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Final report

Small research and development activity

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1 Acknowledgments

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2 Executive summary

The objectives of this small research and development activity were to:

1. Scope the potential for the development of a Centre for the Biocontrol of Eucalypt Pests, enabling improved international collaboration on invasive pests of eucalypts and their natural enemies.

2. Provide a focal point for R&D of natural enemies of eucalypt pests using *Thaumastocoris peregrinus* (the priority pest for South Africa, Brazil, and other countries) as a case study.

3. Develop an 'over the horizon' surveillance network for emerging biosecurity threats to protect Australia's planted and native forests. Initially this would focus on eucalypts, but in the future could also be expanded to include *Acacia* and areas where Australian-developed *Pinus* germplasm is deployed.

These objectives were achieved through a variety of targeted project activities. These included:

1. Presentation of the project concept by Dr Lawson to the IUFRO Forest Health Joint Meeting, "Pathogens, insects and their associations affecting forestry worldwide" held in Uruguay in November 2011. A side meeting was held and attended by 10 interested parties representing collaborators and potential collaborators in South Africa, Brazil, Argentina, Uruguay and Israel. Five broad themes for the biological control of eucalypt pests globally were developed at this meeting.

- Identifying new potential biocontrol agents and wider genetic diversity in existing agents
- Host specificity testing of biological control agents
- Data-basing (including barcoding) of agents released around the world
- Enhancing information sharing and communication.
- Assessing the potential impact of the Convention on Biodiversity (CBD) and Access and Benefit Sharing (ABS) on biocontrol.

A project development workshop was held in Hanoi in February 2012 for potential Southeast Asian partners (Vietnam, Laos, Thailand, Malaysia and China) to define the needs for biological control in the region.

- The blue gum chalcid, *Leptocybe invasa*, was the agreed priority target pest for this region and work was subsequently commenced on developing a concept proposal for a large-scale ACIAR project focussed on this pest in the region.

A week long meeting and associated field tour of affected eucalypt plantations was held in South Africa in March 2012 with the SRA project's South African and Brazilian collaborators to prioritise biological control activities supporting the eucalypt plantation industries in those countries and the wider global industry.

- The bronze bug, *Thaumastocoris peregrinus*, was the agreed priority target pest for South Africa and Brazil, with the blue gum chalcid also very important for both countries. There was overlap with other pests, but Brazil has some unique challenges.

- It was considered that the required R&D in Australia to support activities in these countries would need to come mainly from direct industry funding, leveraged against other funding sources. Such work would synergise and assist with potential ACIAR project activities in SE Asia.

Following the successful establishment of a core 'centre' focussed on SE Asia (ACIAR funded) and Brazil and South Africa (Industry/Government funded) consideration should be given to adding additional countries (e.g. Argentina, Uruguay, China, Portugal, India etc.) as soon as practicable on an equitable funding basis commensurate with industry size.

2. A total of seven shipments of the bronze bug (*T. peregrinus*) egg parasitoid *Cleruchoides noackae* were made to South Africa (4 shipments) and Brazil (3 shipments) between September 2011 and June 2012. All collections were made by Dr Ann Noack from *T. peregrinus* populations from Sydney and Nowra, depending on availability.

These shipments enabled cultures of *C. noackae* to be maintained in both receiving countries and have supported specificity testing and basic studies into the biology and behaviour of this parasitoid. For Brazil, this resulted in *C. noackae* being released from Quarantine restrictions in early July 2012 for subsequent multiplication of numbers in the University of São Paulo's laboratories before controlled plantation releases. The parasitoid remains under Quarantine restrictions in South Africa.

3. The IUFRO meeting in Uruguay and the project development workshop/meeting in Vietnam and South Africa have contributed to establishing an informal network of researchers interested in pests of eucalypts around the world. Those who attended these meetings have been registered as users of the project website (http://bicep.net.au), where a 'newsblog' page has been established to facilitate conversations on emerging threats to plantations around the world. There is also a password protected 'Members' page where more confidential information can be shared.

The site is still very much under development, but we anticipate adding a significant amount of new content by October 2012. The site has so far (as at 20 July 2012) had 1,304 views since it went live in early November 2011 (the total includes site development visits). The busiest day (January 6, 2012) had 66 views.

