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CABI Annual Report
Europe UK
2012

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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

This annual report was prepared by the staff of CABI Europe UK and covers activities in 2012. Images are attributed to the photographers as far as is known and are by CABI staff unless specified.

Front cover photo – Three generations of smallholders in Eastern Highlands Province, Papua New Guinea (photo: A. Brook)

Inside front cover photo – Plant doctor Mr Lee inspects a grape sample brought into the plant clinic in Guangxi Province, China (photo: R. Reeder)

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preface

Welcome to the 2012 annual report for CABI's UK science centre at Egham. Many exciting activities and achievements took place during the year; centre staff were very busy working with other CABI colleagues and project partners at 'home' and across the globe on ongoing projects and consultancies in all of CABI's major business themes. We enjoyed visits by scientists and others throughout the year and also hosted students from several UK universities.

In 2012 CABI's Plantwise programme staff based in the UK, working in tandem with staff from other CABI centres, were actively involved in the development and delivery of plant doctor training, taking them to over 17 countries and almost all parts of the world.

Bioservices' Molecular Biology laboratory achieved UKAS accreditation for bacterial identifications using molecular means; it is the only laboratory in the UK that has this status and it adds substantial capacity to our existing identification services. In addition the Molecular Biology team together with commodity-based project staff developed a novel method for detecting *Fusarium* wilt in pollen using a polymerase chain reaction approach, which provides a reliable means for screening oil palm for this important quarantine disease on behalf of countries in Southeast Asia.

Our teams in Invasive Species and Commodities continue to work globally, with projects covering pest/weed surveillance and risk assessment, biological control, climate change and integrated pest management for countries stretching from Brazil to Vanuatu.

Worldwide, biological control by use of host-specific natural enemies is attracting much interest from those involved in invasive species management. Significant strides have been made in our work on invasive riparian weeds in the UK. For example, the host-specific nature of a *Puccinia* rust fungus of Himalayan balsam has been clarified and thus confirms the potential of the fungus as a biological control agent for this weed; and for Japanese knotweed, larger-scale releases and monitoring of the Japanese psyllid, *Aphalara itadori*, were made at several sites while research on leaf-spot fungus (*Mycosphaerella*) as a potential additional biological agent has been rekindled under new funding from the UK Department for Environment, Food and Rural Affairs. Work has also begun on invasive species management for the UK Overseas Territories in the South Atlantic, with an assessment to identify those invasive species that can be effectively targeted by biological control.

In the UK, progress has been made in our work on biopesticide development: successful field trials of a formulation of *Beauveria bassiana* developed at Egham have been conducted against important grain beetles that infest grain silos; this work will facilitate European Union regulatory approval for what will be a 'first' mycoinsecticide for the grain sector in Europe.

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

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

highlights in International Development

Plantwise: a global programme

In 2012 the Plantwise programme was extended to all of CABI's centres around the world, bringing together expertise from across the organization. This is one of CABI's largest programmes and presents a unique opportunity for staff from all centres to work together. While CABI staff based in the UK were actively involved in the development and delivery of plant doctor training, CABI colleagues at other centres were busy making contact with the various national partners involved in plant health systems.

The success of Plantwise is dependent on the partnerships it makes with organizations such as government ministries, diagnostic services, agro-input suppliers and research institutions. The role of Plantwise is to facilitate the linking of these stakeholders in order to stimulate institutional change and the strengthening of national plant health systems.

Throughout 2012 there were many positive steps towards forming these partnerships through planning workshops and the establishment of national forums and steering committees to guide the Plantwise programme. Significant progress was also made in expanding the clinics' services with over 300 plant clinics running regularly across 24 countries.

Other highlights of the year include the full launch of the Plantwise Knowledge Bank in July 2012 to which staff from Egham contributed. This important online resource provides detailed diagnostic information on at least 2500 pests and diseases for over 100 crops. It also holds over 1600 factsheets giving treatment advice which is often country-specific. Its innovative design and features were recognized in the 2012 Association of Learned and Professional Society Publishers (ALPSP) awards were it was highly commended.

The Plantwise Diagnostic Advisory Service in partnership with the UK's Food and Environment Research Agency (Fera) was able to confirm the identity of a new maize disease in Kenya from samples submitted by the Kenya Plant Health Inspectorate Service (KEPHIS). The disease, named maize lethal necrosis (MLN) is new to Africa and involves the interaction of two viruses. In combination the viruses produce devastating results leading to significant yield losses and even death of the crop. Identifying the cause of the disease is the first step towards understanding the problem and developing appropriate control measures.

Japanese knotweed biocontrol agent petition submitted in the USA

A petition for the release of the Japanese knotweed psyllid, *Aphalara itadori*, was submitted to the US authorities in October 2012 after results showed that the biocontrol agent was safe to release there. Following on from field trials conducted in the UK in summer 2011 that showed US native flora to be at low risk from an introduction of the psyllid, results in 2012 showed that buckwheat, which had received eggs in previous studies, remains at low risk of attack.

Himalayan balsam rust life cycle elucidated

The life cycle of the rust *Puccinia* cf. *komarovii* from the Indian Himalayas has been fully replicated on its host, Himalayan balsam (*Impatiens glandulifera*), in our UK quarantine laboratory and molecular evidence supporting this obtained in collaboration with the Hungarian Academy of Sciences. This achievement confirms the rust's specificity to the target plant and paves the way for clarifying its status as a specific rust variety, both of which will help support applications for its introduction as a biocontrol agent.

new project on yellow Himalayan raspberry

Funding from the United States Department of Agriculture, Forest Service (USDA-FS) in Hawaii has allowed CABI to begin exploration for natural enemies of one of 'One Hundred of the World's Worst Invasive Alien Species': yellow Himalayan raspberry or *Rubus ellipticus*. In Hawaii *R. ellipticus* is threatening the Hawaii Volcanoes National Park where native systems have over 90% endemism. Weed biological control scientists from CABI, in collaboration with the Indian National Bureau of Plant Genetic Resources (NBPGR – an Institute of the Indian Council for Agricultural Research, ICAR) are carrying out the first surveys for natural enemies of this plant in the Indian Himalayas.

baseline studies assess potential for biological control of invasive plants

CABI carried out baseline studies to rank the feasibility for the classical biological control (CBC) of invasive plants in China. The study, which used a prioritization tool developed in Australia, provides a starting point to develop projects in collaboration with the Ministry of Agriculture – CABI Joint Laboratory of Bio-safety in China (MoA–CABI Joint Lab) and the Chinese Academy of Agricultural Sciences (CAAS).

Baseline studies undertaken for Brazil and Myanmar will give these countries a similar starting point.

lantana biocontrol agent approved

A damaging variety of the leaf rust pathogen *Puccinia lantanae* from Peru has been approved by New Zealand's Environmental Protection Authority for release in New Zealand and shipments of the rust can now be prepared for sending.

biocontrol targets for UK Overseas Territories in the South Atlantic

Both plants and terrestrial invertebrates were the focus of a project funded by the UK Department for Environment, Food and Rural Affairs (Defra) to investigate the potential for biological control of invasive species in the South Atlantic UK Overseas Territories (UKOTs), with the Falkland Islands, South Georgia and Ascension Island selected as case studies. Using a recently developed prioritization tool, high-priority targets for the Falklands were identified as the weeds *Berberis microphylla, Pilosella officinarum* and *Ulex europaeus* plus the European earwig, *Forficula auricularia*. While no targets were found for South Georgia, it was a different story on Ascension, where four high-priority weeds *(Prosopis juliflora, Nicotiana glauca, Argemone mexicana* and *Lantana camara*) were identified, with good potential also suggested for CBC of the cottony cushion scale insect, *Icerya purchasi*. A full assessment including stakeholder workshops has been suggested for St Helena and Tristan da Cunha.

success in storage pest mycoinsecticide silo trials

The prospect of a new biopesticide for use against grain pests in Europe has moved a step closer following field trials run in farm grain silos as part of a project funded by the Technology Strategy Board (TSB). A formulation of *Beauveria bassiana* developed during the project inflicted more than 90% mortality on the saw-toothed grain beetle, *Oryzaephilus surinamensis*, and the rusty grain beetle, *Cryptolestes ferrugineus*, within 14 days of application. Data generated during these trials will help the product secure European Union (EU) regulatory approval for what will be the first mycoinsecticide product approved for grain protection in the EU.

jatropha disease in West Africa identified

The cause of a widespread disease in jatropha (*J. curcas*) in the West African countries of Mali and Burkina Faso has been identified as an athracnose-causing fungus, *Colletotrichum truncatum*. In jatropha symptoms are severe, with leaf lesions and stem cankers and stems above the cankers dying and producing no fruit. As this pathogen is known to attack other crops, including beans and solanaceous crops such as chili, tomato and aubergine, preliminary management measures focus on pruning, sanitation and avoiding susceptible intercrops while further research is carried out to develop an optimum management strategy.

cocoa farmers in Vanuatu adopt integrated pest and disease management

Cocoa in the South Pacific, neglected for a decade owing to low prices, is ripe for rehabilitation in order to take advantage of a projected increase in world cocoa demand and prices, coupled with the region's fine-flavour varieties and favourable climatic conditions for producing premium cocoa. A project to rehabilitate cocoa, funded by the Australian Centre for International Agricultural Research (ACIAR), involved working with farmers to assess the efficacy of integrated pest and disease management (IPDM) measures to reduce black pod disease (*Phytophthora palmivora*) and rats in their neglected crops. Seeing the advantages of the measures being tested, even before the end of the trial lead farmers were expanding these practices beyond the trial plots and were already observing increased yields and the potential for increased income.

coffee berry borer surveillance in Papua New Guinea

Building on-the-ground surveillance capacity in Papua New Guinea (PNG) has put the country in a state of better preparedness for dealing with the coffee berry borer (CBB, *Hypothenemus hampei*) if or, as seems inevitable, when it arrives. A standard surveillance methodology developed through fieldwork in collaboration with the Coffee Industry Corporation (CIC) was rolled out with the help of a training workshop held in 2012. This aimed to equip the 28 participants with skills and knowledge to recognize the signs and symptoms of CBB damage and to know what to do if they were found; as the participants were drawn from all over PNG, this expertise is being widely disseminated in the country. CABI also contributed to a two-day biosecurity meeting in PNG to discuss an emergency response plan to CBB and its implementation.

assessing a mite threat to palms in Trinidad's Nariva Swamp

Nariva Swamp, on Trinidad's east coast, is the largest freshwater wetland in Trinidad and Tobago. It has been designated a Wetland of International Importance under the Ramsar Convention and its palms are important both in themselves and as roosts for macaws. The threat to the palms from the invasive alien red palm mite (RPM, *Raoiella indica*) is being investigated as part of the Global Environment Facility (GEF) 'Mitigating the Threats of Invasive Alien Species in the Insular Caribbean' programme, with co-financing from the Government of Trinidad and Tobago Ministry for Food Production. Early results indicate that RPM is infesting moriche palm (*Mauritia flexuosa*) in the swamp but no other key species. With a view to protecting palms, native and exotic pathogens from CABI's Genetic Resources Collection (GRC) are being screened against RPM to search for an isolate with potential as a biopesticide.

growing coffee under climate change

Unprompted by interviewers, coffee farmers and extension workers in three countries/regions – Brazil, Vietnam and Central America's Trifinio zone, on the borders of El Salvador, Guatemala and Honduras – cited climate change as a production problem. The intensity and nature of the issues varied by country/region, but farmers and extension workers painted a similar picture in each – although gathering relevant meteorological data has been slower to yield results. A common problem reported was increasing drought coupled with failing water supplies. Pilot field adaptation activities have thus focused on tools to reduce soil evaporation and to improve the water supply to coffee trees, and it quickly emerged that different countries and zones need different solutions even when the tools being adapted have a common origin.

farmland birds benefit from lenient grazing

Seven years of grazing experiments in southern England have clearly demonstrated the benefits of lower intensity grazing of grassland for farmland birds such as skylarks, buntings and finches. Swards in these improved grasslands were maintained at greater heights which supported larger populations of invertebrates, and also more perches from which birds could forage. The constituent invertebrate groups and species varied over the season, but included the larger invertebrates that form the birds' prey.

Biofuels Information Exchange on jatropha

The Biofuels Information Exchange (**biofuelexperts.ning.com**) provides objective information on this contentious topic and continues to attract interest. In 2012, its outputs included a five-part series of papers by CABI's Peter Baker along with Zoheir Ebrahim, which analysed the status of jatropha (*Jatropha curcas*) as a biofuel crop worldwide. These in-depth reviews provide scientific insight into why a crop in which much hope was invested is not achieving its anticipated potential in so many places.

how does trade liberalization affect food security?

Although economic theory supports the argument that liberalization of trade contributes to economic growth, which in turn helps poverty reduction and food security, there seems less practical evidence that it has been beneficial in rural economies. As part of a wide-ranging systematic review programme by the UK Department of International Development (DFID), CABI was a partner during 2012 for a systematic review of evidence for links between agricultural trade liberalization in developing countries and food security. While no consistent outcome was found, a number of issues were identified pertinent to making such links, in particular the uncertainty surrounding how food security is measured, the context in which trade liberalization occurs, and different methods used to assess its impact on food security. Careful interpretation indicated that price and the relationship between price series play a central role in food security.

Bioservices highlights

MIRRI: working beyond Europe

Although the Microbial Resource Research Infrastructure (MIRRI) is being established as a pan-European resource, CABI has a task within it to extend the lessons learned to regional activities elsewhere in the world. In 2012 CABI provided the conduit to activities in Africa, South and North America and into Asia.

CABI met with African biopesticide producers at a workshop at Leeds University in the UK supported by the African College. A project to support bringing Brazilian expertise to Kenya to help CABI provide a better understanding of all the hurdles, capacity and resources needed in order to take a microorganism from the soil to the marketplace so it can contribute to the local bioeconomy is currently at the concept stage. In Chile, CABI is playing an instrumental part in supporting a network of country agricultural organizations coordinate their microbial diversity activities. In Brunei, CABI is supporting the development of a local microbial domain biological resource centre. Thus, through diverse activities, CABI is bringing a critical mass together to help member countries conserve and utilize their microbial diversity.

an Environmental Monitoring Kit

Following the successful launch of the Fungal Sampling Kit in 2011, CABI's Bioservices team has introduced the Environmental Monitoring Kit as a method for carrying out a primary evaluation of airborne fungal spores in the home or workplace. Like the fungal kit, the new kit is easy to use, comes with full instructions, and on return to Bioservices' Environmental and Industrial Biology laboratory, full counts of fungi are made and it can be scanned for specific organisms of concern.

UKAS accreditation and second molecular identification training course

Bioservice's capacity in molecular identification is achieving an increasing profile. This year the Molecular Biology laboratory achieved UKAS accreditation for bacterial identifications made entirely by molecular means, placing them in a unique position in the UK. They also ran a second well-received molecular identifications course in 2012.

novel method for detecting oil palm fungal wilt in pollen

Collaboration between Molecular Biology staff and colleagues in Commodities led to the development of a novel method for detecting an important quarantine disease of oil palm. Diseases that could be inadvertently introduced from other regions are a constant threat to Southeast Asia's oil palm industry, with wilt disease a particular concern. However, new germplasm is essential to allow breeding of improved and more productive lines, and CABI has for decades provided intermediate quarantine to check that any seed being sent to Southeast Asia is free from wilt fungus. Seed is bulky, though, and pollen is growing in popularity as

a germplasm source. Using their newly developed and optimized real-time PCR (polymerase chain reaction) methodology, the Molecular Biology team developed a method for pollen to be checked for wilt fungus. Contaminated shipments are destroyed, thus extending the protection of Southeast Asia's oil palm sector.

student highlights

Kerala home gardens provide fertile ground for research

Kate Jones had an unfortunate start to fieldwork in Kerala in southern India for her MSc in Practising Sustainable Development, when security concerns meant a rapid re-think of her planned project. Thanks to the support and hard work of Dr V. Anitha and Dr K.V. Sankaran of the Kerala Forest Research Institute (KFRI), a new workplan was rapidly formulated and approved by Royal Holloway, University of London (RHUL), and Kate was able to start her new project which involved visiting home gardens, the mainstay of Kerala's agriculture, and interviewing farmers. She found that increasing global connectivity means farmers are becoming cash crop orientated and there is also an extremely high abundance of invasive plants, which overall has meant greater homogenization of the environment thus reducing resilience in the system. Kate was awarded an MSc with Distinction together with the Alan Mountjoy Prize.

visitors and meetings

Commodities hosts Georgian scientist

Dr Medea Burjanadze, a Senior Research Scientist at the Department of Forest Protection in the Vasil Gulisashvili Forest Institute, Agricultural University of Georgia, worked with Dave Moore, Belinda Luke and Alan Buddie at Egham from 14–21 July 2012. During her visit she worked on molecular identification of isolates of entomopathogenic fungi, storage of isolates and took part in many discussions on biopesticide use and potential projects.

Indian Society of Mycology and Plant Pathology

Phil Taylor travelled to Udaipur in Rajasthan to present the Plantwise concept to the Indian Society of Mycology and Plant Pathology in January 2012. The lecture showcased Plantwise across the world, raising the profile of the programme within India and highlighting the potential benefits to both the extension services and smallholder farmers.

ECCO in Portugal

Bioservices was strongly represented by seven poster presentations at the 31st European Culture Collections' Organisation (ECCO) Meeting at the Micoteca da Universidade do Minho at Braga in Portugal on 'Biological Resource Centres: Closing the Gap between Science and Society' in June 2012.

sharing expertise in cryopreservation

CABI's expertise in developing cryopreservation regimes for recalcitrant organisms using cutting-edge technologies was the theme of two presentations by Matt Ryan, the first at the ECCO meeting in Portugal (see above), and the second at the Society for Low Temperature Biology meeting 'Advances in Low Temperature Biology' held at the Linnean Society in London in October.

