wheat, rice and cotton.

Invasive Species: we are helping to reduce the spread and impact of invasive weeds such as Japanese knotweed and water hyacinth and insects such as coffee berry borer and cocoa pod borer. We also advise countries at a policy level about agriculture, trade and the environment.

Knowledge for Development: we work with farmers, extension workers, researchers and governments to deliver agricultural knowledge and develop communication strategies and systems. We provide information and support for community-style telecentres, and facilitate the establishment of plant clinics around the world to help farmers identify pests and diseases affecting their crops.

Knowledge Management: we use information and communication technologies to provide farmers, researchers and policy makers with the information they need to make informed decisions and to lift people out of poverty. We produce interactive databases and encyclopaedic compendia that give access to detailed and easy-to-search information on subjects like crop protection and animal health.

microbial services

We manage one of the world's largest genetic resource collections: the UK's National Collection of Fungus Cultures. We conduct microbiological identifications, provide cultures for sale, and offer preservation and consultancy services. We are also screening our collection, looking for natural products such as antibiotics, vitamins and enzymes.

For more information about CABI please visit our website: www.cabi.org

acronyms

AAB	Association of Applied Biologists (UK)
ACIAR	Australian Centre for International Agricultural Research
ACP	African, Caribbean and Pacific (group of states)
ADAS	*formerly* Agricultural Development Advisory Service (UK)
APCC	Aquatic Phycomycetes Culture Collection
APHIS	USDA Animal and Plant Health Inspection Service
ARDN	ASENET Regional Diagnostic Network
ASEAN	Association of Southeast Asian Nations
BAS	British Antarctic Survey
BBSRC	Biotechnology and Biological Research Council (UK)
BMGF	Bill and Melinda Gates Foundation
BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung/Federal Ministry for Economic Cooperation and Development (Germany)
BS	British Standards
BuRO	Bureau for Risk Assessment and Research Programming (the Netherlands)
CAAS	Chinese Academy of Agricultural Sciences
CABI-MoA Joint Laboratory	CABI – Chinese Ministry of Agriculture Joint Laboratory for Bio-safety
CABRI	Common Access to Biotechnology Resources Information
CBB	coffee berry borer, *Hypothenemus hampei*
CBC	classical biological control
CBD	Convention on Biological Diversity
CCI	Cocoa Coconut Institute (PNG)
CGS	coffee green scales, *Coccus* spp.
CIC	Coffee Industry Corporation (PNG)
CIRAD	French Agricultural Research Centre for International Development/Centre de Coopération Internationale en Recherche Agronomique pour le Développement
CPHST	USDA-APHIS Center for Plant Health Science and Technology
CSDPA	Utthan Centre for Sustainable Development and Poverty Alleviation, Allahabad (India)
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
CTA	Technical Centre for Agricultural and Rural Cooperation
CTFC	Centro Tecnológico Forestal de Catalunya (Spain)
DAFF	Department of Agriculture, Fisheries and Forestry (Queensland, Australia)
DAS	Diagnostic and Advisory Service (Plantwise)
Defra	Department for Environment, Food and Rural Affairs (UK)
DFID	Department for International Development (UK)
DGIS	Directorate-General for International Cooperation (the Netherlands)
DODS	Directory(ies) of Diagnostic Services (Plantwise)
DR Congo	the Democratic Republic of the Congo

EC	European Commission
ECCO	European Culture Collections' Organisation
EIB	Environmental and Industrial Biology
ERA-ARD	European Research Area - Agricultural Research for Development (EC)
ESFRI	European Strategy Forum on Research Infrastructures
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FEPAF	Fundação de Estudos e Pesquisas Agrícolas e Florestais, UNESP (Brazil)
Fera	Food and Environment Research Agency (UK)
FuEDEI	Foundation for the Study of Invasive Species/Fundación para el Estudio de Especies Invasivas (Argentina)
GDP	gross domestic product
GEF	Global Environment Facility
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (Germany)
GPS	global positioning system
GRC	Genetic Resources Collection (CABI)
ICAR	Indian Council of Agricultural Research
ICCO	International Cocoa Organization
ICCRI	Indonesian Cocoa and Coffee Research Institute
ICO	International Coffee Organization
IDA	International Depository Authority within the Budapest Treaty (1977)
IDH	Sustainable Trade Initiative (the Netherlands)
IEC	International Electrotechnical Commission
INIFAP	Instituto Nacional de Investigaciones Forestales y Agrícolas y Pecuarias, Veracruz (Mexico)
IOPRI	Indonesian Oil Palm Research Institute
IPDM	integrated pest and disease management
IPM	integrated pest management
IPP	Institute of Plant Protection, CAAS (China)
ISO	International Organization for Standardization
ITS	internal transcribed spacer
JNCC	Joint Nature Conservation Committee (UK)
KARI	Kenya Agricultural Research Institute
KESREF	Kenya Sugar Research Foundation
KUL	Katholieke Universiteit Leuven (Belgium)
LGB	larger grain borer (*Prostephanus truncatus*)
mBRC	microbial domain Biological Resource Centre
MIL	United States Military (standard)
MIRCEN	Microbial Resource Centre (UNESCO)
MIRRI	Microbial Resource Research Infrastructure (EC)

MIS	Microbial Identification Service
MoA	Ministry of Agriculture (China)
MPOB	Malaysian Palm Oil Board
MRC	microbial resource collection
NAQIA	National Agricultural Quarantine Inspection Authority (PNG)
NBPGR	National Bureau of Plant Genetic Resources, an institute of ICAR (India)
NCWRF	National Collection of Wood Rotting Fungi (UK)
NERC	Natural Environment Research Council (UK)
NGO	non-governmental organization
NPPO	national plant protection organization
NTNC	National Trust for Nature Conservation (Nepal)
NVWA	Netherlands Food and Consumer Product Safety Authority
PCR	polymerase chain reaction
PIPOC	MPOB International Palm Oil Congress
PMDG	Pest Management Decision Guide (Plantwise)
PNG	Papua New Guinea
PRA	pest risk analysis
qPCR	quantitative polymerase chain reaction
RINSE	Reducing the impact of invasive non-native species in Europe (EU)
RPM	red palm mite (*Raoiella indica*)
rRNA	ribosomal ribonucleic acid
RSPB	Royal Society for Protection of Birds (UK)
SAIS	South Atlantic Invasive Species (RSPB)
SDC	Swiss Agency for Development and Cooperation
SE	standard error
SIDA	Swedish International Cooperation Development Agency
SPC	Secretariat of the Pacific Community
STDF	Standards and Trade Development Facility
TEF	translation elongation factor 1α
TNCH	The Nature Conservancy of Hawaii (USA)
TSB	Technical Strategy Board (UK)
UKAS	United Kingdom Accreditation Service
UKNCC	United Kingdom National Culture Collection
UKOT	United Kingdom Overseas Territory
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESP	Universidade Estadual Paulista (Brazil)
USDA	United States Department of Agriculture
WFCC	World Federation for Culture Collections
ZSL	Zoological Society of London (UK)

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