In summary, the recommendations of the project are that:

- Consideration should be given to establish a 'Centre' in Australia to address a demonstrable need for improved global coordination of approaches to the effective biological control of Australian-origin eucalypt pests.
- Such a 'Centre' could be supported by both government agencies such as ACIAR with a focus on in-need countries, and by the international eucalypt plantation industry, especially from countries with well-developed, mature plantation industries (e.g. Brazil, Argentina, Uruguay and Chile in South America, South Africa, China, and European countries). Significant synergies and cost-savings could be achieved by such an approach.
- As part of this 'Centre', priority should be given to establishing a regional, large-scale ACIAR project in SE Asia focussed on biological control of the blue gum chalcid, *Leptocybe invasa*, as the core.

3 Introduction

Introductions of invasive Australian pests and pathogens to the major eucalypt plantation growing regions overseas have accelerated and this is likely to continue into the future as volumes of trade and movements of people increase (Lawson et al. 2010 and Murphy et. al in prep). Not only has the rate of these introductions increased, but the speed with which these insects have subsequently invaded other regions following the initial introduction has also increased. Examples include the gall wasps *Leptocybe invasa* and *Ophelimus maskelli* and the sap-sucking bug *Thaumastocoris peregrinus*. These insects were either unknown (*L. invasa*) or very poorly known (*T. peregrinus*) in Australia prior to them being found overseas. Together, speed of invasion and the lack of basic biological knowledge on these insects are compromising efforts to coordinate and optimise biological control programs around the world. Colleagues in South Africa and Brazil have highlighted the inadequacy of the current piecemeal approach to the identification, evaluation, selection, collection and shipping of natural enemies to affected regions and have emphasised the need for a more coordinated and cooperative approach.

Within Australia, herbivorous pest insects can exploit eucalypt plantation monocultures and reach damaging population densities before native natural enemy populations can respond. Certification for sustainability (e.g. through the Forest Stewardship Council and the Australian Forestry Standard) limits the ability of eucalypt growers to apply broad-spectrum insecticides as control measures and emphasises biological control-based approaches to pest management. There is therefore a growing need in Australia to reduce pest populations by means other than by conventional approaches.

Endemic insects that attack eucalypts in Australia have a suite of co-evolved natural enemies that provide some regulation of pest populations in plantations. For many of these pests, little is currently known about what natural enemies are present in plantations and the role they play in population regulation. More research is thus required to obtain a detailed knowledge of these natural enemies to support develop of management approaches, such as augmentative biological control and tritrophic manipulation.

In addition, endemic insects and pathogens overseas that have host-switched to eucalypts (e.g. the cossid moth *Coryphodema tristis*) or are extreme generalists (e.g. Gypsy Moth) pose a biosecurity threat to Australia's plantations and native eucalypt forests (Paine et al. 2011). A recent example is the introduction of Myrtle Rust (part of the guava/eucalypt rust complex) to Australia in 2010. New pests and pathogens of eucalypts overseas are constantly emerging and Australia urgently needs to establish an active 'over the horizon' surveillance network in the world's major eucalypt growing regions to proactively assess and manage risk.

This project aimed to address the needs outlined above through scoping the formation of a 'Centre' in Australia which would (a) coordinate the evaluation and provision of biological control agents (initially to South Africa and Brazil, but in future years more widely), (b) research the role natural enemies play in pest population regulation in Australian eucalypt plantations and how this may be enhanced, and (c) form a network focussed on forest biosecurity with an emphasis on eucalypt pests and pathogens.

The specific objectives of this small research and development activity were to:

1. Scope the potential for the development of a Centre for the Biocontrol of Eucalypt Pests, enabling improved international collaboration on invasive pests of eucalypts and their natural enemies.
2. Provide a focal point for R&D of natural enemies of eucalypt pests using *Thaumastocoris peregrinus* (the priority pest for South Africa, Brazil, and other countries) as a case study.

3. Develop an ‘over the horizon’ surveillance network for emerging biosecurity threats to protect Australia’s planted and native forests, Initially this would focus on eucalypts, but in the future could also be expanded to include *Acacia* and areas where Australian-developed *Pinus* germplasm is deployed.