International Congress on Invertebrate Pathology and Microbial Control

Steve Edgington presented a poster 'Increasing food availability by reducing crop losses for smallholder farmers' at the 2012 International Congress on Invertebrate Pathology and Microbial Control, held in Buenos Aires, Argentina, on 6–9 August 2012. The poster summarized the Plantwise programme and was presented as part of a 'Crop Health' poster session. There were approximately 400 delegates at the conference, with the British Mycological Society providing financial support for attendance.

invitations to CABI's commodities experts

Julie Flood gave an invited presentation on 'Understanding the biology of *Ganoderma* and *Fusarium* as a tool for improved management and biosecurity planning' to the Malaysian Palm Oil Industry in Kuala Lumpur in September. Then Peter Baker gave a keynote presentation on 'The changing climate for sustainable coffee' at the 24th International Conference on Coffee Science in San José, Costa Rica in November. Julie also made an invited presentation, co-authored by Mike Rutherford and Jayne Crozier, on 'Food safety in cocoa; promoting producer and consumer confidence' at the First World Cocoa Conference in Abidjan, Côte d'Ivoire, also in November; the invitation was extended by the International Cocoa Organization (ICCO) who organized the meeting as part of their Memorandum of Understanding with CABI.

Neobiota in Spain

Neobiota meetings are always a good opportunity for invasion biologists to get together and discuss theories but at this year's meeting, held in Pontevedra in Spain on 12–14 September, there seemed to be more interest in actually doing something about the problems. So our CABI Invasives team's presentation on biological control proved stimulating, especially given the likelihood of a piece of European legislation on invasive species in the coming years. Our message was that for many of the worst species all is not lost.

introduction

The CABI Invasives team based in the UK has continued to tackle the escalating problems surrounding invasive alien species (IAS) around the globe. Managing both weed and pest IAS has been at the heart of CABI's mission since its inception over 100 years ago and remains a mainstay of the service we provide. Although we advocate an integrated pest management (IPM) approach, our work focuses on biological control to underpin other control methods. Raising the profile of IAS is crucial and our blog (**cabiinvasives.wordpress.com**) goes from strength to strength. The blog is aimed at giving an accessible discussion of current and emerging IAS issues and raises CABI's profile.

Our European initiative continues to be an important focus of our weed biological control work. It was set up to raise awareness of, and deliver solutions for, invasive weeds in Europe, in particular those that threaten the ability of EU member states to meet their Water Framework Directive obligations. In April 2010 we made the first officially sanctioned releases of a weed biocontrol agent in any EU member state in the form of the Japanese knotweed psyllid, *Aphalara itadori*. This showed that we had found a path through the European regulations in one member state and that this potentially useful tool could soon be available for all.

Thanks in the main to funding from the UK Department of Environment, Food and Rural Affairs (Defra), work continued in 2012 on the biological control of a number of aquatic and riparian plant invaders. For Himalayan balsam (*Impatiens glandulifera*) a rust pathogen belonging to the genus *Puccinia* is showing real promise, and we hope its release in the UK will follow hot on the heels of the release of the psyllid against Japanese knotweed. Floating pennywort (*Hydrocotyle ranunculoides*) is a very high profile weed in Europe and we have been able to establish a culture of a damaging stem-mining fly in our UK quarantine facility. Surveys in Australia have resulted in the discovery of weevils and stem-mining flies, as well as two pathogens, both species of *Colletotrichum*, that attack Australian swamp stonecrop (*Crassula helmsii*), and these agents are also now in culture in our quarantine facility.

Rhododendron ponticum is a target, not so much for its role as an IAS, but as a host of the damaging introduced plant pathogens *Phytophthora kernoviae* and *P. ramorum*; the latter is the causal agent of 'sudden oak death'. Trials set up in 2010 to test the impact of a wood-rotting fungus, *Chondrostereum purpureum*, as a cut-stump bioherbicide to prevent re-sprouting of *R. ponticum*, continued to be monitored this year. The aim is to reduce the inoculum load of these two devastating *Phytophthora* pathogens in the environment.

Research investigating the natural enemies of kahili ginger (*Hedychium gardnerianum*) for New Zealand and Hawaii is progressing well. This weed originated from Sikkim and we were again able to collect and export natural enemies to the UK, and successfully establish a culture of the chloropid fly *Merochlorops dimorphus* as well as the rhizome-boring weevil *Tetratopus* sp. Progress on other fronts has not all been plain sailing, however, as our research on the host range of a rust of *Hygrophila polysperma*, a serious invasive in the USA, revealed it to have an alternative host, which led to its dismissal from further consideration. In contrast our efforts on the white blister rust *Pustula spinulosa*, a potential control agent for the invasive *Cirsium arvense* in the USA, established a better understanding of its life cycle and infection parameters, allowing immediate progress to be made.

Not all our activities have been in the field or laboratory and considerable time has been spent doing desk-based analyses using CABI's Development Fund. As a result we have carried out prioritization activities for the biocontrol of weeds in Brazil, China and Myanmar which should help these countries to target limited resources for the best benefit. Similarly, a Defra-funded study of the invasive species in the South Atlantic UK Overseas Territories (UKOTs) has yielded a prioritized list for potential biocontrol targets, and stakeholder meetings were held in spring 2012 on the Falkland Islands and on Ascension to discuss the findings.

This year the Invasives team has been very active in publicizing their activities with 11 peer-reviewed publications, five articles, seven project reports, three posters and more than 15 oral presentations at conferences, meetings and workshops in the UK and around the globe. One of the most significant meetings, from the perspective of implementing the biological control of weeds in Europe, was the Neobiota meeting in Spain. Implementing this management approach in Europe was considered to be highly relevant in the fight against IAS, particularly in light of new European legislation. Finally, one member of the Invasives team successfully defended their PhD and another, their MSc!

Dick Shaw (Regional Coordinator) and **Carol Ellison**/**Marion Seier** (Theme Coordinators), Invasive Species

Suzy Wood counting psyllid eggs (photo: K. Jones)

Japanese knotweed leaf infected with *Mycosphaerella* leaf spot in the quarantine greenhouse UK (photo: M. Seier)

Sarah Thomas and Kate Pollard assessing field material of the *Mycosphaerella* leaf spot (photo: M. Seier)

biological control of Japanese knotweed

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 UK in 2010. Adults were observed in early 2011, indicating that they had successfully survived the winter. Larger releases were made at an additional five sites in England and Wales in spring 2011.

In 2012 concentrated psyllid rearing allowed releases of around 11,000 adults per site in May. An intense five-year monitoring programme being run by our ecology team revealed adults and eggs at most sites six and 15 weeks after releases but no psyllids were seen more than 250 m away from the release sites. Climate data suggest that adults seen in early October are a new generation that should overwinter. It is hoped that these large releases will assist the psyllid to become established and eventually go on to have an impact on the target knotweed.

There is continuing interest from North America in the psyllid as a potential biological control agent. The opportunity to carry out open field host-range tests in the UK was exploited in 2011 and confirmed the very narrow realized host range of the psyllid and low risk to non-target species owing to much lower oviposition and survival rates. Further field trials were conducted for North America in 2012 which attempted to imitate a scenario where buckwheat, a closely related crop, is found growing near a Japanese knotweed site supporting a large population of adult psyllids. The findings from two separate studies confirmed the low risk of attack on buckwheat from the Kyushu biotype psyllid that has been released in the UK, and provided essential information for the petition for release of the psyllid in North America, which was submitted in October 2012.

Research into the potential of the *Mycosphaerella* leaf-spot fungus as an additional biocontrol agent for Japanese knotweed in the UK recommenced in 2012 with new funding from Defra. The main aim of the current two-year phase is to elucidate the pathogen's life cycle under quarantine conditions and to complete host-range testing. Regular shipments of infected Japanese knotweed leaf material bearing infective ascospores required for the host-specificity assessments were received from Japan. Good progress has been made with the evaluation of remaining test species and to date none of these exhibited distinctive disease symptoms that could be attributed to the pathogen. Experimental studies in the UK attempting to induce ascospore development of the leaf spot on its host have been complemented by molecular research in Japan. The latter showed that in order for the pathogen to complete its life cycle, mating between two isolates with complementary mating genes must take place. This recent understanding of the pathogen's genetics will greatly facilitate the ongoing experimentation to complete its life cycle under artificial quarantine conditions.

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Suzy Wood and Kate Jones releasing adult psyllids at a field site (photo: R. Shaw)

prioritizing target weeds for potential classical biological control in Brazil

This CABI Development Fund-supported project has evaluated the potential for CBC of invasive alien weeds in Brazil. The project builds on the results of previous work, notably a similar project for China and most recently for the South Atlantic UKOTs (see p.25).

South American countries are high-risk areas for invasive non-native plant species entering natural areas of high conservation potential. Brazil is one of the world's biologically mega-diverse countries and is threatened by invasive species that have the potential to threaten natural biodiversity, infrastructure and the pasture systems that support the hugely valuable cattle industry. Up to now, cross-continental utilization of CBC agents against weed species has, from Brazil's perspective, been largely a one-way process in which South America has been the source of a large number of biological control agents yet the recipient of only 5% of worldwide releases. To date there have been no releases of CBC agents against weed species in Brazil even though the country contains over 117 plant species regarded as invasive. Thus CBC remains an unutilized yet highly promising tool.

An impartial scoring system, originally developed for use in Australia, was applied to over 100 weeds in order to prioritize the many potential targets for their current impact, likely susceptibility to biological control and availability of 'off-the-shelf' agents identified by programmes implemented elsewhere in the world. Extensive literature reviews were undertaken on all the weeds and the results inputted into a tailored database which generated ranking scores for biological control potential.

A paper relating to the activities of the project was presented at the Brazilian Weed Congress in September 2012 and a final publication will be prepared for submission to the international Ecology and Management of Alien Plant Invasions Conference which takes place in Brazil in September 2013.

Rubbervine weed (*Cryptostegia madagascariensis*) was found to be the Brazilian weed with the highest potential and efforts will now focus on making biological control of that weed a reality.

CABI: **R.A. Tanner** (r.tanner@cabi.org) and **R. Shaw** (r.shaw@cabi.org), in collaboration with **G. Trivellato** and **R. Barreto** (external consultants). Funded by the CABI Development Fund.

Rubbervine weed climbing over carnauba palm in Ceara State, Brazil (photo: R. Barreto)

Urediniospores on lower leaf surface (photo: R.A. Tanner)

biological control of Himalayan balsam for the UK and Canada

Himalayan balsam, *Impatiens glandulifera*, is a highly invasive annual plant. It 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 and a weed of riparian habitats, the plant dies down in the autumn leaving dead material to be incorporated in the waterbody increasing flood potential and bank erosion. This in turn may have a negative impact on the spawning grounds of fish. *Impatiens glandulifera* also invades railway banks and lines, which has serious implications for the safety of the rail network by obstructing the line of vision for drivers and limiting access for maintenance and safety work. It affects native biodiversity by displacing native species and by competing for pollinators.

Since 2010, research has concentrated on the host range and life cycle of *Puccinia komarovii*, a rust fungus that was collected and exported to the UK from the Indian Himalayas. Host-range testing has proved that it is highly specific to Himalayan balsam. In 2012, a test plant list for North America was compiled by Dr Alec McClay, and in collaboration with Rob Bourchier (Agriculture and Agri-Food Canada; AAFC) we worked to source these species from UK and Canadian stock. We obtained and tested *Impatiens namchabarwensis, I. flanaganae, I. gomphophylla, Cyrilla parvifolia, Dodecatheon pulchellum, Strax americanus* and *Symplocos paniculata*. Furthermore, we have seed stock of *I. aurella, I. pallida* and *I. capensis* and these species will undergo testing in due course.

Control (left) and infected (right) Himalayan balsam plants; note the elongated hypercotyl of the infected plant (photo: R.A. Tanner)

In 2012, we fully replicated the life cycle of the rust under quarantine conditions proving that all spore stages observed on Himalayan balsam in the native range belong to the same species. In collaboration with the Hungarian Academy of Sciences, we derived molecular evidence to confirm this finding. Although our rust was identified as *P. komarovii*, this species is known to infect *Impatiens parviflora* in its native and exotic ranges. However, through cross-inoculation studies using both the rust collected on *I. glandulifera* in India, and rust collected from *I. parviflora* in China and Hungary, we showed that the rust we are working with remains specific to the host. Therefore, interestingly, we now aim to rename this rust as a variety of *P. komarovii,* namely *Puccinia komarovii* var. *glanduliferae*. Following the International Code of Nomenclature, a manuscript is in preparation to this effect.

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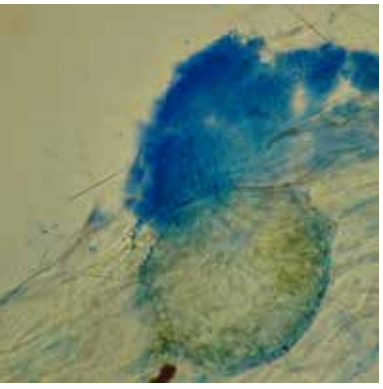

Microscopic image of a pycinia with pycniospores oozing out (photo: R.A. Tanner)

Himalayan balsam in flower (photo: R.A. Tanner)

biological control of *Rubus ellipticus*

Rubus ellipticus, yellow Himalayan raspberry, is regarded as one of the world's 100 worst invasive species. Native throughout much of Asia, yellow Himalayan raspberry was first introduced into Hawaii around 1961 and began to naturalize in the vicinity of Volcano. A single plant can grow into a 4-m-tall impenetrable thicket, with a main stem exceeding 10 cm in diameter. Its recurved prickles and sturdy stems make it extremely unpleasant for livestock and humans alike. *Rubus ellipticus* has the ability to invade and become established in undisturbed sites, where it crowds and/or shades out other species and forms monospecific stands, thus threatening Hawaii's native flora. The site of the introduction of *R. ellipticus* in Hawaii, adjacent to Hawaii's Volcanoes National Park, is particularly problematic from the standpoint of threats to native systems with over 90% endemism.

To date there have been no studies on the natural enemies of *R. ellipticus* in the Indian region of the Himalayas. Previous studies conducted in China show that the plant harbours an array of natural enemies in its native range; however, no natural enemies have been discovered in China that would be suitable as biological control agents in the invasive range.

Collaboration was established with one of CABI's long standing partners in India, NBPGR, to fulfil the requirements of the project.

An initial survey in the Indian Himalayas revealed that *R. ellipticus* does not exhibit the same invasive traits as it does in Hawaii, due mainly to the plant being kept in equilibrium with the ecosystem because of pressure exerted by natural enemies. A number of invertebrate species were collected and deposited at ICAR and formal identification was obtained. Lepidoptera species collected in India were damaging in the field and further collections will be needed in future phases of the project to rear, identify and conduct host-range testing on them. A moth species from the genus *Thyatira* may have potential as a biological control agent due to its high host specificity.

Plant pathogens were abundant and damaging to *R. ellipticus* in India. Two leaf-spot fungi were common and highly damaging to *R. ellipticus* populations and a *Phragmidium* rust fungus was also found attacking *R. ellipticus* in India. All three species were collected and deposited in India's national herbarium.

Further surveys are needed to encompass all of the plant's native range within the Indian Himalayas.

It was recommended to the sponsors of the project that the biological control programme continues in 2013, when further activities will include export of potential biological control agents to CABI in the UK for life-cycle evaluations and host-range testing.

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Funded by USDA-FS, Pacific Southwest Research Station.

Damaging leaf-spot fungus on *Rubus ellipticus* (photo: R.A. Tanner)

Caterpillar of the lasiocampid moth *Trabala vishnou* found on Himalayan raspberry (photo: R.A. Tanner)

Dr Mool Chand Singh (NBPGR) surveying *Rubus ellipticus* (photo: R.A. Tanner)

Phragmidium rust fungus infecting *Rubus ellipticus* leaves (photo: R.A. Tanner)

Ageratina adenophora has invaded diverse habitats in China (photo: R.A. Tanner)

baseline studies on invasive plants in China

China is now the world's largest agricultural economy and also one of the world's biologically mega-diverse countries. Many of the 400 or more non-native plant species introduced into China have the potential to invade both natural environments and agricultural systems thereby reducing endemic biodiversity and threatening food security. CBC of weeds targets non-native invasive plant species in their exotic ranges through the introduction of natural enemies (arthropods or fungal pathogens) from the native range of the target plant species. As a management tool, CBC constitutes an environmentally friendly and less labour-intensive approach for weed control than the more traditional methods of mechanical and chemical control.

Due to the high number of potential targets, prioritization is essential to focus effort and limited resources on those species where CBC is most likely to have significant tangible impacts. Based on a prioritization tool recently developed for Australia, we ranked the feasibility of biological control for over 250 non-native invasive plant species in China. The prioritization tool takes into account the economic and ecological impact of the species, in both the area of concern and other geographical regions, the feasibility of surveying and identifying potential biological control agents in the plant's native range, and whether or not the species has been a successful target for biological control in other geographical regions.

We will now use this prioritized list of potential targets for biological control to progress project development efforts for invasive plant species in China. The team attended and presented the initial results of the project at the VIth International Weed Science Congress in Hangzhou, China on 17–22 June 2012. Following the conference, we visited weed scientists at national organizations in Beijing to further collaboration and project development.