A side meeting and two workshops/meetings were held to evaluate the need for better coordination of biological control efforts worldwide. These were:

- Side meeting at the International Union of Forest Research Organisation Forest Health Joint Meeting "Pathogens, insects and their associations affecting forestry worldwide" in Uruguay, November 2011.
- Project development workshop in Vietnam, February 2012
- Project development meeting with South Africa and Brazil in South Africa, March 2012.

4 Project Development

4.1 IUFRO Forest Health Joint Meeting "Pathogens, insects and their associations affecting forestry worldwide".

This meeting provided an ideal opportunity to gather together many of the potential key participants in eucalypt insect biocontrol around the world, and in South America in particular. A brief report on the meeting was also posted on the BiCEP website (http://bicep.net.au/?p=575)

4.1.1 Presentation

Project leader Dr Lawson presented a paper entitled "Eucalypt insects - pests at home and abroad: the growing need for a coordinated approach to biological control". The abstract is reproduced below:

Abstract:

"Eucalypt insects - pests at home and abroad: the growing need for a coordinated approach to biological control". Lawson, S.A., Nahrung, H.F, Griffiths, M.W. Murphy, B.D., Wylie, F.R.

Pests of Australian origin are a worldwide problem following the large-scale expansion of eucalypt plantations over the last few decades. In the absence of co-evolved natural enemies, Australian eucalypt herbivores can reach devastating population densities and rapidly colonise new regions. Introductions of invasive Australian pests to the major eucalypt plantation growing regions of the world have accelerated over the past 10 – 20 years - a trend likely to continue as volumes of trade and movements of people increase. Not only has the rate of introductions increased, but the speed with which they have subsequently invaded other regions following the initial introduction has also increased. Examples include the gall wasps *Leptocybe invasa* and *Ophelimus maskelli* and the sap-sucking bug *Thaumastocoris peregrinus,* insects which were unknown (*L. invasa*) or poorly known (*T. peregrinus*) in Australia prior to being found overseas. Together, their speed of invasion and the lack of basic biological knowledge on these insects compromise efforts to coordinate and optimise biological control programs around the world. This highlights the inadequacy of the current piecemeal approach to the identification, evaluation, selection, collection and shipping of natural enemies to affected regions and emphasises the need for a coordinated approach. Within Australia, such herbivores also exploit artificial monocultures represented by eucalypt plantations and reach damaging population densities before natural enemy populations can respond. Furthermore, overseas herbivores and pathogens have adapted to colonise and exploit eucalypt plantations, presenting a significant risk to plantation productivity there, and a significant biosecurity threat to Australia. There are therefore complementarities between the needs of eucalypt growers overseas and in Australia in relation to managing pests through biological control and for monitoring future threats. An opportunity therefore exists to establish a 'centre' in Australia to research and assist in coordinating biological control efforts for both local and international eucalypt growers.

The full presentation is included as **Appendix 1**.

4.1.2 IUFRO Conference side-meeting

Following conference presentations at the IUFRO joint meting on the 8th November 2011, an informal side meeting was organised for those participants interested in the biological control of eucalypt pests and to progress ideas for project development.

Meeting attendees:

Prof Mike Wingfield, Prof Bernard Slippers, Dr Jeff Garnas, Dr Brett Hurley (Forestry and Agricultural Biotechnology Institute, South Africa); Prof Carlos Wilcken (Forestry Science and Research Institute [IPEF], Brazil); Dr Leonardo Barbosa (Embrapa Forestry, Brazil); Prof José Cola Zanuncio (University of Viscosa, Brazil); Dr Eduardo Botto (National Institute of Agricultural Technology [INTA], Argentina); Dr Gonzalo Martinez (National Agricultural Research Institiute [INIA], Uruguay); Dr Dror Avisar, Futuragene,

Five broad themes for eucalypt pest biological control were identified during the course of the meeting.

1. Identifying new potential biocontrol agents and wider genetic diversity in existing agents.

Biocontrol solutions are likely to be different in different parts of the world, so genetic diversity is required. Research in Australia would provide a greater range of options and better biogeographic matching to different regions around the world. Target species could initially be:

- *Thaumastocoris peregrinus*: basic biological/ecological discovery work on what natural enemies are present where, and how effective they are. This would be guided by an enhanced understanding of the pest insect's centre of origin, assisted by molecular ecological studies. The latter work could start very soon.
- *Glycaspis brimblecombei* and *Gonipterus scutellatus*: Collecting already established natural enemies (*Psyllaephagus bliteus* and *Anaphes nitens*, respectively) from geographical locations/hosts better suited to areas overseas where the current biotypes are not effective. This should also be backed up with molecular ecological studies.
- *Leptocybe invasa* and *Ophelimus maskelli*: Uncovering the complex ecological relationships within galls and assessing which natural enemies may be most effective.

2. Host specificity testing of biological control agents

Australia has an important role to play in supporting specificity testing of agents around the world. Preliminary testing in Australia can be carried out without the need for quarantine, and test insects can be field-sourced most of the year. This testing would supplement that being carried out in individual countries, providing additional data that could be used in release assessments. In addition, some nations (e.g. Uruguay) do not have quarantine facilities and so depend on others in the region (e.g. Brazil, Argentina) or Australia to carry out testing. This also applies to developing countries around the world.

<u>Bronze Bug</u>

- Host specificity testing of the *Thaumastocoris peregrinus* egg parasitoid *Cleruchoides noackae* and other potential biocontrol agents (such as the *Ooencyrtus* sp. (Encyrtidae) that has occasionally been reared out in Quarantine labs).

In particular, there is a need to test these agents against other genera within the Thaumastocoridae and on other species within the genus to ascertain their parasitic status. For example, *C. noackae* could be tested in Australia against the endemic *Baclozygum*/*Onymocoris* spp. in place of the *Discocoris*/*Xylastodoris* spp. in S. America that are hard to find/test against, and also against the closely related *T. safordi* that occasionally outbreaks in spotted gum plantations in the subtropics. Testing could also be carried out against other insects that co-occur with *T. peregrinus* on eucalypts to establish if parasitoids utilise alternate hosts in the natural environment.

3. Data-basing (including barcoding) what agents have been released around the world

Documentation on what potential biocontrol agents have been tested and rejected or released, their source, when and where releases were made and efficacy post-release is currently only recorded haphazardly. Systematically compiling this information would assist in answering questions such as: Ophelimus has recently been found in Indonesia with associated parasitoids. What are they and where was their origin? Barcoding of agents would assist in targeting future collections and climate/host matching to release locations.

4. Enhancing information sharing and communication.

Information sharing and communication is absolutely vital to the success of biological control programs. Rearing methods for *T. peregrinus* and *C. noackae* are an example. Sharing techniques would enhance the prospects of success in quarantine specificity testing programs and potentially reduce the lag between importation and release. Sharing of specificity testing results is also very important in expediting the release approval process. Given the current impatience of growers awaiting solutions to these pest problems, this is a high priority. The security of the BiCEP collaborative website as a central repository of this knowledge would assist in these collaborations.

5. Impact of Convention on Biodiversity (CBD) and Access and Benefit Sharing (ABS) on biocontrol.

Issues arising from these international processes are beginning to impact negatively on the on-the-ground application of biological control in some countries. In addition, regulatory authorities in many countries are now dominated by environmental agencies and are less responsive to industry needs. Plantation forestry therefore needs to be active in shaping how new ABS protocols are implemented in each country (see recent Editorial by the IOBC President in this regard). There is one channel already available which could be used to further these goals and another which potentially could be developed. These are:

- IUFRO Working Party 7.03.13 – Biological control of forest insects and pathogens (Dr Marc Kenis is coordinator).
- Form an IOBC working group on plantation forestry biological control. Among the 20 current working groups there is only one that is forestry related and that has a highly specific focus (oaks).

4.2 Vietnam Project Development Workshop

Following discussions with Dr Ian Naumann, Director, SPS Capacity Building Program, Office of the Chief Plant Protection Officer, Australian Department of Agriculture Fisheries and Forestry (DAFF), a decision was made to jointly run project development workshops in Hanoi, Vietnam, focussed on forest health in the region. Cost savings for each organisation were achieved through this cooperative approach. The workshops were held from the 15-17 February 2012 (DAFF 15th and 16th & ACIAR 17th) and generously hosted by the Forest Science Institute of Vietnam (FSIV) at their Hanoi headquarters.