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Pistia stratiotes invades rice paddies in China and affects productivity (photo: R.A. Tanner)

Eichhornia crassipes is a major weed of waterbodies in China (photo: R.A. Tanner)

baseline studies on invasive plant species in Myanmar

Invasive plant species are one of the largest causes of biodiversity loss globally. They seriously threaten natural environments and productivity of agro-environments in Myanmar. Currently, little is known about the distribution and scale of impacts of invasive plant species on rural communities in this country. The majority of people in Myanmar are dependent on the natural resource base for their survival with more than 60% of the working population involved in agricultural activities. Agriculture is also one of the most important economic sectors, contributing more than 40% to national GDP. Research at a global level has indicated that, on average, weeds in crop production systems reduce yields by about 30% in developing countries.

The current lack of awareness and capacity with regard to the status of invasive alien plants and their management in Myanmar impacts significantly on small-scale farmers who are so dependent on this natural resource base. With rapid population growth, increased labour costs and rapid urbanization, it is critical to enhance food production in Myanmar by developing and implementing cost-effective and sustainable weed management practices. Failure to develop and implement best management practices for invasive species may also impact negatively on trade in agricultural commodities between Myanmar and the international community in the coming decades.

The objectives of the project were to:

- Conduct a literature review of invasive plant species in Myanmar
- Establish links with scientists in-country to assess priorities for future project development
- Assess project development ideas and highlight potential funders
- Produce concept note(s) for dissemination

As a result of the project, contact has been made with a number of non-governmental organizations (NGOs) in Myanmar which will hopefully lead to future collaboration on project development. In addition, a concept note titled ‘Capacity building for sustainable weed management in Myanmar’ is being drafted and will be submitted to the Livelihoods and Food Security Trust Fund (LIFT) in 2013.

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Mining damage caused by *Eugaurax floridensis* larvae (photo: K. Jones)

Suzy Wood hand delivers *Eugaurax floridensis* from the USA into CABI's quarantine facility in the UK (photo: K. Jones)

Collaborators propagating *Hydrocotyle* in Brazil (photo: I. Wenzel)

biological control of floating pennywort, *Hydrocotyle ranunculoides*

In 2011, Defra committed funding to tackle floating pennywort (*Hydrocotyle ranunculoides*), one of the UK's most pernicious water weeds, as part of its efforts to meet the targets defined under the EU's Water Framework Directive. The four-year project builds on wide-ranging exploration and research conducted in 2010 and aims to identify the most specific agent(s) for floating pennywort through comprehensive host-range testing in our UK quarantine facility, with a view to completion of a pest risk assessment and applying for release by the end of the project term.

Research and surveys in 2010 and 2011 had highlighted the potential of many insect and pathogen species from the native range of the plant in Argentina and Brazil. In particular, the highly damaging weevil *Listronotus elongatus* and a complex of shoot-mining flies were prioritized for host-specificity studies. With many biological control programmes around the world falling victim to strict implementation of the Convention on Biological Diversity (CBD) guidance on access and benefit sharing, a hiatus on export of these species from South America persisted throughout 2012. However, collaborations with the Foundation for the Study of Invasive Species (FUEDEI; formerly the USDA South American Biological Control Laboratory, SABCL) in Argentina and the Universidade Estadual Paulista/Fundação de Estudos e Pesquisas Agrícolas e Florestais (UNESP/FEPAF) in Brazil ensured that important scientific information on the prioritized species was collated and cultures maintained for future shipments while permissions for export were being sought.

A damaging leaf-mining fly, *Eugaurax floridensis*, from the North American distribution range of the weed was successfully hand-carried to the UK and host-specificity studies initiated.

Test plant list approval is pivotal to any biological control initiative and the proposed *Hydrocotyle* list was reviewed and agreed by the botanical expert from the Natural History Museum (London) expert and steering committees. The list now stands at 79 species, and sourcing and propagating all these non-target species continues apace with confirmation that shipments of weevils and other natural enemies from South America will be received for host-range testing in the UK in 2013.

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biological control of *Crassula helmsii* in the UK

Crassula helmsii, or Australian swamp stonecrop, is an invasive aquatic weed originally from Australia and New Zealand as the common name suggests. Introduced to the UK in the 1900s, this alien weed has gradually spread throughout the British Isles, dominating native habitats and smothering native plant species. Control of the species is a problem owing to restrictions on the use of chemicals near waterbodies and manual control spreading viable fragments. In 2009 CABI was commissioned to investigate the potential for controlling *Crassula* using CBC. Since then, several exploratory surveys have taken place in the plant's native range to examine the natural enemy complex that exists on this plant. Several promising agents were imported to CABI's quarantine facility and are awaiting further research.

In 2012, CABI scientists returned to Australia to carry out an extensive survey in search of plant pathogens infecting *Crassula*. A promising stem- and leaf-infecting *Colletotrichum* species and a leaf-infecting *Cercospora* species were collected and imported into CABI's quarantine facility in the UK for further assessment. The *Colletotrichum* species was prioritized as a species with good potential as a biological control agent. Infection parameters were investigated and infection on UK biotypes of *Crassula* was achieved.

In 2011, a species of *Steriphus* weevil from Tasmania had been imported into our quarantine facility and host-specificity testing carried out to assess its suitability as a biological control agent. Testing, which continued in 2012, involved exposure to native, related plants and those which share a similar habitat to *Crassula*. These tests revealed that the weevil had an unacceptably broad host range and could develop and feed on related, native species. Therefore, it was rejected for further study.

Investigations also took place into the life history of another prioritized insect: the stem-mining fly *Hydrellia perplexa*, which was imported into our quarantine facility in December 2011. The larvae of this species feed within the stem where they develop and pupate before emerging as adult flies. Host-specificity testing was initiated with this species and it remains promising with minimal non-target feeding recorded so far.

Further research and more field surveys in Australia will take place in 2013 during different seasons and the host-specificity testing will continue with *H. perplexa* and initiated with the *Colletotrichum* species.

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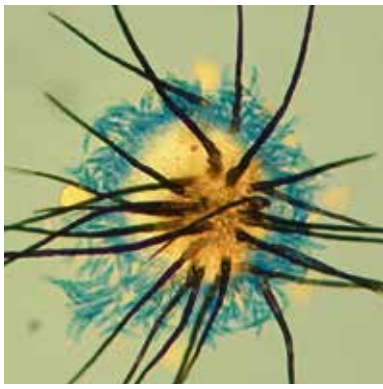
Hydrellia perplexa on a *Crassula helmsii* flower (photo: S. Varia)

Richard Holloway of the University of Tasmania surveying *Crassula* in the field (photo: S. Varia)

Infestation of *Crassula helmsii* in southern England (photo: S. Varia)



Microscopic image of setae and spores of *Colletorichum* sp. infecting *Crassula helmsii* at ×40 magnification (photo: M. Seier)

Puccinia lantanae leaf infection (photo: S.E. Thomas)

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

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 pan-tropical 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. In South Africa it is distributed from the northern provinces, through the coastal provinces around to the Western Cape. Twenty-nine forms of the species are invasive in Australia, two in New Zealand and at least 18 in South Africa.

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, New Zealand and South Africa.

Symptoms of *Puccinia lantanae* infection on *Phyla canescens* leaves (photo: S.E. Thomas)

Screening work for Australia was completed in 2010 and the dossier prepared was externally evaluated during 2011 and 2012. The main issue of concern: that the rust was found to cause mild infection symptoms on the purported Australian native species *Verbena officinalis*, has caused a delay in the decision on whether the rust should be released in Australia, and what further work needs to be undertaken to help in this process.

Following the successful completion of host-range screening of non-target plants for New Zealand, an application to release the rust was made to the Environmental Protection Authority in 2011. Permission was granted in 2012 and arrangements for shipment of the rust to New Zealand began.

Screening of the same isolate of *P lantanae* was completed for the Agricultural Research Council–Plant Protection Research Institute (ARC-PPRI), South Africa. Twelve test plant species from the family Verbenaceae were selected for host-specificity testing. Ten of the species were scored as either immune or resistant. Small, restricted telia were observed on leaves of *Phyla nodiflora* and on both leaves and stems of *P. canescens*. Whether further testing of the two *Phyla* species is needed or whether the rust can be imported into South Africa has yet to be decided.

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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 Eurphorbiaceae. 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. In 2008 the programme was expanded to include the evaluation of fungal pathogens as potential biological control agents and CABI was tasked with the research into the biology, pathogenicity and host specificity of the rust fungus *Phakopsora arthuriana* (formerly *P. jatrophicola*) which is associated with the invasive shrub as well as other *Jatropha* species in its native range.

Initial limited 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*. Limited sporulation was observed on selected non-target *Jatropha* species, namely the biofuel crop species *J. curcas*, itself a recorded host of the rust. However, strain specialization towards *J. gossypiifolia* was apparent and the other *Jatropha* species cannot be considered as fully susceptible hosts for this strain. Screening of additional *P. arthuriana* strains ex *J. gossypiifolia* from different geographic areas and regions for their infectivity and virulence towards the target *J. gossypiifolia* and the non-target *J. curcas* led to the selection of a Trinidadian isolate for full host-range testing as it exhibited reliable infection and high virulence towards all major Australian biotypes of *J. gossypiifolia* and lower virulence towards *J. curcas*.

In 2012, host-specificity testing was conducted for this Trinidadian strain of *P. arthuriana* against 38 non-target species according to a defined test plant list. Based on macroscopic and microscopic examination of inoculated leaf material the majority of test plant species was classed as immune or resistant to the rust. Five species however, including three species in the genus *Jatropha* (*J. curcas*, *J. multifida* and *J. integerrima*) and two species within the same tribe, Crotonoideae (*Aleurites moluccana* and *Beyeria viscosa*), proved to be susceptible, although to varying degrees. The testing of two other non-target species, which have been difficult to acquire, is set to be completed by early 2013. In order to paint a more detailed picture of the susceptibility of Australian native plant species, additional non-targets within the genera *Aleurites* and *Beyeria* are also likely to be included in the evaluations.

Experiments to determine the full life cycle of *P. arthuriana* were progressed during 2012. However, unanswered questions remain that would need to be addressed through further experimental work.

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

Non-target species *Aleurites moluccana* showing restricted sporulation of *Phakopsora arthuriana* during host-specificity testing (photo: K. Pollard)

Jatropha gossypiifolia infected with *Phakopsora arthuriana* in the quarantine greenhouse (photo: M. Seier)

Hispine beetles feeding on *Hedychium gardnerianum* (photo: C. Pratt)

Suzy Wood examines rhizomes in Sikkim (photo: C. Pratt)

biological control of kahili ginger, *Hedychium gardnerianum*

With continued support from a US and New Zealand consortium, the project to control kahili ginger (*Hedychium gardnerianum*), an invader of native forests and major threat to delicate island ecosystems, entered into its fifth phase. A number of arthropod and pathogen species were highlighted as having potential for biological control following repeated surveys to the area of origin of the plant and export of priority agents to the UK was achieved in late 2010. With host-range testing subsequently initiated in 2011, this continuing phase of research looked to build on this momentum and export greater numbers for more comprehensive host-specificity testing.

Two surveys to Sikkim in the foothills of the Himalayas in June and October allowed collections to be made of the ubiquitous and damaging shoot-mining fly, *Merochlorops dimorphus*, as well as the rhizome-boring weevil, *Tetratopus* sp. Collaboration with Sikkim Government College facilitated student participation and training with a view to more long-term research collaborations, and new Lepidoptera species were identified from a *Hedychium* sp.

In an effort to reduce the developmental time of the *Tetratopus* weevil (probably one generation per year in the field) and hence facilitate delivery of host-range testing, attempts were made to develop a nutrient-rich, semi-artificial diet. Modifications to the formulation are planned to further encourage feeding and facilitate subsequent rearing.

Results indicate that the biological control potential of the fly is high as development appears to be restricted to the target weed and, while adult weevil feeding is broad within the Zingiberaceae, its egg laying and larval development so far seems to be restricted to *Hedychium* species.

Host-range testing of these species is ongoing although both present rearing challenges. Hispine beetle species and a number of leaf-feeding moths remain of interest and we hope export of these species to the CABI quarantine facility in the UK can be achieved in the near future to assess their suitability.

The test plant list for Hawaii was reviewed by local horticulturalists, nature conservancies and the Department of Agriculture in Hawaii and approved to include 60 species, largely of horticultural importance, as well as six mandatory native species. The New Zealand test plant list was modified to include an extra species of *Zingiber* and now stands at 12 species.

Opportunities to recruit other international stakeholders to the funding consortium continued to be investigated and collaborations were strengthened in Sikkim to facilitate more in-country research in the future.

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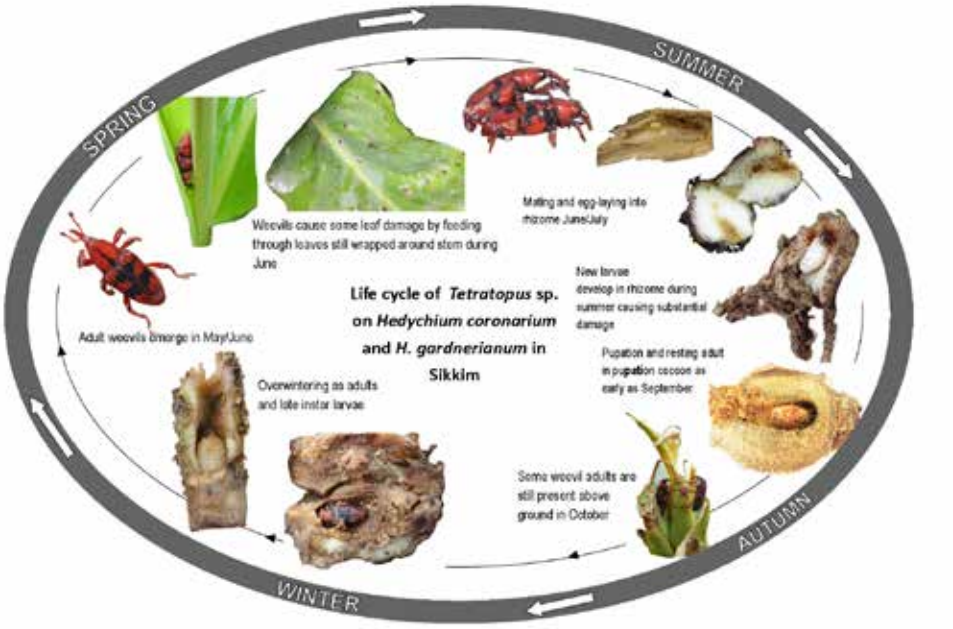

Proposed *Tetratopus* sp. life cycle

assessment of the rusts *Ravenelia acaciae-arabicae* and *R. evansii* for biological control of prickly acacia in Australia

Prickly acacia (previously known as *Acacia nilotica*, but recently reclassified as *Vachellia nilotica*), in the family Mimosaceae, was introduced as a shade and fodder tree into Australia during the early 20th century. The plant currently invades around six million hectares of arid and semi-arid land in Queensland, impacting greatly on the environment as well as the economy, particularly the livestock industry. Prickly acacia has the potential to spread throughout the arid regions of the whole of northern Australia and is therefore widely considered as one of Australia's worst weeds and classed as a 'Weed of National Significance'. *Vachellia nilotica* has been the target of a biological control programme since the early 1980s with survey work for natural enemies conducted in parts of Africa and Pakistan. More recently the Australian populations of this Afro–Asian tree were identified as *V. nilotica* ssp. *indica* and the focus for survey work shifted to India, from where this subspecies originates. Taxonomic studies revealed that two distinct rust fungi are associated with the species in India: *Ravenelia acaciae-arabicae* and *R. evansii*. Both rusts were considered to have potential as biological control agents due to the impact on their host and their apparent field host specificity.

The preliminary evaluation of both rust species, studying aspects of their infection biology and host specificity under quarantine conditions at CABI's facility in the UK, was completed in 2011. However, outstanding questions with respect to their taxonomy and life cycle still needed to be addressed during the first quarter of 2012, in particular, whether rust aecia observed to cause galling on *V. nilotica* ssp. *indica* in India are part of the life cycle of either *R. acaciae-arabicae* or *R. evansii*.

Shipments of fresh aeciospore material were received from India at the beginning of 2012 and inoculation studies were conducted under quarantine conditions in the UK, which resulted in the successful development of uredinial sporulation on prickly acacia. Based on the morphology of the resulting uredinia and urediniospores the aecial stage of the previously unidentified rust could be positively linked to *R. acaciae-arabicae*.

Research demonstrated that under quarantine greenhouse conditions both evaluated rust species, *R. acaciae-arabicae* and *R. evansii*, are able to sporulate on *Vachellia sutherlandii*, a Queensland-native species growing sympatrically with *V. nilotica* ssp. *indica* in the field. Therefore, neither of the two pathogens can be considered as suitable biological control agents for *V. nilotica* ssp. *indica* in Australia, as the overall risk to Australia's native flora must be deemed as too high.

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Funded by Queensland Government (Land Protection Fund; Blueprint for the Bush – Reclaim the Bush – a pest offensive) and Meat and Livestock Australia.

Uredinia of *Ravenelia acaciae-arabicae* developing on *Vachellia nilotica* ssp. *indica* following inoculation with field aeciospore material under quarantine greenhouse conditions (photo: M. Seier)

Field collection of rust aecia bearing aeciospores causing galling on a *Vachellia nilotica* ssp. *indica* shoot (photo: M. Seier)

Prickly acacia invasion in north Queensland, Australia (photo: K. Dhileepan, DAFF)

Uredinial sporulation of *Ravenelia evansii* on *Vachellia nilotica* ssp. *indica* in the quarantine greenhouse (photo: M. Seier)

Wan Huanhuan looking at *Cirsium arvense* plants in the field in the UK (photo: C.A. Ellison)

Cirsium arvense leaf successfully infected with the white blister 'rust' (photo: Wan H.)

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 potential agents of *C. arvense* into North America, we are now focusing on the potential of pathogens.

China was selected 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. CABI's fungal expertise lies with staff in the UK, who are therefore the project leaders, in cooperation with CABI staff in China and Switzerland.

During surveys in 2010, different pathogens had been collected on *C. arvense*, and a white blister 'rust' in the genus *Pustula* identified as the most promising pathogen. Recent molecular phylogenetic and morphological studies clearly showed that the *Pustula* lineage, usually referred to as *P. tragopogonis* s.l., can be differentiated into several distinct species including *P. spinulosa* on *Cirsium* species, which is distinct from the species attacking *Helianthus annuus* (sunflower). It is posited that different pathotypes of *P. spinulosa* have evolved that are specific at the species level. This would be a necessary requirement if this pathogen is to be considered for introduction into North America.

After unsuccessful attempts to develop an inoculation method during 2011, Wan Huanhuan from the MoA–CABI Joint Lab in China spent six weeks in spring 2012 at our centre in the UK, receiving training in spore germination and inoculation techniques. In August 2012, fresh *C. arvense* material infected with *P. spinulosa* was collected in Xinjiang and Gansu provinces in northwestern China. Laboratory-based studies established that it is critical to inoculate plants with freshly collected zoosporangia from the field, and infected plants need to be maintained under controlled conditions similar to those in the field; 22°C/16°C (day/night) and 85% relative humidity. Successful infection of plants originating from Gansu was achieved; initial infection symptoms (leaf chlorosis) were observed on leaves 9–14 days after inoculation and fully developed symptoms, i.e. mature white pustules, started to appear after 17 days. This was an important step forward in this project.

The next step is to achieve consistent and reliable infection under controlled conditions in order to establish a 'rust' culture, and then to inoculate *C. arvense* of US origin. If the plants from the USA are susceptible, host-specificity tests with *Cirsium* species native to North America will then be started.

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Wan Huanhuan inoculating a *Cirsium arvense* plant with the white blister 'rust' (photo: Li H.)

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

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. Not only is this species threatening native biodiversity and impacting on commercial forestry operations, it also hosts the damaging introduced plant pathogens *Phytophthora kernoviae* and *P. ramorum*. Both *Phytophthora* species pose a serious threat to trees and native heathland species (in particular *Vaccinium*) by causing foliage dieback and sap-seeping lesions known as 'bleeding cankers' on the trunks. *Rhododendron ponticum* is one of the main sporulating hosts, harbouring both pathogens without being killed. Since *R. ponticum* populations act as a prolific source of spore inoculum, their management has become crucial, not only for 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. This is part of a five-year disease management programme funded by Defra. Led by Forest Research in collaboration with CABI, one remit of this project is to assess the efficacy of specified chemical, biological and physical treatments to cut-stumps of *R. ponticum* to find 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. While it has been successfully used in parts of Europe and North America to control re-sprouting in various woody species, this fungus has neither been trialled against *Rhododendron* species nor tested in the UK.

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 the summer treatments on regrowth was assessed after 25 months in September 2012, when the number of cut-stumps with live regrowth, the total biomass of the regrowth as well as the height of the tallest regrown stem per cut-stump within the different treatment plots were recorded. Stumps treated with *C. purpureum* were 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 assessment of the winter treatments will be undertaken early in 2013, after which all results will be compiled in the final report to the donor, Defra.

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The experimental field site in southwest England (photo: S. Varia)

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

Sampling wood from the cambium/xylem region of a treated stump for potential re-isolation of *Chondrostereum purpureum* (photo: S. Varia)

Sarah Thomas sampling a stump treated with *Chondrostereum purpureum* (photo: S. Varia)

Azolla filiculoides (photo: C. Pratt)

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. 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 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 weed. 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.

Interest in and adoption of the azolla weevil, *S. rufinasus*, as a water fern management method continues to increase in the UK with over 75,000 weevils shipped for release at *Azolla*-infested sites during the summer of 2012. This has led to investment and scaling up of CABI's weevil rearing facility at Egham.

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Stenopelmus rufinasus adult (photo: C. Pratt)

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 evaluated the potential for CBC of invasive alien species (IAS), specifically terrestrial invertebrates and plants, in the UK Overseas Territories (UKOTs) of the South Atlantic. The project has been conducted by CABI and administered through the Joint Nature Conservation Committee (JNCC). It builds on the results of previous work, notably the recently completed South Atlantic Invasive Species (SAIS) project led by the Royal Society for the Protection of Birds (RSPB), and complements strategies and recommendations arising from that project.

The main project objectives were to:

1. Assess the potential for CBC of introduced invasive plants on all the South Atlantic UKOTs, using a recently developed prioritization tool.

2. Conduct a preliminary review of the potential for CBC of invertebrate species prioritized by the SAIS project, using the arthropod biocontrol database (BIOCAT) held by CABI.

3. Use the Falkland Islands and South Georgia as the focus for more detailed assessments (case studies) of priority invasive weeds and invertebrates for which CBC is considered feasible. (This more detailed approach was subsequently extended to Ascension Island.)

Individual non-native species were assessed using the method developed originally to prioritize Australian weeds, which was modified for application to the South Atlantic UKOTs and further adapted for assessment of invertebrate species. The 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 included in this study. Preliminary results were refined through stakeholder workshops and field site visits on 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 the highest-priority species for which CBC is likely to provide a cost-effective and sustainable management option. The case studies for the Falklands and Ascension Island indicate that a range of high-priority species are particularly suitable for CBC, and further detailed assessments of these are recommended. For the Falklands, high-priority species include *Berberis microphylla, Pilosella officinarum* and *Ulex europaeus* plus the European earwig *Forficula auricularia*. On Ascension Island high-priority weeds are *Prosopis juliflora, Nicotiana glauca, Argemone mexicana* and *Lantana camara*, and there is also good potential for CBC of the scale insect *Icerya purchasi*. In contrast no priority species suitable for CBC were identified for South Georgia.

For St Helena and Tristan da Cunha, a preliminary evaluation of priorities for both non-native plants and terrestrial invertebrates was made without the benefit of field site visits or detailed stakeholder consultations. Consequently, species for which CBC is feasible and recommended are subject to further consideration. Nonetheless, the uptake of CBC measures is provisionally highly recommended for the fast-spreading *Asparagus densiflorus* on St Helena and the scale insect *Pseudococcus viburni* currently threatening endemic gumwood trees on St Helena.

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

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

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

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

developing a biopesticide for the control of cockroaches

The Biopesticides team at CABI has a history of working with entomopathogenic fungi in numerous countries and environments around the world. Their expertise varies from laboratory-based research to mass production and field trials with both researched-based and commercial partners. With such a background, CABI was approached by a commercial company who wished to investigate the possibilities of producing a biopesticide to control cockroaches.

Due to increased urbanization and growth of trade routes, cockroaches have spread around the world becoming urban pests, above and below ground. Though there are a number of chemically based insecticide products on the market, it was felt that a fungus-based insecticide would provide pest controllers with an additional tool.

CABI was employed by the commercial company to advise and mass produce conidia from various fungal isolates received from a European university. CABI provided fungal formulations enabling a number of dose–mortality assays to be carried out by the company. The collected data enabled the original isolates to be reduced to one for further research.

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biological control of hygrophila in Florida's waterways with natural enemies from India

Hygrophila polysperma, commonly known as hygrophila or Indian swamp-weed, is an aquatic plant that can grow both as an emergent and submerged plant in shallow freshwater habitats and boggy areas. It is native to India and surrounding countries, and was introduced to the USA in the 1940s for growing in aquariums. However, it soon found its way into the waterways of south Florida, where it established and has displaced much of the native flora in many areas. It clogs irrigation canals and flood control systems, as well as negatively impacting on rice production. In Florida it is highly competitive and able to tolerate a variety of climatic conditions, including temperatures below zero. In its native range, it is attacked by a suite of coevolved natural enemies (insects and diseases), which help prevent it from dominating its habitat.

Hygrophila polysperma infected with aecial rust in Assam, India (photo: C.A. Ellison)

Attempts to control the weed have had limited impact; herbicides provide only marginal control, and mechanical harvesting tends to spread the problem since the plant is able to propagate from even tiny sections. The clear need to find an effective, affordable control method led to a project at the University of Florida to investigate the potential of biological control. Both insects and plant pathogens are being considered for introduction into Florida from the weed's centre of origin in India. CABI has been contracted to help the team from the University of Florida to search for natural enemies, harnessing logistical support in India from CABI's South Asia office and collaborators at Assam Agricultural University (AAU).

The initial surveys in West Bengal and Assam identified three key biological control agents: a leaf-mining beetle (*Trachys* sp.), a leaf-eating caterpillar (*Nodaria* sp.) and a systemic aecial rust pathogen. A Memorandum of Understanding was established between CABI and AAU and, under this agreement, an investigation of the life cycle of these agents was undertaken which included field observations and shade house and laboratory studies. Field surveys were also undertaken in China in collaboration with CABI's office in Beijing to try and identify additional potential biological control agents.

Inoculation of fresh *H. polysperma* plants with aeciospores under controlled conditions did not result in infection. Detailed field observations over the growing season were undertaken in natural habitats where *H. polysperma* is commonly found infected with the aecial rust. In April 2012 urediniospores were found at one site on the suspected primary host of the rust, the native grass *Hermarthria compressa*, which is commonly found growing with *Hygrophila polysperma*. Although this is the first time urediniospores have been observed on *Hermarthria compressa* over the three-year study period, taken together with the unsuccessful inoculation of *Hygrophila polysperma* with aeciospore, it provides evidence that the rust has two hosts (i.e. is heteroecious) and is thus unlikely to be considered suitable for introduction into the USA. Inoculation tests are underway at AAU to confirm the evidence.

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Chen Ting from Guangdong Academy of Agricultural Sciences collecting *Hygrophila polysperma*, Guangdong, China (photo: Wan H)

Reducing the Impact of Invasive Non-native Species in Europe (RINSE)

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 the 1990s and has more recently been successfully deployed in the UK (see p.24).

RINSE
Reducing the impact of non-native species in Europe

Both the weed and the weevil are naturalized in western Europe, including the RINSE region, and this study aims to demonstrate the potential of weed biocontrol in Europe using an established agent against a widespread weed. Permission for operating in each RINSE country must first be secured. Once this has been achieved, field surveys will be carried out to locate and identify weevil populations in each country. The aim is to mass rear weevils separately for each country, using material collected in-country. Weevil-free azolla-infested field sites will then be identified and releases of the weevil made.

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Funded by the EU.

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

Farmland birds such as skylarks and buntings have experienced population declines on pastoral landscapes particularly in western areas of the UK. Factors contributing to their decline include reduced availability of seed and invertebrate prey due to intensification. Specific objectives were: (i) to assess the biodiversity benefits and agronomic costs of continuous and intermittent lenient cattle grazing of agricultural grassland, and (ii) to recommend lenient grazing options suitable for inclusion in Natural England's Entry Level agri-environment schemes.

The project started in 2010 with different combinations of grazing treatments being established on plots across 18 semi-improved grass fields in south Devon. Sites were selected that were known to support populations of priority farmland birds (buntings, finches and skylarks). Different combinations of management measures were tested: (i) continuous reduced intensity grazing or 'continuous lenient': livestock density is manipulated to maintain a constant sward height of 9–12 cm throughout the grazing season; and (ii) intermittent reduced intensity grazing or 'intermittent lenient': grazing proceeds until the sward height reaches 8–9 cm and then the sward is rested (no grazing) until its height reaches 12–13 cm when grazing resumes.

These were compared with the control plots, grazed to a sward height of 6–8 cm throughout the season. The aims of both lenient grazing treatments are to generate fine-scale structural heterogeneity, to enhance invertebrate abundance throughout the avian breeding season and to provide access for foraging birds.

Both lenient grazing regimes are associated with increased invertebrate abundance, including large invertebrates (>5 mm long) that are important in bird diets. These two management regimes also increase the number of potential bird foraging positions (a measure of fine-scale structural heterogeneity). The project fieldwork was completed in 2012, and the final report is to be submitted in 2013.

- Birdfood invertebrates were more abundant in lenient grazing treatments, but abundance in all treatments declined during the experiment.
- Different invertebrate taxa responded differently in June and July, e.g. Diptera being most abundant in the continuous lenient treatment in June, and Auchenorrhyncha, and to some extent the Coleoptera, followed this trend in July.
- Lenient grazing provided a suite of different birdfood invertebrates over the summer months sampled, which may not always be obvious when aggregated. However, the overall reduction in accessible point densities may limit the availability of invertebrates to farmland birds.

Over the course of these grazing experiments (seven years) on semi-improved agricultural grassland, inter-year differences in both plant and invertebrate abundance were linked to fluctuating weather patterns. High spring–summer rainfall decreased the abundance of invertebrates important in the diet of farmland birds.

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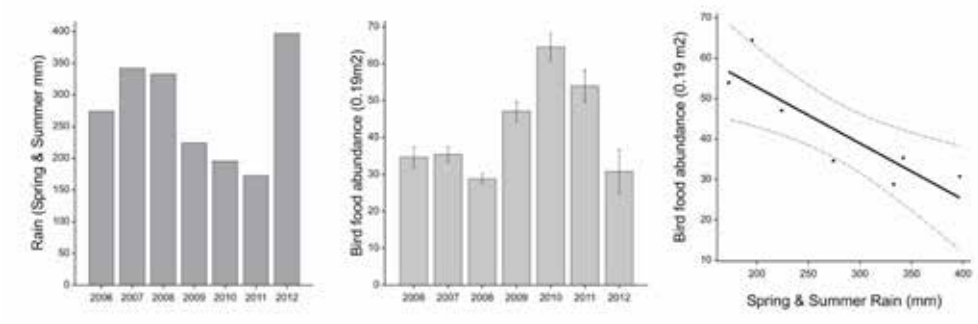

Left = spring and summer rainfall for southwest England, middle = mean birdfood (subset of invertebrates >2 mm deemed potential bird food groups); right = regression plots of invertebrate groups and spring and summer rain (March–June, mm). Error bars = 1 s.e.m, and dashed lines = 95% confidence intervals.

After completing the fieldwork in south Devon, the CABI team celebrates by spelling CABI using their equipment (photo: A. Brook)

A steer grazing in south Devon (photo: A. Brook)

Dave Moore herds cattle in south Devon (photo: A. Brook)

One-horned rhinoceros feeding in tall grassland invaded by *Mikania micrantha*, Chitwan National Park (photo: S.T. Murphy)

Riverine forest in Chitwan National Park invaded by *Mikania micrantha* (photo: S.T. Murphy)

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

Grassland–forest ecosystems of Chitwan National Park (CNP) – comprising a core area and buffer zone – form an important landscape supporting rural communities and wildlife; the buffer supports over 200,000 people and CNP is a World Heritage Site for the conservation of endangered fauna and flora including the one-horned rhinoceros (*Rhinoceros unicornis*) and Bengal tiger (*Panthera tigris tigris*). The buffer zone was delineated in 1996 allowing the involvement of communities in conservation. During the last 10–15 years, invasive alien plants have become a critical issue in CNP but other grassland–forest parks in Nepal are also affected. The South American species, *Mikania micrantha* and *Chromolaena odorata* currently dominate in CNP.

Previous mapping/research by the Nepalese National Trust for Nature Conservation and Department of National Parks and Wildlife Conservation, CABI and the Zoological Society of London shows that invasive alien plants cover over 50% of CNP and have degraded community forests and native grasses with significant loss of natural resources. This impact has severely reduced the harvesting efficiency of grasses (e.g. for fodder), wood, etc., by the communities, and increased time for weeding farmland, and thus many livelihoods have become vulnerable; rural people have expressed deep concern about the problems. Invasive alien plants also have a negative impact on the demography of the one-horned rhinoceros; other fauna are likely to be affected.

The plant invasions are chiefly driven inadvertently by current local community agricultural and natural resource collection practices, particularly the extensive burning of CNP each year to stimulate grass regeneration. The major invasive plants are fire-adapted and can outcompete native flora under intense burning regimes.

The US Fish and Wildlife Service are funding a new small project (which started in October 2012) to assess the efficacy of low-technology cultural and mechanical controls, including reduced burning schemes and improved natural resource harvesting and transport methods. Surveillance methods to assess the broader spread of invasive plants in the region are also being assessed. The methods are being 'tested' by project partners and this will be followed by further socio-economic validation of the control methods with some pilot local communities living in the buffer zone. The project is managed by the Zoological Society of London with the Nepalese partners and CABI is providing scientific and technical guidance through consultancies on invasive plant ecology and management.

In 2012 an inception workshop was held for the project at the National Trust for Nature Conservation offices at CNP. Sean T. Murphy attended and advised on experimental plans for assessing invasive plant controls and surveillance methods. Experimental plots will be established in the core area of CNP and trials begun in early 2013.