Six participants were invited from what were seen as the key countries in the SE Asian region that could be interested players in these projects (i.e. Vietnam, Laos, Thailand, Indonesia, Malaysia and China). Country representatives were:

- Dr Pham Quang Thu, Head of the Forest Protection Research Division, Forest Science Institute of Vietnam, Vietnam
- Mr Sounthone Ketphanh, Deputy Director of Forestry Research Center, National Agriculture and Forestry Research Institute, Laos
- Mr Supachote Eungwijarnpanya, Group Leader, Royal Forest Department, Thailand
- Mr Neo Endra Lelana, Head of Forest Protection Division, Forestry Research and Development Agency (FORDA), Indonesia
- Dr Su-See Lee, Head, Forest Health and Conservation Programme, Forest Research Institute, Malaysia
- Dr Xudong Zhou, Head of R & D Platform, FuturaGene Biotech (Shanghai) Co., Ltd. (formerly Professor, China Eucalypt Research Centre, Chinese Academy of Forestry)

The Australian Department of Agriculture, Fisheries and Forestry funded air travel and accommodation associated with the DAFF forest health surveillance and capacity building workshop for the overseas participants, and the ACIAR project funded Dr Lawson's air travel, his accommodation and accommodation associated with the ACIAR workshop for the overseas participants. Mr Sounthone Ketphanh from Laos was unable to attend the meeting at the last moment due to transport difficulties, but sent a presentation that was delivered by Dr Pham Quang Thu of Vietnam.

4.2.1 Workshop Agenda

1. Introduction to the need for coordinated biological control for Australian invasive eucalypt pests worldwide (S. Lawson - IUFRO presentation – Attachment 1)

2. Country Reports (see section 4.2.2 for summaries of these reports and Appendixes 11.2 to 11.7 for the presentations)

3. Discussion points

3.1. What is/are the priority Australian eucalypt insect pests in your country?

3.1.1. Thailand

3.1.2. Malaysia

3.1.3. Laos

3.1.4. Vietnam

3.1.5. Indonesia

3.1.6. China

3.2. What other Australian insects not yet established are of major concern for your country?

- *Thaumastocoris*
- *Ophelimus*
- *Glycaspis*

3.3. What is the status of current efforts against these pests in your country?
   - Identifying resistance taxa/clones.
   - Chemical control.
   - Has a biological control program already been initiated/considered?
   - If, so what progress has been made?

3.4. Biological control capacity within country?
   - Quarantine facilities.
   - Capacity to carry out host specificity testing.
   - Capacity to carry out field releases in multiple sites across country.
   - Capacity to monitor establishment/success of releases?

3.5. How could an ACIAR Project assist you in managing these pests?

4.2.2 Country Reports

Vietnam

Plantation Estate

Vietnam currently has about 400,000 ha of eucalypt plantations. Plantations since 2000 have been mostly composed of *Eucalyptus tereticornis, E. camaldulensis* and hybrids (UxE/ExU) planted in the centre, south and southwest, *Eucalyptus urophylla* in the north and *Eucalyptus microcorys* and *E. saligna* in the central highlands

Key Pests

There are a number of endemic pests that have adapted to eucalypt plantations in Vietnam, with some causing significant damage. These include defoliators such as the Lappett Moth (*Trabala vishnou*) and stem borers such as *Aristobia testudo*, *Sarathocera lowi* and *Zeuzera coffeae*.

The most significant pest in Vietnam at present is the invasive Australian gall wasp *Leptocybe invasa*. This pest can be controlled with chemicals in the nursery but not in the field. Chemical control has been trialled in the field but was not effective and if used can lead to environmental problems. Surveys are urgently needed to define the range of this pest in Vietnam.

In addition, a second invasive Australian gall wasp, *Ophelimus maskelli*, has now been found in Hanoi as of October 2011. As with *L. invasa*, no effective controls are established for this pest and its range outside Hanoi is not known.