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Project partners assessing sampling unit sizes for measuring native and invasive plant species' abundances in tall grassland, Chitwan National Park (photo: S.T. Murphy)

introduction

The goal for the Commodities theme is to enable smallholder commodity producers (especially with our focus crops of cocoa, coffee, cotton, HVH [high-value horticulture], bananas and oil palm) to better compete in global markets and improve their livelihoods. Specifically, we aim to:

1. Promote sustainable production methods, especially to raise productivity of our focus crops.

2. Improve postharvest processing and market access for producers to earn better incomes.

3. Improve capacity building through knowledge dissemination.

Projects across our theme fit within these three priority areas, with much of the work conducted at Egham being done in conjunction with CABI colleagues worldwide. Under priority area 1, staff based at Egham are working with other CABI colleagues to reduce pest/disease constraints in coffee, e.g. coffee berry borer (CBB; *Hypothenemus hampei*) in Sulawesi in Indonesia, which aids sustainable production. They are also supporting efforts to try to prevent CBB's incursion into Papua New Guinea (PNG) by 'on the ground' capacity building for surveillance through training in symptom recognition and pest identification. In addition to a training course, in 2012, UK-based staff contributed to a two-day biosecurity meeting in PNG to discuss an emergency response plan and its implementation should CBB be detected in the country. The coffee portfolio at Egham also includes a Phase 2 ACIAR-funded project on coffee green scales (*Coccus* spp., CGS). Currently CGS is described as the most serious pest of coffee in the highlands of PNG. This project focuses on quantifying the impact of the pest in terms of yield loss, trying to estimate the potential economic consequences of CGS and estimating the overall loss attributable to it in highland smallholder coffee production. Preliminary analysis of data collected in 2012 suggested that coffee tree flowering and the number of cherry-bearing nodes were negatively associated with increased levels of CGS. This trend will allow estimates of the impact of CGS on yield to be calculated. A further coffee project being implemented by staff based in Egham is part of a public–private partnership with GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit), SIDA (Swedish International Cooperation Development Agency) and international coffee partners (Tchibo, Lavazza and others) to develop practical tools and techniques to help coffee farmers (especially smallholders) adapt to climate change. CABI's specific task for 2012 was to evaluate how climate change is affecting coffee production in Brazil, Vietnam and the Trifinio zone of Central America and to advise on pilot adaptation activities in farmers' fields. Climate featured as a production problem in parts of all of these countries, though the intensity and nature of specific difficulties varied. CABI used the data collected to develop pilot field adaptation activities; much of the field effort is oriented to adaptation tools to reduce soil evaporation and improve water supply to coffee trees.

We continue to work on the integrated management of basal stem rot (BSR, *Ganoderma boninense*) of oil palm in Indonesia, which is a significant constraint to the crop, and also provide third-country quarantine for oil palm seeds being transported from West Africa to Southeast Asia; this continued in 2012. In further work on palms, a new project on the management of red palm mite (RPM; *Raoiella indica*) started in 2012. This mite has devastated coconut production in the Caribbean and has spread to southern Florida and several countries in South and Central America. The project objectives are to design and implement a sampling programme to estimate RPM population densities on coconuts and native palms as well as estimate densities of native entomopathogenic fungi and natural enemies associated with RPM within the Nariva Swamp in Trinidad. Screening of native and exotic pathogens from CABI's Genetic Resources Collection (GRC) against RPM to develop a biopesticide has also been initiated.

Studies continued in 2012 on the impact of diseases on crop establishment and fruit production in jatropha (*Jatropha curcas*) under our collaborative EU-funded project which is examining the impacts of growing this biofuel crop on rural livelihoods and ecosystem services. Guidelines are being developed to help farmers manage the increasing negative impact of pests and diseases. For example, in 2012 a new stem-canker forming disease of jatropha was identified in West Africa, and management plans are being developed.

Under priority area 2, we have continued working with UK-based partners to improve the control of cereal storage pests in the UK through the use of biocontrol agents, making further improvements to the formulation and application of *B. bassiana* and generating data to register a product suitable for treatment of EU grain stores. In 2012, our scientists worked in a consortium to run two full-scale trials in grain silos in order to test the efficacy of a formulation which had been developed and tested at laboratory and pilot scale previously. The trials yielded extremely promising results with over 90% mortality of the saw-toothed grain beetle and the rusty grain beetle being attributed to the formulation.

Under improving capacity building through knowledge dissemination (priority area 3), the Biofuels Information Exchange, which was launched in 2009, is an initiative based on requests from CABI member countries for independent information on biofuels. It provides scientifically based information, independent of vested commercial/political interests. The aim is to objectively inform policy makers, researchers and producers in both the developed and developing world, and provide a forum where experts in this field can discuss their research, experiences and findings. Jatropha (*J. curcas*) continued to be the main focus of the forum in 2012, with contrasting views on the

promise of this plant as a biofuel crop. This included a five-part series of papers by Peter Baker and Zoheir Ebrahim analysing the status of jatropha as a biofuel feedstock worldwide. In addition, our capacity building activities in cocoa were expanded in the Pacific using ACIAR funding to help rehabilitate cocoa production in Vanuatu. During 2012, visits were made to farmer groups on the islands of Malekula and Epi to follow up on their progress with black pod disease and rat management following training and initiation of trial blocks in 2011. Farmers had seen numerous advantages in pruning their cocoa trees; removal of dead branches, diseased pods and reduction of the overall tree height increased sunlight and airflow into the tree canopy thus creating a less favourable environment for black pod disease and rats. Some of the lead farmers had decided to expand these management practices beyond the trial plots as they had already observed increased yields and the potential of increased incomes.

Julie Flood, Global Director, Commodities

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

CABI's centre in the UK has provided intermediate quarantine of oil palm for organizations in Southeast Asia for more than four decades. Until 2011, this involved detecting the wilt fungus *Fusarium oxysporum* f. sp. *elaeidis* in oil palm seed germplasm. Pollen is also now being used as a germplasm source and in 2012, a new technique was developed and introduced to allow detection of the disease in pollen.

The 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, if introduced, could cause significant losses to the industry.

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.

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. 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, as has traditionally been done, is a bulky and expensive operation and to reduce the bulk, pollen is now being used as a germplasm source by some organizations. Pollen is also able to transmit the wilt fungus and although this is not a common occurrence, testing still needs to be undertaken as a quarantine precaution. CABI has developed a molecular method for detecting the wilt fungus in oil palm pollen (see p.58). Unlike seeds, there is no method for treating pollen and contaminated pollen accessions can be disposed of in the UK to minimize the risk of infected germplasm materials entering Southeast Asian oil palm production systems.

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

join the debate:
CABI's Biofuels Information Exchange

Biofuels are increasing in prominence as the need to replace our reliance on fossil fuels to supply future energy needs becomes more critical. Many problems are emerging as countries try to accelerate the development of viable alternatives to meet government targets: these are not just technological but political, social and environmental. Government policies need to be science-based and encourage investments in research and development that will lead to the introduction of sustainable biofuel technologies. In April 2009, CABI launched the Biofuels Information Exchange (**biofuelexperts.ning.com**) in response to requests from CABI's member countries. This web-based resource provides scientifically based information, independent of vested commercial/political interests. The aim is to objectively inform policy makers, researchers and producers in both the developed and developing world, and provide a forum where experts in this field can discuss their research, experiences and findings. Jatropha (*Jatropha curcas*) continued to be the main focus of the forum in 2012, with contrasting views of the promise of this plant as a biofuel crop.

The site is free to join and provides 35,000 research records pertinent to biofuels from the CAB Abstracts database, as well as links to third-party biofuels reports and books. With CABI Development Fund support, CABI has commissioned review papers on issues in biofuels which are posted on the website, and the latest biofuels news is fed to the site by Google every hour. Hand-selected biofuels news articles are shared by Biofuels Information Exchange staff and the event page is updated to promote conferences and workshops to members and site visitors alike. By the end of 2012, the site had around 590 members from research institutes, extension staff, private entrepreneurs and investors in the biofuels industry; this continues to increase daily. During 2012 there were over 15,000 pageviews on the Biofuels Information Exchange from more than 5500 visitors.

CABI posts summaries and viewpoints on the Biofuels Information Exchange home page which in 2012 included a five-part series of papers by Peter Baker and Zoheir Ebrahim analysing the status of jatropha as a biofuel feedstock worldwide. These in-depth reviews provide a damning analysis of the jatropha business and present the scientific shortcomings that have resulted in the resounding failure of this crop despite early hype.

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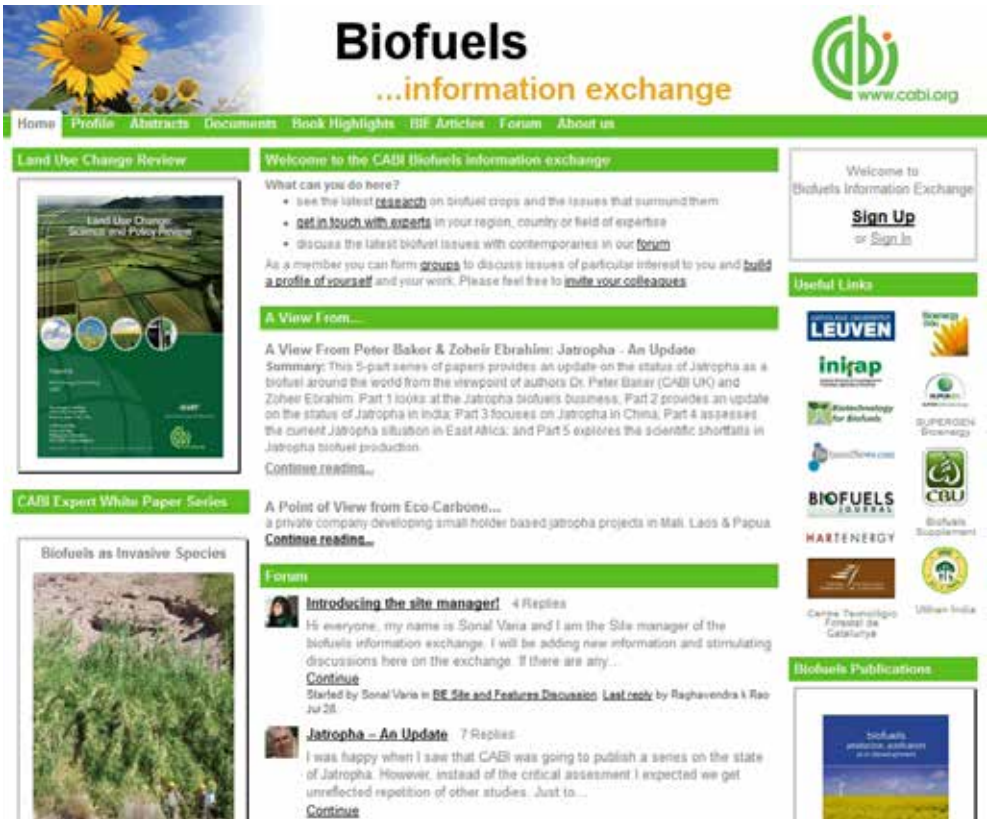

The CABI Biofuels Information Exchange homepage

the battle continues to protect oil palm production in Southeast Asia

The incidence of basal stem rot (BSR) caused by the basidiomycete white rot fungal pathogen *Ganoderma boninense* continues to increase in oil palm plantings in Southeast Asia. This increase is to be expected given such large-scale monoculture plantings. BSR decays the lower stem and sometimes the root system, leading to severe symptoms such as flattening of the crown and unopened spear leaves. High incidence of *Ganoderma* infection has been reported in Indonesian oil palm estates. In one estate where CABI is working with Indonesian partners, the latest census conducted using GPS recorded the percentage of *Ganoderma* infection on palms less than six years old to be as low as 0–1.5% but percentage infection increased dramatically in palms more than 16 years old, with 13–87% infected palms or missing points recorded. When the number of standing palms drops below 100 palms per hectare then yields decline dramatically.

One strategy to minimize *Ganoderma* infection is the adoption of good sanitation practices at replanting, thus reducing the amount of *Ganoderma* inoculum in the soil. Long-term field trials at Bah Lias Research Station in north Sumatra have indicated that shredding oil palm biomass (into slices about 10 cm thick) at replanting time is effective in reducing *Ganoderma* infection in the subsequent replanting.

Research on methods to augment palm waste compost using the fungus *Trichoderma* is progressing. *Trichoderma* strains are well documented as antagonists to *Ganoderma*. Trials using augmented compost are expected to limit or delay root infection.

In addition, fallowing for one year has been shown to have a significant effect on reducing infection in the subsequent planting and further fallowing trials are ongoing to verify these results on different estates and to determine the optimum fallow period. Shredding and fallowing as combined treatments are also underway. These practices will be combined with other estate practices such as augmentation with *Trichoderma* to produce an integrated management package of measures for this disease.

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BSR symptoms on a mature palm (photo: J. Flood)

Ganoderma fruit bodies on the stem base of an oil palm (photo: B.J. Ritchie)

Leaf and stem infection caused by the fungus *Colletotrichum truncatum* (photo: C.A. Ellison)

Close-up of leaf infection caused by *Colletotrichum truncatum* (photo: C.A. Ellison)

assessing the impact of diseases on the biofuel crop *Jatropha curcas*

Jatropha curcas (*jatropha*) is a perennial shrub or small tree from the Euphorbiaceae and produces oil-rich seeds that are easily extractable and require minimal processing to produce biodiesel. Since jatropha can survive in arid regions or on marginal land, resource-poor farmers have been encouraged by their governments to plant it. However, yields have not been as high as anticipated, and concerns are now being raised globally on the impacts of growing this crop. For example, in some places it has been planted instead of food crops, and has indirect land-use change impacts on biodiversity.

CABI is the lead partner in an EU-funded project entitled 'Impacts of tropical land use conversion to jatropha and oil palm on rural livelihoods and ecosystem services in India and Mexico', working with project partners from Mexico, India, Spain, Mali and Belgium. In 2012 Burkina Faso became a project partner, taking over some of the activities from Mali, following deterioration in the political situation there. The project, which runs from June 2009 to February 2013, aims to assess profitability, together with economic, social and environmental impacts, of the cultivation of *J. curcas* as a bioenergy crop.

CABI staff based in the UK are looking at the impacts of pathogens on plant growth and fruit production of *J. curcas*, and developing management plans to control the key diseases. CABI staff based in Switzerland are, in tandem, undertaking a similar study for the pests.

In 2012, reports were received of a new disease of jatropha in Mali and Burkina Faso that causes leaf lesions and stem cankers which results in the stems above cankers dying and producing no fruit yield. A survey in Burkina Faso's Sissili and Comoé provinces found the disease to be widespread, and a laboratory-based investigation isolated and identified an anthracnose-causing pathogen, *Colletotrichum truncatum*. This pathogen is able to attack a number of different crops from the bean family (Fabaceae) and some belonging to the Solanaceae, such as chili, tomato and aubergine. This is a potentially significant issue for species from these families that are intercropped with jatropha, particularly beans which are commonly grown. A preliminary management plan has been developed for farmers, although further research is needed to investigate the best management approaches. It is currently recommended that jatropha plants in fields that had been diseased in the previous year are pruned well below the stem cankers, and the cut plant material burned. Pruners should be disinfected between each tree. Intercropping with beans, chili, tomato and aubergine should be avoided, since *C. truncatum* may be able to jump between susceptible plant species.

A workshop, funded by the Swiss Agency for Development and Cooperation (SDC) and held in Nairobi, Kenya, in November 2012 was co-organized with partners of two other projects in the ERA-ARD (EU European Research Area – Agricultural Research for Development) programme on *J. curcas*. During this meeting, major findings from the three projects were discussed and disseminated to stakeholders, and opinion papers and policy briefs were produced for wider dissemination.

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Alizèta Sawadogo, a student from Faso Biocarburant, discussing the jatropha disease problem with farmers in Burkina Faso (image C.A. Ellison)

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 its efficacy against target pests and capability for producing large numbers of high-quality conidia when mass produced, 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 Technology Strategy Board (TSB) as part of a larger consortium (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 register a product suitable for treatment of EU grainstores.

In 2012, CABI scientists worked with the consortium to run two full-scale field trials within grain silos to test the efficacy of a formulation which had been developed and tested at laboratory and pilot scale previously. CABI scientists developed application methodologies and calibrated application equipment prior to the trial, and ran tests post application to calculate the dose applied and measure product viability over time. Trials yielded 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 conducted experiments to check the storage capabilities of the formulated compared to unformulated conidia, how long applied conidia remained viable and how much is transferred onto grain once applied. Throughout the project CABI has also performed quality control tests on all conidia produced.

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CABI scientists preparing swabs to check conidia viability within the grain silo during the trial (photo: E. Thompson)

Grain attacked by *Sitophilus granarius* – the grain weevil (photo: B. Taylor)

Cocoa farmer with healthy tree in Epi, Vanuatu (photo: B.J. Ritchie)

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 the 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.

In 2011, farmers participated in a 12-month trial to assess the effectiveness of a range of different IPDM methods. During 2012, visits were made to the farmer groups on the islands of Malekula and Epi to follow up on their progress with black pod disease and rat management.

Farmers saw numerous advantages from pruning their cocoa trees. Removal of dead branches and diseased pods and reducing the overall height of the trees increased sunlight and airflow into the tree canopy. These conditions provided a less-favourable environment for black pod disease and rats. Well-pruned trees also exhibited increased flower production and facilitated easier harvesting of healthy pods.

Some of the lead farmers had decided to expand these management practices beyond the trial plots as they could already observe increased yields and the potential for increased incomes.

Black pod disease of cocoa (photo: S.E. Thomas)

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

Cocoa farmers' training session in Epi, Vanuatu (photo: S.E. Thomas)

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

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 (EHP). The impact of CGS on yield will be estimated as part of overall yield loss, and also by comparisons of smallholder farms both with and without CGS.

In 2012 the project team recruited the required number of smallholder farms in EHP and surveys have been conducted on a regular basis:

- To collect data on CGS infestations and their associated impact on yield on a selection of smallholder farms in the EHP
- Using interviews with smallholders, to determine both their understanding of yield loss due to CGS and their estimation of production costs and income
- To collect data on yield loss due to CGS using controlled research station experiments
- Using survey and interview data from larger-scale coffee farmers (plantations that hold records) and processors, to gather historical information on CGS and yield and yield loss

Overall yield loss will be estimated by comparing smallholder farms with well-managed coffee systems (e.g. some large farms) and data from field experiments. By the end of 2012 the first data were circa 50% complete because the growing season straddles two calendar years. 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 in order to estimate the impact of CGS on yield, and therefore produce estimates of yield loss. For this we need data on a full complement of overall cherry production in a year, which will come in the last quarter of 2013. In 2013/2014 the incidence of CGS will be surveyed in other coffee growing provinces such as Western Highlands, Jiwaka and Simbu provinces to estimate the economic impact of CGS there.