Malaysia

Plantation Estate

Currently Malaysia has a very limited estate of eucalypt plantations and any future expansion will be mainly in Sabah and Sarawak. Sabah presently has only 150 ha established, but with a future target of 8000 ha. Sarawak currently has approx 5000 ha established, mostly of *E. deglupta* and *E. pellita*, and these have been established very recently (all approx.1 y.o.). The estate may expand somewhat in the future as some growers switch from *Acacia mangium* plantations due to issues with root rot and *Ceratocystis* wilt. In Peninsular Malaysia about 1000 ha of *E. grandis* x *E. urophylla* hybrids have been established by a private individual who brought the germplasm in from China.

Key Pests

Malaysia has a similar range of endemic pests in eucalypt plantations to other SE Asian nations, including the stem borers *Zeuzera coffeae*, *Endoclita hosei* and others, and a variety of foliar and root diseases.

At present, Malaysia has not recorded the presence of either *L. invasa*, *O. maskelli* or any other invasive Australian insects, although extensive surveys have not been carried out.

(NB: *L. invasa* has now been confirmed as present in Sabah on *E. grandis* during a visit by Prof Mike Wingfield (FABI), Dr Su See Lee (FRIM) and Mr David Boden (Boden & Associates, Forestry Consultants) in May 2012)

Thailand

Plantation Estate

Thailand has about 400,000 ha of eucalypt plantations overall, most in the private sector. Taxa planted include *E. camaldulensis*, *E. urophylla* and hybrids.

Key Pests

Leptocybe invasa has been established in Thailand since 2006 and occurs in the North, Northeast and West, where the heaviest damage has been recorded. *E. camaldulensis* and some of its clones are the main taxa affected, but *E. urophylla* and hybrids are also attacked.

With the exception of some ecological studies carried out by the Royal Forest Department (RFD), Kasetsart Univ and the private sector (Sangtongpraow et al. 2011), only limited work on *L. invasa* have been carried out in Thailand and no formal biological control program yet attempted (funding by the RFD has been sought in the past, but has not been successful).

Some parasites have been reared out from galls including: *Megastigmus* spp. (approx. 3 spp.), *Aprostocetus* spp and *Quadrastichus* spp. It is not known if these are the same Australian parasitoids released in Israel or SE Asian natives. Specimens of some of these parasitoids have been sent to Australia/Israel for ID, but with no response as yet. Observed rates of parasitism have not been high.

China

Plantation Estate

China currently has a plantation estate of about 2.6 M ha. Eucalypts are grown in 18 Provinces including subtropical and temperate zones. In the south, the industry is based on <10 clones (major clones are of *E. grandis*, *E. urophylla*, and *E. camaldulensis*), and 70-80% of current plantings are of a single clone meaning the estate is highly vulnerable to pests and diseases.

Key Pests

There are many endemic pest and disease problems, of which diseases alone cause an estimated annual loss of about $70 M according to CERC-FABI Eucalyptus Protection Programme (CFEPP) figures. Some endemic pests are relatively well known including *Buzura supressaria*, a moth defoliator in southern China, but in general the endemic insect pest situation not well understood.

Leptocybe invasa has spread into major eucalypt plantations and is causing significant economic losses. It was first found in Dongxing in Guangxi province in 2007, spreading more widely by 2008 and now has been reported as present in the 1.7 M ha of plantations located in the southern provinces. Again, some parasitoids have been reared out and specimens and photos sent to Dr John La Salle, but no ID's have been forthcoming. There is no effective chemical available, and biocontrol could provide the solution. China believes that regional/global collaboration is the key to achieve the goal of managing this pest.

Indonesia

Plantation Estate

Indonesia currently has a eucalypt estate of about 130,000 ha. A number of *Eucalyptus* spp. are grown in Indonesia but *E. pellita* is the most common species, especially clone EP05. Similarly to Malaysia, the estate is due to expand somewhat as some growers switch from Acacia to Eucalyptus.

Key Pests

Indonesia has a number of endemic insect pests including: *Helopeltis* spp. (Mosquito bugs), *Alcides* sp. shoot borer, termites and the stem borer *Zeuzera coffeae*. *Sycanus* assassin bugs are mass reared for biological control of *Helopeltis* and leaf rollers pests in some Acacia and Eucalyptus plantations.