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Three generations of smallholders in EHP (photo: A. Brook)

CGS-infested coffee leaf in PNG (photo: A. Brook)

PNG smallholders talking with CIC staff (photo: A. Brook)

Smallholders tending food crops (photo: A. Brook)

Coffee cherry from Indonesia showing frass around the CBB entry hole (photo: B. Taylor)

Course participants looking for signs of CBB infestation during fieldwork (photo: B. Taylor)

CBB from Indonesia (top) and a local scolytid pest in PNG (below) exhibit morphological similarities (photo: B. Taylor)

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

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

Activities by CABI's UK staff in 2012 focused on building on-the-ground capacity for surveillance in PNG. In 2011, we drew on surveillance work and methodology testing carried out during previous trips to PNG, where CABI staff and PNG's Coffee Industry Corporation's (CIC) research and extension officers had worked together to extend the national surveillance strategy for CBB in PNG, and we completed a report recommending a standardized surveillance methodology to be adopted by PNG. To help implement this, in 2012 UK staff travelled to Aiyura in PNG to run a training workshop aimed at equipping personnel with skills and knowledge to recognize the signs and symptoms of CBB damage and what to do if a suspected infestation were discovered. Elements of scolytid morphology and taxonomy and CBB characters were covered in the course, but the main emphasis was on being able to identify infestations through the use of a combination of field characters and morphology. In total there were 28 course participants from a wide geographic area of PNG, thus ensuring their expertise would be available widely in the country.

In addition to the training course, UK staff contributed to a two-day biosecurity meeting held in Kainantu in PNG, which discussed an emergency response plan and its implementation if CBB were to be detected. CABI presentations provided stakeholders from industry and government with the latest recommendations resulting from work carried out during this project.

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Training workshop participants (numbers in green circles) came from across PNG

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 in 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 coconuts (*Cocos nucifera*) and banana (*Musa* spp.). Populations of up to 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 GEF 'Mitigating the threats of invasive alien species in the insular Caribbean' programme with co-financing from the Government of Trinidad and Tobago Ministry for Food Production. The objectives are to design and implement a sampling programme to estimate RPM population densities on coconuts and native palms, in addition to estimating densities of native entomopathogenic fungi and natural enemies associated with RPM within the swamp during one wet season and one dry season. The project is also screening 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.

During 2012, links were made with the Forestry Department to obtain permits to undertake sampling within the Nariva Swamp. Surveys were initiated in October 2012 and impacts of RPM, and natural enemy and acaropathogenic fungi densities, were recorded on a range of native palms in the swamp. Early indications from results are that RPM has been able to establish on moriche palms (*Mauritia flexuosa*) within the protected 'Bush Bush' area of the Nariva Swamp, but no RPM were found on the royal palm, manac palm or cocorite palm (*Roystonea oleracea, Euterpe oleracea, Attalea maripa*). An acaropathogenic fungus was isolated from mites collected in the swamp, but not from RPM. This isolate will be screened along with isolates from CABI's GRC. Several previously unreported mite predators were also recorded in association with RPM. Further results will be reported in 2013.

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Coconuts exhibiting RPM symptoms at the entrance to the Nariva Swamp (photo: B. Taylor)

Gibellula pulchra, a spider pathogen collected during surveys in October 2012 (photo: B. Taylor)

CABI and Forestry Division scientists sampling palm leaflets in the Nariva Swamp (photo: B. Taylor)

Drought-affected coffee
(photo: P. Baker)

adapting to climate change

The Coffee & Climate Initiative (**www.coffeeandclimate.org**) is a public–private partnership funded by the BMZ (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung, Germany) programme develoPPP, SIDA and a number of coffee companies including Tchibo, Lavazza, Tim Hortons and Paulig. CABI, along with Hanns R. Neumann Stiftung and GIZ are implementing the project. The objective is to help smallholder farmers especially to adapt to climate change.

CABI's specific task for 2012 was to evaluate how climate change is affecting coffee production in three project localities – Brazil, Vietnam and the Trifinio zone of Central America – and advise on pilot adaptation activities in farmers' fields.

The evaluation was accomplished by a triangulation process whereby field data are collected from farmers and extension workers and then compared with available meteorological data and scientific studies. We asked farmers: what are your main production problems? In order to avoid affecting the answers, we did not ask leading questions and did not mention climate change. We asked similar questions to local experts, principally extension workers.

In parts of all three pilot countries, climate featured as a production problem, though the intensity and nature of specific difficulties varied. Farmers' and extension workers' responses were very similar. Scientific data were sometimes harder to interpret and this has led to the initiative commissioning work, especially to present meteorological data in a form that is relevant to coffee growing (e.g. to show how climate has changed over the past 30 years to corroborate field results).

Having gathered these data, we have used them as a basis for developing pilot field adaptation activities, focusing on areas of particular concern resulting from the triangulation process. A principal problem everywhere is increasing drought coupled with failing water supplies, so much of the field effort is oriented to adaptation tools to reduce soil evaporation and improve water supply to coffee trees. A major lesson has been that adaptation tools, although having a similar generic origin, will be quite different in specific countries and zones.

Brazilian coffee farmer involved in climate change adaptation trials
(photo: P. Baker)

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Funded by BMZ's develoPPP programme, SIDA and the following European coffee companies: Gustav Paulig Ltd, Joh. Johannson Kaffe AS, Löfbergs Lila AB, Neumann Gruppe GmbH, Tchibo GmbH, Fondazione Guiseppe e Pericle Lavazza and Tim Hortons.

Erosion in coffee in Central America following severe storms
(photo: P. Baker)

Farmer workshop in Vietnam (photo: P. Baker)

introduction

As Plantwise activities expand across the globe, CABI staff based in the UK have been working closely with CABI's centres in other regions to support activities in countries worldwide. Plantwise makes a major contribution to CABI's Knowledge for Development objectives through strengthening capacity of agricultural institutions and organizations to identify and respond to plant health problems. Too often major initiatives focus on single issues in specific cropping systems; although these approaches can have significant impacts, their narrowness does not give them the flexibility to respond to the changes brought about by climate change, rising populations and globalization. Capacity is needed for countries and communities to innovate and respond to the challenges and opportunities of a constantly changing environment. Plantwise aims to improve countries' capacity to identify and manage crop health problems by improving the advisory services and strengthening the organizations that make up the plant health system. CABI staff work with national partners to put in place networks of clinics and catalyse changes and new ways of working among stakeholders, which increases system capacity to respond to new and emerging crop health problems.

CABI's UK staff also provide a number of key supporting activities to the Plantwise programme including the provision of expert diagnostic services. The UK-based laboratory provides diagnosis and treatment advice to plant clinics when local diagnostic support is not available.

The core training modules and materials for extension staff are developed and managed in the UK, including the translation of materials into many languages.

The collection and interpretation of data from the clinics is an important activity that helps to inform and support decision makers in the Plantwise countries. The Plantwise data manager is based at CABI's centre in the UK and works closely with the Knowledge Bank team to develop processes to collect and manage clinic data and provide quality assurance.

In 2012 Plantwise worked in 24 countries in Africa, Asia, Latin America and the Caribbean and helped to set up approximately 413 clinics to provide advisory services to farmers in their areas.

Dannie Romney, Global Director, Knowledge for Development

Plant doctors receiving Module 1 training in Hanoi, Vietnam (photo: R. Reeder)

Plant doctor handing a prescription sheet to a farmer at a plant clinic in Uganda (photo: R. Reeder)

Plantwise supporting the development of plant health systems

UK staff contribute to the Plantwise initiative by providing support to CABI's country coordinators in Africa, Asia and Latin America. This year the focus of activities has been on developing the partnerships necessary to create a solid framework for the establishment and expansion of plant clinics. An important step in this process has been the creation of national forums to discuss and plan activities with stakeholders together with the election of national coordinators. The national coordinators' role is to oversee the operation of the clinics programme and to monitor the collection and analysis of pest and disease data. UK support staff found themselves fully engaged in supporting the training of the new plant doctors and developing materials and methodologies for use within the programme.

Plant clinics work at the grassroots level to give farmers practical solutions to problems and collect vital information on the frequency and distribution of pests and diseases. They are the entry point for engaging with government, extension, input suppliers, and research, and are the thread that draws together these institutions to form a cohesive plant health system. The involvement of all partners is essential in ensuring the sustainability of clinics and embedding them within the framework of the participating institutions.

A key facet of the Plantwise programme is the training of extension staff to become plant doctors. The training materials consist of a series of modules teaching different aspects of plant health. Modules 1 and 2 are prerequisites for becoming a plant doctor and teach the principles of field diagnosis and how to give practical disease management recommendations to farmers. These materials underwent considerable revision by UK staff throughout the year with the development of video guides and the initiation of a training manual to backstop what is learnt through the courses.

UK staff provided in-country support to CABI country coordinators in the delivery of the training modules with significant progress being made in all of the 15 Plantwise countries supported.

The Plantwise Diagnostic and Advisory Service underwent restructuring this year with the services being brought under the Bioservices' umbrella. The service offers advice and identifications of plant pests and diseases from plant samples received from around the globe. The service uses in-house expertise to offer authoritative identifications of bacteria, nematodes and fungi. 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, although certain restrictions apply (see website for more details: **www.plantwise.org/**).

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Group photo of participants at Plantwise Module 1 training in Guangxi Province, China (photo: R. Reeder)

supporting plant health systems in Africa, Asia and the Americas

During 2012 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 four of the seven African Plantwise countries: the Democratic Republic of the Congo (DR Congo), Rwanda, Tanzania and Uganda. A total of 107 plant doctors were trained and 48 new clinics established across these countries. Training in the production of factsheets resulted in the development of 15 factsheets for Rwanda and 32 for Tanzania, written in both English and Kiswahili. A national forum meeting organized in DR Congo brought together the heads of 12 institutes in the region. In Uganda local government and university staff participated in the first training of trainers session. This is an important first step for the scaling up of the plant clinic programme within a country. Although clinics have been operating for some time in Uganda, the official Plantwise launch took place in 2012, led by the Commissioner for Crop Protection.

Asia

The existing Plantwise countries of Bangladesh, Nepal, Pakistan, Sri Lanka and Vietnam were joined in 2012 by Afghanistan, China, Cambodia and India. One hundred and ninety-two new plant doctors were trained across these nine countries and a further 78 new clinics established. In China, as well as clinics being established in the Beijing area and Guangxi Province, discussions were held with the plant protection agencies to strengthen the links between diagnostic laboratories and plant clinics. In Afghanistan good progress was made with the development of an operating plan for the Bamyan region. Factsheet writing training given in Cambodia, Vietnam and Pakistan resulted in 50 factsheets being produced in 2012 with more planned for next year.

the Caribbean and Central America

UK-based staff supported CABI country coordinators in three Caribbean and two Central American countries. In the Caribbean a total of 54 plant doctors were trained, with eight clinics operating in Trinidad, eight clinics in Grenada and two clinics in Barbados. Training on how to write factsheets was also carried out in each of the three countries producing a total of 53 factsheets. Honduras saw the establishment of nine plant clinics run by 23 newly trained plant doctors. Training on how to write factsheets produced 13 factsheets for use in Honduran clinics and the first plant health campaign was conducted. Plantwise activities continued in Nicaragua increasing the total number of clinics to 18 and plant doctors to 23. Thirteen new factsheets were produced and a training of trainers session created 15 new plant doctor trainers.

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Plant doctor Mr Lee inspects a grape sample brought into the plant clinic in Guangxi Province, China (photo: R. Reeder)

Ministry of Agriculture staff in Barbados examine a citrus sample brought in by a local farmer (photo: P. Taylor)

Rwandan farmers bring their crop samples to a plant clinic session held at a market in Rwanda (photo: N. Phiri)

Trainee plant doctors practise completing the clinic prescription form during plant doctor training in Rwanda (photo: N. Phiri)

In-country partners running a pilot plant clinic during Plantwise Module 1 plant doctor training in Cambodia (photo: M. Rutherford)

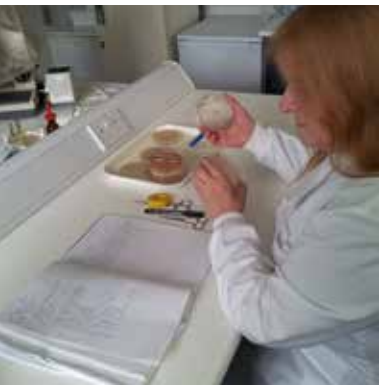
Plantwise diagnostic activities

Establishment and strengthening of plant health systems, based on a network of plant clinics that provide information and management advice to farmers, is central to the Plantwise concept. However, to ensure pest and disease outbreaks are tackled appropriately and effectively, any information and advice offered to farmers must be based on accurate diagnosis of the plant health problem in question. During 2012, CABI's UK staff progressed a number of activities to develop diagnostic capacity within Plantwise, and to specifically support the needs of the plant clinics. This included assistance in the training of in-country personnel to become plant doctors capable of establishing and regularly running plant clinics that provide a direct diagnostic service to farmers and others in rural agricultural communities. Module 1 training focuses on development of an individual's ability to differentiate and ultimately diagnose abiotic and biotic problems. It also provides information and guidance on the role and importance of diagnostic laboratories to plant clinics, and how samples and specimens should be prepared and submitted to laboratories for examination.

Ideally, plant doctors and other partners in Plantwise countries should be able to access diagnostic support within their own country, rather than sending samples and specimens elsewhere. To facilitate this, a survey has been initiated to identify local organizations and laboratories that already provide a diagnostic service, and to determine the scope of services and information resources available. Survey results are compiled into a 'Directory of Diagnostic Services', which can be viewed and downloaded from the Plantwise Knowledge Bank. Work has also progressed to identify, develop and assess mechanisms by which national partners, and plant clinics in particular, can more readily access diagnostic support within or beyond their national boundaries. In 2012 efforts were focused on Southeast Asia to develop national diagnostic networks and strengthen the links between diagnostic organizations including CABI's centre in Southeast Asia where a clearing house has been established to direct samples to the most appropriate regional diagnostic capacity.

Diagnostic support is also available through the Diagnostic and Advisory Service, located at CABI in the UK. Funded by Plantwise, this service can receive samples from anywhere in the world and, subject to conditions, offer free diagnoses and advice to Plantwise partners. The extensive capacity of experts at CABI in the UK to diagnose and advise on problems caused by bacteria, nematodes and fungi is supplemented by the Microbial Identification Service also operating there, and expertise on viruses, phytoplasmas and arthropod pests provided by Diagnostic and Advisory Service partner organizations in the UK such as Fera.

See the Plantwise website (**www.plantwise.org/**) for further information on Plantwise diagnostic activities.



Examination of plant pathogenic fungi in the Plantwise Diagnostic and Advisory Service laboratory (photo: M. Rutherford)

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Front cover of the first edition of the 'Directory of Diagnostic Services' produced for Vietnam (photo: M. Rutherford)

Location of diagnostic services in Southeast Asia as highlighted in Knowledge Bank pest distribution maps (photo: M. Rutherford)

developing data validation protocols for the Plantwise programme

The plant clinics offer a means of collecting grassroots information about the frequency and distribution of pests within a country. These data offer exciting possibilities for countries to detect and monitor pest outbreaks and apply resources in a coordinated manner. However, how do we know that the pests reported are being accurately identified and that plant doctors are giving the best quality advice? One means of monitoring this is by examining the data being collected from the plant clinics and assessing the quality of the diagnoses and advice given through a process of validation.

Validation identifies where abnormalities and internal inconsistencies in the data exist. This helps to identify potential problems with procedures and/or gaps in the knowledge of plant doctors. Targeted training can then be given to improve the quality of the data and advice being given to farmers. Data that do not pass validation are either disregarded, or further information requested to support their inclusion in country records.

Protocols for validating the data have been produced in consultation with country partners and are under pilot testing. In the future, validation will be undertaken by expert validators within country as they are best placed to ensure that locally relevant control options are recommended.

Validated records are fed back to the national data manager for dissemination to national stakeholders. These include policy makers and the extension staff who actually collect the information. Feedback of this nature is essential as it allows decision makers to plan national and regional strategies and extension staff to feel that they are performing a useful function within the plant health system. The feedback to the plant doctors is critical if improvements in the quality of information recorded and advice given to farmers is to be improved.

Through a network of plant clinics and careful examination of the data it may be possible to detect new disease outbreaks within a country. These need to be verified through laboratory testing and consultation with the National Plant Protection Office. Information on new diseases discovered through plant clinics remains under the control of the national government and only when permission is granted will CABI make the clinic data available to a wider audience through publication in journals and on the Plantwise Knowledge Bank website.

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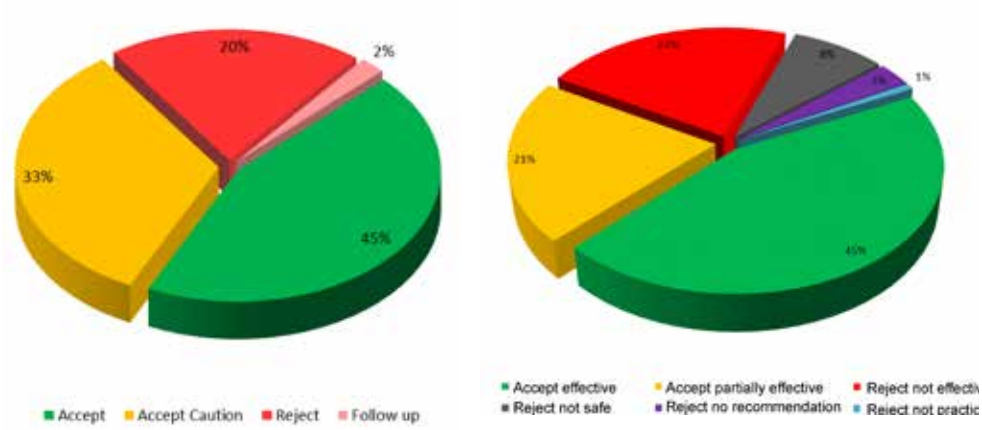
Trainee data validators get to grips with the Kenyan plant clinic data at the national data validation workshop in Kenya (photo: R. Reeder)

validation results for diagnosis

validation results for recommendations



Example of validation results for diagnosis and recommendations. With improved training and feedback from the validation process we would hope to see the number of rejected records reducing over time (photo: R. Reeder)

A student at a training session in Sri Lanka practises filling in the Plantwise prescription sheet (photo: P. Taylor)

development of Plantwise training material

Plantwise training material has continued to be refined and developed and material is now available in a variety of languages including Chinese, French, Portuguese and Spanish.

Distribution of Plantwise training material was originally through the provision of 'memory sticks' but now much of it is available through the online trainer web portal. Password-protected, the locked material can be downloaded in a few minutes even with a poor internet connection. The portal allows updates to be provided to everyone quickly so that all trainers are working with the most up-to-date material. Instructional videos are also available, which provide clear instructions on how to deliver the training and the important messages behind that training. This material is not only for CABI trainers but for local partners who are increasingly involved in the training of plant doctors.

To increase the amount of extension material produced under the auspices of Plantwise and to cement the idea, central to Plantwise, that there should not be an over-reliance on chemical control, a 'Pest Management Decision Guide' (PMDG) training course has been developed. PMDG training is broadly based on an idea that originated from CABI's former International Organization of Biological Control and follows the same 'green–yellow–red' traffic light system. Extension material, which is produced during this training, encourages the use of non-chemical means to tackle pests and to choose chemical intervention only if these are ineffective. To further increase environmental awareness within the clinics, CABI has amalgamated international lists of undesirable (but sometimes legal) chemicals and this is provided to the plant doctors as part of the Module 2 training.

The data produced by the clinics are valuable to national officials for policy and strategy development. A Plantwise Online Management System has been developed, which allows sophisticated manipulation and interpretation of the data. Data management training has also been developed to show how to use the data 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 and need reliable data to inform decisions.

Newly qualified plant doctors celebrate in their clinic uniforms in Uganda (photo: P. Taylor)

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Ugandan students examining chemical inputs as part of Module 2 training (photo: J. Buwule, Landmark Media Consultants)

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

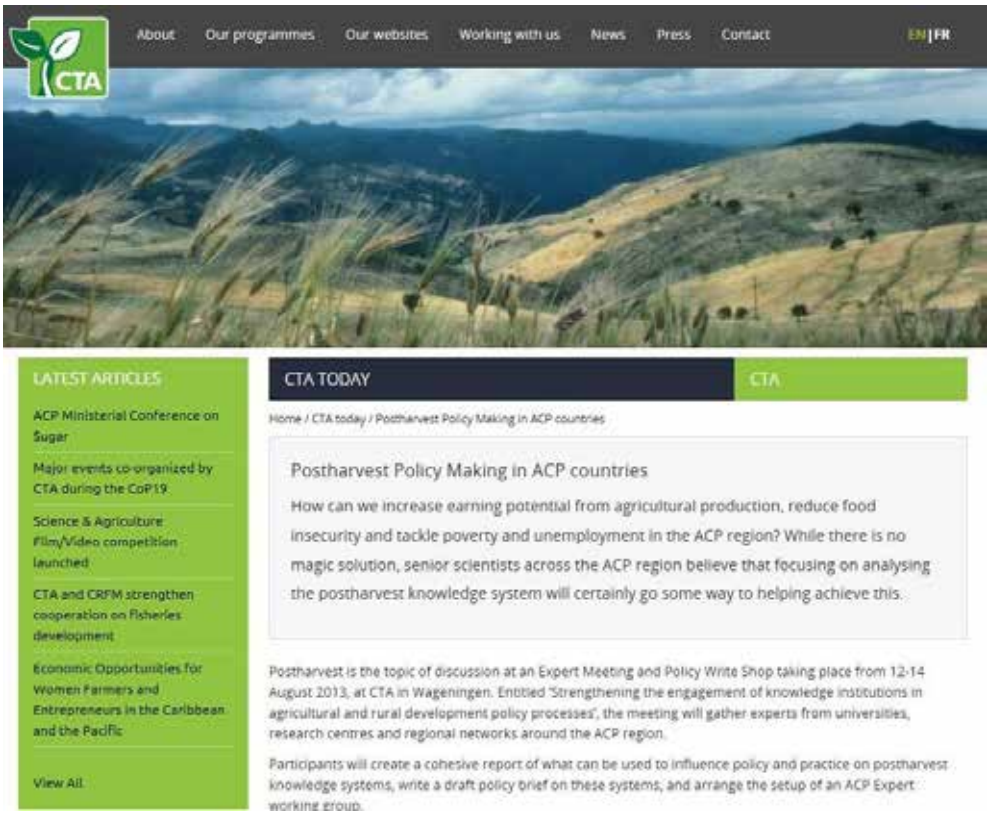
compilation of folders for CTA's Knowledge for Development bilingual website

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 2012, this involved commissioning scientists to write lead articles on topics such as innovations in tertiary agricultural education, technological advances in the livestock and fisheries value chain, and innovations in poultry processing and production. 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, these are translated before posting on the website so that they are available in both languages to be of maximum use to the ACP community.

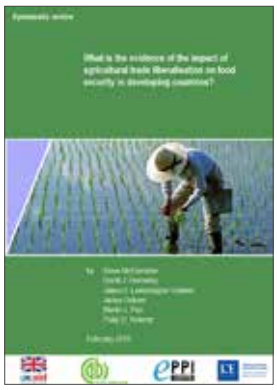
In addition to commissioning the lead articles, the project involves the identification of key documents and links relevant to particular topics. In the second phase of this project, links and documents for phosphorus depletion, indigenous fruits and vegetables, and measuring impacts of research and development have been identified and made available with descriptions in French and English. The folders are available at: **knowledge.cta.int/index.php/en/Dossiers/**

CABI: **D. Hemming** (d.hemming@cabi.org), **J. Lamontagne-Godwin** (j.lamontagne-godwin@cabi. org) and **M. Parr** (m.parr@cabi.org), in collaboration with **J.A. Francis** (CTA). Funded by CTA.



Dossier-specific online scientific and policy literature, as well as specific articles, commissioned by CABI, were integrated onto the CTA platform for open access by the world's international development community

systematic review on ‘What is the evidence of the impact of agricultural trade liberalization on food security in developing countries?’



Food security remains a crucial issue in many developing countries, especially given recent commodity price spikes, and the impact of trade reforms such as the Doha Round is the subject of debate. CABI conducted a systematic review on behalf of DFID to examine the evidence of the impact of agricultural trade liberalization on food security in developing countries.

The argument that openness to trade contributes to economic growth and is in turn beneficial for poverty reduction and food security is well grounded in conventional economic theory, and is supported by some studies. However, the apparent lack of success in stimulating development in many rural economies following economic and trade policy reform programmes has resulted in a wide-ranging debate that has recently broadened to consider the impact of not only domestic structural adjustment programmes, but also globalization forces, including the global trade reform agenda. Systematic reviews involve using objective criteria to find the literature relevant to the question and then extracting the data from these papers to compare studies of different sizes and that use different techniques fairly. They were pioneered in the field of medicine but are increasingly being used in new fields such as agricultural economics. The study involved a team with search, socio-economics, statistics and systematic review skills from CABI, and an external collaborator who is an expert in the specific subject area of the investigation.

The systematic review focused specifically on the evidence for links between agricultural trade liberalization in developing countries and food security. It involved an in-depth appraisal of 34 studies that addressed this issue. The evidence indicated no consistent outcome, as 13 studies suggested that agricultural trade reform has led to an improvement in food security, while ten studies reported a decline. The remaining 11 studies indicated a more mixed outcome. We highlighted a number of issues that are pertinent to linking agricultural trade reform with food security outcomes, including how food security is measured, the context in which agricultural trade liberalization occurs and the different methods used to assess its impact on food security. The uncertainty surrounding them underpins why no unambiguous outcome emerged from the current evidence. These points were used in the review as a means of interpreting the individual studies. We found that prices and price transmission (the relationship between two – or more – price series) play a central role in effects on food security. We suggested specific aspects of further research needed to understand the links between trade and food security.

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introduction

Bioservices is one of the four science themes in CABI's International Development strategy, and is based at CABI's centre at Egham. Bioservices provides microbiological expertise and resources in both service and research activities, with particular emphasis on agricultural and biotechnological applications. The present day Bioservices can trace its origins to the Imperial Bureau of Mycology that was founded in 1920, and in 2012 it continues to provide services in support of the identification and characterization of fungi and bacteria.

Bioservices provides services in six areas: microbial identification, culture sales and deposit, environmental and industrial investigation, contract research, publications and training. The laboratory and training aspects are underpinned by two major resources, the Culture Collection and the Molecular Biology facility. Bioservices works closely with CABI's publishing division to produce the *Index of Fungi* and the *Bibliography of Systematic Mycology*, and Bioservices staff produce CABI's *Descriptions of Fungi and Bacteria* series and contribute to the CABI *Distribution Maps of Plant Diseases*. Bioservices scientists continue to produce significant numbers of peer-reviewed publications, together with invited book chapters and other journal articles.

The laboratory-based services are used by a wide range of CABI's International Development projects and academic and commercial clients worldwide. Bioservices provides identification service support to the Plantwise programme through the activities of the Plantwise UK diagnostic unit. The Environmental and Industrial Biology laboratory also works closely with Conidia Bioscience Ltd, providing research and development and testing.

The year 2012 saw a number of significant developments for Bioservices. The bacterial identification achieved accreditation to ISO17025 under UKAS. Both industrial consultancy and microbial identification business from commercial customers grew during the year and work with Conidia Bioscience Ltd was focused on developing new testing capabilities with particular advances in developing a new test for particular bacterial fuel contaminants. The involvement of CABI Bioservices in establishing and developing genetic resource centre networks further developed during 2012, with the start of the MIRRI (Microbial Resources Research Infrastructure) project within the ESFRI (European Strategy Forum on Research Infrastructures) roadmap.

An overview of some Bioservices services and resources in 2012 is presented in this report. The stories given demonstrate some of the major directions of our current services and research and, while space limits reporting on all of our activities, I hope that they give an overall indication of the continuing developments in the Bioservices portfolio.

Paul Bridge, Director, Bioservices

the Microbial Identification Service

The Microbial Identification Service provides a worldwide service for the identification of filamentous fungi, yeasts and bacteria. Our clients come from a range of industries, mainly the pharmaceutical, food and manufacturing sector, as well as plant pathologists, plant health authorities and researchers working in agriculture, horticulture, forestry, quarantine, biodiversity assessment and biological control. In 2012, the Microbial Identification Service gained UKAS accreditation to ISO 17025 for the molecular identification of bacteria. This service is unique in the UK, as it is the only service to be UKAS accredited for the entire identification process including providing the name of the organism.

In addition to identifications, the service provides DNA fingerprinting analysis. This enables detailed characterization to assess similarity of individual strains. It is also used both to validate reference organisms and to produce reference profiles of proprietary strains. The latter is often necessary in order to comply with the requirements of regulatory authorities for purposes such as strain release.

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

Identifications undertaken for commercial organizations account for around 80% of our business, with 20% provided to research establishments. In 2012, a total of 1135 identifications were provided to 53 organizations from 17 countries.

Regulatory authorities recommend genotypic identifications as preferable to those based on phenotype. All bacteria and yeasts and the majority of fungi are processed using this technology. For bacteria, the standard method used is to sequence part of the 16S rRNA (ribosomal RNA) gene subunit. Identifications of filamentous fungi and yeasts are carried out by sequencing the internal transcribed spacer (ITS) region of the rRNA gene cluster. This locus encompasses ITS1-5.8S-ITS2, the region which is 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 team of taxonomic specialists, to establish the sample's identity. In cases where determination to species level cannot be resolved using ITS sequencing, alternative loci are sequenced. An example is the genus *Fusarium*, which contains many significant plant pathogens. In this case, part of the translation elongation factor 1α (TEF) gene is sequenced to provide definitive identification. Specialized methods also include sequencing of part of the calmodulin gene to distinguish closely related species of *Aspergillus*, and sequencing of the beta-tubulin gene to establish the identity of *Penicillium* species.

As part of CABI's member country benefits, the Microbial Identification Service, in conjunction with Plantwise, provides a free service to member countries in bands 1–4. This service provides specifically for identification of bacteria and fungi of agricultural importance or origin, relating to food security or plant health, including quarantine organisms. Within each qualifying member country, the free service is available to national and regional agricultural research centres, government institutions responsible for agriculture, and university departments whose studies relate to agricultural research. Thirteen organizations from a total of seven member countries benefited from this free service in 2012.

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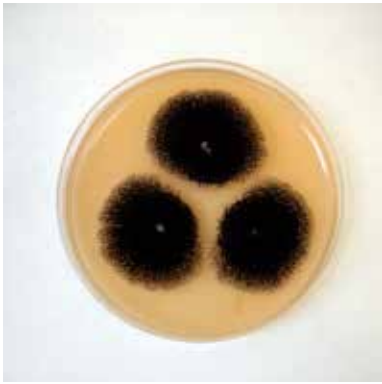


Culture of *Aspergillus niger* (photo: T. Caine)

Alan Buddie operating the genetic analyser (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 Genetic Resources Collection (GRC) holds over 28,000 living 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 also 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 from 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. In 2012, presentations were given to the Society for Low Temperature Biology meeting 'Advances in Low Temperature Biology' held at the Linnean Society, London, and the annual meeting of the European Culture Collections' Organisation (ECCO) held in Braga, Portugal.

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 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) within the Budapest Treaty (1977).
- The collection is a partner in the Global Biological Resource Centre Network (GBRCN) demonstration project.

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 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**).

During 2012 the collection provided cultures and safe deposit services to external clients and collaborators. We provided cultures and other preservation services for CABI's 'in-house' activities including projects in CABI's International Development projects and the operation of the CABI Bioservices business. Collection expertise was provided to the EU European Consortium of Microbial Resources Centres (EMBaRC) and MIRRI projects.

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 the British Antarctic Survey (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 our Genetic Resources Collection (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 2011–12 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: **M. Ryan** (m.ryan@cabi.org), **L. Offord** (l.offord@ 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)

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

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

CABI's David Smith is on MIRRI's Steering Committee

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

Microbial resources are essential raw material for advancing human health, food security, biotechnology, research and development in all life sciences but to date less than 1% of the estimated number of known species are described and able to be harnessed by man.

When new species are discovered, expertise is needed to accurately identify them. Modern tools for identification, such as public sequence databases, are expanding rapidly but the information in them is often of poor quality and not backed up by biological material. In addition, millions of strains are sourced for research without proper authentication, so easy access is required to high-quality biological materials and associated information to provide innovative solutions to global problems.

Microorganisms also need to be used in such a way that they deliver fair returns to the places from which they originate. With resources fragmented across Europe, there is a need for coordination, common standards and sharing of activities.

The European Commission (EC) has funded the preparatory phase of MIRRI which is on the ESFRI roadmap 2010. It brings together 16 public microbial resource centres (in Belgium, France, Germany, Italy, the Netherlands, Poland, Portugal, the Russian Federation, Spain and Sweden) and is supported by 17 European and several non-European collaborating partners to build a pan-European coordinated research infrastructure dedicated to microbial diversity. The project aims to connect microbial resource centres with their academic and industrial users, policy makers, funders and researchers in order to deliver resources and services more effectively and efficiently.

MIRRI's microbial resources for biotechnology innovation will accelerate the discovery process

MIRRI will also build links internationally, including in the Americas, Asia and Africa, facilitating CABI to support its regional activities particularly in Brunei, Chile, Kenya and Malaysia to improve the understanding and use of microbial diversity. With the current global economic challenges, MIRRI will help spread the financial burden of global research. This work will help focus activities to resolve key problems and address the big challenges in healthcare, food security, poverty alleviation and climate change.

MIRRI will provide researchers with high-quality microbial resources and aid the preservation of organisms collected through research. MIRRI will work with biotechnologists to ensure they get the right microorganisms with the properties they need for product development, therefore accelerating the discovery processes.

Overall, this project will encourage and facilitate innovation, research and development in pharmaceutical, biotechnological, healthcare and agriculture. It will also help deliver the EU's Innovation Union goals, address social challenges and support the competitiveness of the EU in the knowledge based bio-economy.

CABI: **D. Smith**, Project Manager (d.smith@cabi.org), in collaboration with Deutsche Sammlung von Mikroorganismen und Zellkulturen GmbH, Germany; Institut Pasteur, France; Service Public Fédéral de Programmation Politique Scientifique, Belgium; Koninklijke Nederlandse Akademie van Wetenschappen – KNAW, the Netherlands; Culture Collection, University of Gothenburg, Sweden; Universidad de València, Colección Española de Cultivos Tipo, Spain; Belgian Coordinated Collections of Microorganisms/Bacteria Collection, BCCM/LMG, Universiteit Gent – Department of Applied Mathematics and Computer Science, Universiteit Gent, Belgium; Institut National de la Recherche Agronomique – Centre International de Resources Microbiennes, France; Jacobs University Bremen, Germany; Micoteca do Universidade do Minho, Portugal; Mycotheca Universitatis Taurinensis, Italy; Universidad de las Islas Baleares, Spain; All-Russian Collection of Microorganisms, Institute of Biochemistry and Physiology of Microorganisms, Russian Academy of Sciences, Russia; Institute of Agricultural and Food Biotechnology, Culture Collection of Industrial Microorganisms, Poland; Università San Martino, Italy. Funded by the EC (grant agreement no. 312251).

Environmental and Industrial Biology

The Environmental and Industrial Biology 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 meet the principles of 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 challenging items to mould growth against any recognized published standard or to a customer's own specification. 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 the method produced by the Institute of Petroleum, this quantifies fungal and bacterial contamination of aviation and diesel fuels. In this aspect of our work we have a close working relationship with Conidia Bioscience Ltd, based on-site at Egham.

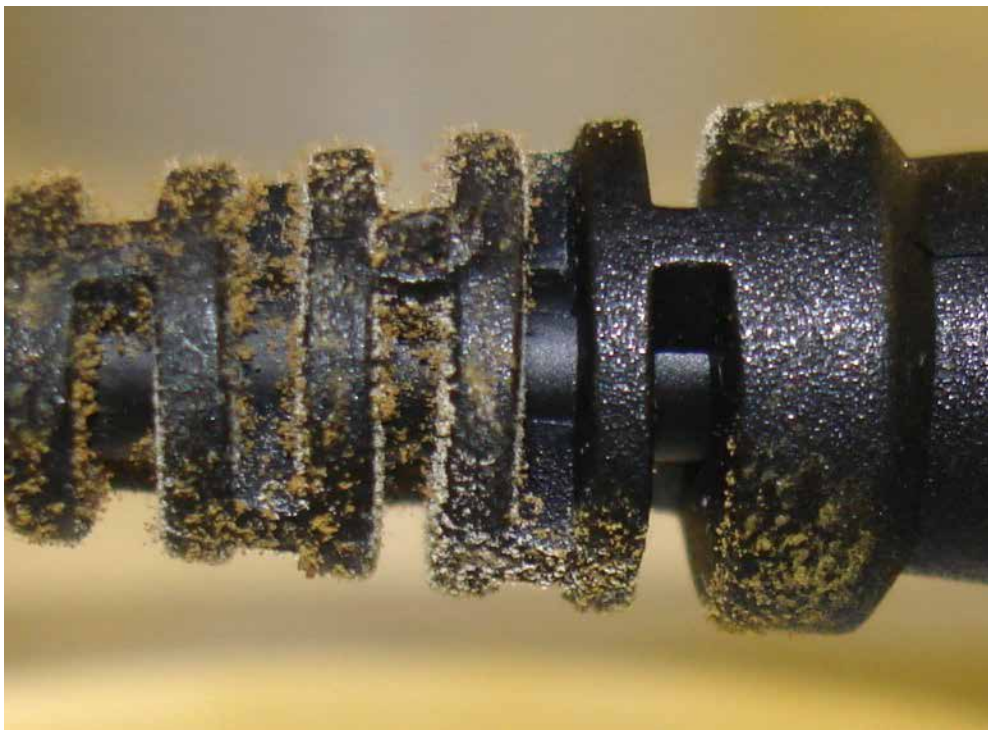
In addition, we offer an isolation and identification service to which customers submit contaminated samples for analysis.

In 2012 Environmental and Industrial Biology launched a companion product to the Fungal Sampling Kit called the Environmental Monitoring Kit, which is a method for carrying out a primary evaluation of airborne fungal spores in the home or workplace. The kit is extremely easy to use and is provided with full instructions. Once returned to the Environmental and Industrial Biology laboratory for analysis, it is examined for total counts of fungi and can be scanned for specific organisms such as *Aspergillus fumigatus* or *Stachybotrys chartarum*, both of which are fungal species implicated in health concerns.

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

Packing cases exposed to damp are vulnerable to fungal growth (photo: G. Godwin-Keene)

Air sampling taking place in a property where a leaking shower has caused extensive fungal growth (photo: G. Godwin-Keene)



Mould growth tests highlight areas in a product that are prone to fungal problems (photo: G. Godwin-Keene)

PCR products being prepared for agarose gel electrophoresis (photo: L. Tymo)

Our qPCR machine has enhanced our capability for molecular diagnostics (photo: L. Tymo)

Molecular Biology

The Bioservices Molecular Biology group is a cross-cutting department which underpins the three Bioservices business units. It continues to be the driving force behind the Microbial Identification Service (see p.53) and 2012 saw a major undertaking that led to us attaining UKAS accreditation for our bacterial identifications, which are done entirely by molecular means. This places us in a unique position, certainly in the UK, with regard to bacterial identifications. The group also provides molecular identifications and bacteriology where needed by the Environmental and Industrial Biology laboratory; and undertakes quality-control checks for the GRC in order to validate the identity of cultures, where appropriate, and to assess genomic (in)stability. A growing area for us has been in contract research in a variety of fields, particularly involving strain characterization.

Our collective experience in applied microbiology and molecular biology has meant that, in addition to our service activities, we have been able to undertake a wide range of activities linked to both our own and other CABI projects and consultancies, and for external clients.

We continue to work closely with the GRC, Environmental and Industrial Biology and Conidia Bioscience Ltd. This has allowed us to conduct some further interesting work on fuel microbiology including the maintenance – and characterization – of bacterial consortia involved in various sulphate-reducing environments.

There is an ongoing eagerness to adopt new techniques in the laboratory. We developed and optimized our real time PCR (also known as quantitative PCR or qPCR) methodology. This was of significant benefit in a large third-party plant health screening programme for oil palm aimed at the detection of a quarantine wilt pathogen in commercial pollen for export (see p.33). The techniques developed will have great future potential for enhancing Bioservices (and Plantwise) diagnostic capabilities.

Our involvement in the NERC low-temperature biopesticide project has included characterization of the relevant strains (by DNA fingerprinting) and their metabolites (by thin-layer chromatography and high-performance liquid chromatography).

We ran our second molecular identifications course during the year and this was as well-received as the previous year's. Finally, we have built on our links with RHUL and have just embarked upon a study of the fungal biodiversity of green/living roofs with Professor Alan Gange as part of a jointly supervised PhD programme.

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

homegardens as a form of sustainable agriculture, invasive plants and resilience in social-ecological systems – a survey of homegardens in Kerala, India

Changes in the environment that affect ecosystems impact on the ability of people to achieve livelihood security which can result in increased vulnerability. Invasive alien species (IAS) are second only to habitat loss as a cause of biodiversity decline. In Kerala, south India, homegardens are the traditional form of agriculture and represent examples of small social-ecological systems (SES). This research outlines the characteristics of homegardens; their diversity and changes over time considering factors influencing farmers' cropping decisions and vulnerability to invasive plants. Semi-structured interviews were conducted with 30 households, including two participatory components – a photo activity and a farm walk. An ecological site assessment also took place and in-depth interviews were conducted with two women's self-help groups and three macro-level representatives. Data collection and analysis used both qualitative and quantitative methods. The findings suggest that, with increasing global connectivity, the economy is becoming cash crop orientated in accordance with reports of a similar worldwide trend from diverse agroforestry systems to cash crop production. In addition, there is an extremely high abundance of invasive plants in the study area, the most prevalent being *Mikania micrantha*, *Mimosa diplotricha* and *Chromolaena odorata*.

In conclusion, changes in farming practices alongside IAS domination of the landscape result in a general homogenization of the environment, which in turn increases the vulnerability and reduces the resilience of the SES. With ever-increasing growth and use of trade routes in addition to factors such as climate change, system resilience must be enhanced to maintain both biodiversity and essential ecosystem services. The future resilience of traditional homegardens as sustainable SES ultimately relies on policy, institution and extension support, which are also pivotal in IAS management.

MSc student (Practising Sustainable Development): **Kate Jones**; University: Royal Holloway, University of London (School of Geography). Supervisors: **Dr J. Mistry** (RHUL), **Dr S.T. Murphy** (CABI); and **Dr K.V. Sankaran** and **Dr V. Anitha** (Kerala Forest Research Institute). Date awarded: October 2012.

an ecological assessment of *Impatiens glandulifera* in its introduced and native range and the potential for its classical biological control

The diversity of vegetation, the above- and below-ground invertebrate community, and the soil mycobiota are intrinsically linked. However, few studies have assessed the impact of non-native invasive plant species at all levels. Here, dynamics of vegetation complexity, the invertebrate community, and abundance of arbuscular mycorrhizae (AM) were evaluated in relation to the abundance of the non-native plant *Impatiens glandulifera* at sites in the UK.

The abundance of above-ground detritivores, herbivores and predators was significantly lower in invaded sites compared to uninvaded sites. The below-ground community showed significant fluctuations within and between years; however, the overall abundance of the below-ground community showed no significant difference. At a species level, monocultures of *I. glandulifera* on exposed riverine sediments impact on the ground beetle community by increasing the abundance of generalist ground beetles in the habitat. The presence of *I. glandulifera* may act to reduce the conservation potential of exposed riverine sediments by increasing competition between generalist and specialist carabid species.

An evaluation of the impact of *I. glandulifera* on AM fungi and native plant performance revealed that below invaded stands, the levels of AM fungi are reduced and this has the potential to impact on native plant performance. These results suggest that invasion by *I. glandulifera* can lead to fragmented, destabilized ecosystems which require sensitive habitat restoration post-removal.

Since 2006, research has been conducted to evaluate the natural enemies on *I. glandulifera* in its centre of origin in the northwestern Himalayas. The autoecious, monocyclic rust pathogen *Puccinia komarovii* has been highlighted as having considerable potential as a biological control agent. A comparison of the ecology of *I. glandulifera* in the native and introduced ranges suggests that *I. glandulifera* performs better in the introduced range and one of the major influencing factors is the release from its coevolved natural enemies.

PhD student: **Rob Tanner**; University: Royal Holloway, University of London, UK; Supervisors: **Professor Alan Gange** (School of Biological Sciences, RHUL) and **Dr Sean Murphy** (CABI). Date awarded: March 2012.

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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
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 Co-ordinator 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
Thomas Sarah, Plant Pathologist
Thompson Emma, Project Scientist (& Centre Project Manager)
Crozier Jayne, Plant Pathologist (seconded through the CABI centre in Trinidad to CATIE, Costa Rica to June; UK-based thereafter)
Ritchie Barbara, Plant Health Specialist
Rutherford Mike, Project Manager, Commodities

Knowledge for Development

Boa Eric, Global Director, Plant Health Systems Development
Reeder Rob, Plantwise Data Manager
Kelly Paula, Plantwise Clinics Coordinator (to 29 February 2012)
Taylor Philip, Plant Health Systems Coordinator

Knowledge Management

Lamontagne-Godwin Julien, Project Scientist (& KFD)

Bioservices

Bridge Paul, Director
Dorsett Allison, Group Administrator and Office Manager
Blench Cindy, Administrative Assistant
Buddie Alan, Molecular Biology Operations Manager
Caine Thelma, Identification Operations Manager
Cannon Paul, Principal Mycologist (to 31 October 2012)
Clayton Teresa, Prep Room Manager
Godwin-Keene, Georgina, Environmental and Industrial Microbiologist
Hudson Ken, Mycology Publications Coordinator
Kasulyte Daiva, Molecular Microbiologist
Kermode Anthony, Preservation Technician, Bioservices
Kirk Paul, Mycology Consultant (to 31 October 2012)
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
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
Cock Matthew, Chief Scientist
Flood Julie, Senior Global Director, Commodities
Kelley Joan, Executive Director, Global Operations
Pearce Trinity, PA to Executive Director Global Operations
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
Mays Steve, HR Operations Manager
Muiruri Alice, Finance Officer
Prickett Carol, Finance Officer
O'Sullivan Kevin, Site Maintenance Officer (from 19 November 2012)
Vine Les, Site Maintenance Officer (to 28 September 2012)
Viney Ann, Receptionist and Administrator (from 1 February 2012, maternity cover)
Wall, Louise, Receptionist and Facilities Administrator

Emeritus Research Fellows

Bridge John
Evans Harry C.
Hunt David (from 21 May)
Waller Jim

CABI Europe UK Associates

Bentley Jeffery, Agricultural Anthropologist
Harling Rob, Plantwise Country Coordinator

temporary staff

Aldridge Emily, Field Assistant, Invasive Species (1 May – 2 November))
Clewley Gary, Field Assistant, Invasive Species (from 1 May)
Pollard Tom, Field Assistant, Invasive Species (6 June – 31 August 2012)

about CABI

what does CABI do?

CABI (**www.cabi.org**), originally established in 1910, is a not-for-profit, science-based development organization, operating under an international treaty agreement amongst its, currently 48, member countries, registered with the United Nations. It has a Headquarters Agreement with the Government of the United Kingdom 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 also 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

AAFC	Agriculture and Agri-Food Canada
AAU	Assam Agricultural University (India)
ACIAR	Australian Centre for International Agricultural Research
ACP	African, Caribbean and Pacific (group of states)
ADAS	*formerly* Agricultural Development Advisory Service (UK)
ALPSP	Association of Learned and Professional Society Publishers
AM	Arbuscular mycorrhizae
APCC	Aquatic Phycomycetes Culture Collection
ARC-PPRI	Agricultural Research Council – Plant Protection Research Institute (South Africa)
BAS	British Antarctic Survey
BBSRC	Biotechnology and Biological Research Council (UK)
BCCM/LMG	Belgian Coordinated Collections of Microorganisms/Bacteria Collection)
BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung/Federal Ministry for Economic Cooperation and Development (Germany)
BSR	Basal stem rot, *Ganoderma boninense*
CAAS	Chinese Academy of Agricultural Sciences
CABRI	Common Access to Biotechnology Resources Information
CBB	Coffee berry borer, *Hypothenemus hampei*
CBC	Classical biological control
CBD	Convention on Biological Diversity
CGS	Coffee green scales, *Coccus* spp.
CIC	Coffee Industry Corporation (PNG)
CNP	Chitwan National Park (Nepal)
CPHST	USDA-APHIS Center for Plant Health Science and Technology
CSDPA	Utthan Centre for Sustainable Development and Poverty Alleviation, Allahabad (India)
CTA	Technical Centre for Agricultural and Rural Cooperation
CTFC	Centro Tecnológico Forestal de Catalunya (Spain)
DAFF	Department of Agriculture, Fisheries and Forestry (Queensland, Australia) (*formerly DEEDI*)
DEEDI	Department of Employment, Economic Development and Innovation (Queensland, Australia) (*now DAFF*)
Defra	Department for Environment, Food and Rural Affairs (UK)
DFID	Department for International Development (UK)
DGIS	Directorate-General for International Cooperation (the Netherlands)
DNA	Deoxyribonucleic acid
DR Congo	Democratic Republic of the Congo
EC	European Commission
ECCO	European Culture Collections' Organisation
EHP	Eastern Highlands Province (PNG)

EMbaRC	European Consortium of Microbial Resources Centres
ERA-ARD	European Research Area - Agricultural Research for Development (EC)
ESFRI	European Strategy Forum on Research Infrastructures
EU	European Union
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 (Argentina)
GBRCN	Global Biological Resource Centre Network
GDP	Gross domestic product
GEF	Global Environment Facility
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (Germany)
GPS	Global positioning system
GRC	Genetic Resources Collection (CABI)
HVH	High-value horticulture
IAS	Invasive alien species
ICAR	Indian Council of Agricultural Research
ICCO	International Cocoa Organization
ICCRI	Indonesian Cocoa and Coffee Research Institute
ID	CABI's International Development division
IDA	International Depository Authority within the Budapest Treaty (1977)
IEC	International Electrotechnical Commission
IFGTB	Institute for Forest Genetics and Tree Breeding, Coimbatore (Tamil Nadu, India)
INIFAP	Instituto Nacional de Investigaciones Forestales y Agrícolas y Pecuarias, Veracruz (Mexico)
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)
KEPHIS	Kenya Plant Health Inspectorate Service
KFD	Knowledge for Development (CABI)
KFRI	Kerala Forest Research Institute (India)
KM	Knowledge Management (CABI)
KNAW	Koninklijke Nederlandse Akademie van Wetenschappen (the Netherlands)
KUL	Katholieke Universiteit Leuven (Belgium)
LIFT	Livelihoods and Food Security Trust Fund (Myanmar)
MIL	United States Military (Standard)

MIRCEN	Microbial Resource Centre (UNESCO)
MIRRI	Microbial Resource Research Infrastructure (EC)
MLN	Maize lethal necrosis
MoA	Ministry of Agriculture (China)
MOAI	Ministry of Agriculture Indonesia
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
PCR	Polymerase chain reaction
PMDG	Pest Management Decision Guide (Plantwise)
PNG	Papua New Guinea
qPCR	Quantitative PCR
RHUL	Royal Holloway, University of London (UK)
RINSE	Reducing the Impact of Invasive Non-native Species in Europe (EU project)
RPM	Red palm mite (*Raoiella indica*)
rRNA	Ribosomal ribonucleic acid
RSPB	Royal Society for Protection of Birds (UK)
s.e.m.	Standard error of the mean
SABCL	USDA South American Biological Control Laboratory
SAIS	South Atlantic Invasive Species (project) (RSPB)
SDC	Swiss Agency for Development and Cooperation
SES	Social-ecological systems
SIDA	Swedish International Cooperation Development Agency
SPC	Secretariat of the Pacific Community
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
UKOTs	United Kingdom Overseas Territories
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESP	Universidade Estadual Paulista (Brazil)
USDA	United States Department of Agriculture
USDA-APHIS	USDA Animal and Plant Health Inspection Service
USDA-FS	USDA Forest Service
WFCC	World Federation for Culture Collections

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