The Australian invasive gall wasp *Ophelimus maskelli* has been reported as occurring in North and central Sumatra and East Java, since at least 2011.

4.2.3 Presentations

Appendices 2 to 7

4.2.4 Discusssion

Following the country reports discussion proceeded according to the agenda items listed above in 4.2.1.

Priority Pests

Leptocybe invasa was agreed as the current priority pest for Laos, Vietnam, Thailand and China.

Ophelimus maskelli was also an agreed priority pest for Vietnam and Indonesia.

Malaysia has yet to detect either of these pests in its plantations (however, see note above p 12) and Indonesia yet to detect *L. invasa*. Given that *L. invasa* is widely established across the region and with its history of rapid spread across the globe, it is highly likely that it will become established over coming years in plantations in Indonesia and Malaysia. Similarly, given that *O. maskelli* has now been detected in Vietnam and Indonesia it too is likely to invade plantations in other countries in the region in the near future.

Countries were also concerned about the potential spread of other invasives such as *T. peregrinus* and *G. brimblecombei*, but they needed to concentrate their limited resources on the species already established in their countries.

Summary of current management practices

Chemical Control

- Chemical control is not effective as a management tool in the field, but can be used relatively effectively in nurseries.

Biological Control

- There are currently no active biological control programs in any countries represented at the meeting. Private companies have made representations to the Royal Forest Department in Thailand, and companies in Laos have actively been developing a project in collaboration with NAFRI in Laos.

Resistance Screening:

- **Vietnam** - clonal trials were assessed soon after *L. invasa* arrived in the country (Thu et al. 2009). However, the mix of hybrids used in plantations has changed since then and no widespread screening of the new material has been done. *E. urophylla* clone U-6 is known to be susceptible.
- **China** - does have an active screening program, including next generation material. The China Eucalypt Research Centre, Guangxi Academy of Forestry and the Guandong Academy of Forestry are carrying out screening. No screening is done by private companies like Stora Enso, as they buy in seedlings from outside.
- **Indonesia** - none known, but private companies like Asia Pulp & Paper (APP) and Asia Pacific Resources International (APRIL) may be doing some screening internally?
- **Thailand** – Royal Forest Department has an *E. camaldulensis* x *E. urophylla* tree improvement program. Private sector has been planting clone K-7, which is susceptible to *L. invasa.* RFD assists with some field screening.
- **Malaysia** – Importing clonal material from elsewhere.
- **Laos** – Oji Paper has an active screening program.

It was also noted that some work is now proceeding at FABI investigating the mechanisms of resistance to *L. invasa*, which may assist in screening programs in the future (Oates et al. 2012).

Quarantine Facilities

- **Thailand** – Well-equipped facilities are available at the National Biological Control Research Center (NBCRC) at Kasetsart University in Bangkok. This facility has been led by the internationally known biological control researcher Prof Banpot Napompeth
- **Vietnam** – The National Institute for Plant Protection (NIPP) has quarantine facilities in Hanoi.
- **China** – The Guangdong Academy of Forestry has quarantine facilities.
- **Indonesia** – The Agriculture Department in Jakarta has quarantine facilities
- **Malaysia** – The Malaysian Department of Agriculture (DOA) has good quarantine facilities including an insect breeding facility at Serdang, near the Universiti Putra Malaysia (UPM).
- **Laos** – NAFRI has quarantine facilities

Capacity for quarantine testing, field release and subsequent monitoring

This was thought to vary widely across the region, but in general it was identified that all countries would need training in:

- Mass-rearing of insects in quarantine and other facilities.

- Assessment of host-specificity of biocontrol agents.
- Release techniques for biocontrol agents
- Large scale monitoring and assessment of pest populations, damage and levels of natural enemies already present and those to be released.
- Evaluation of establishment of biocontrol agents, including determination of parasitism rates in the field.

Infrastructure Needs

FSIV indicated that they currently have no glasshouse facilities at their Hanoi headquarters to use for rearing purposes, and that they would like to see support for this sort of infrastructure as part of an ACIAR project. It was indicated that China had recently built a 200 m^2 glasshouse for around US$10,000. The question was raised about how ongoing running costs for such a facility might then be funded.

4.2.5 Workshop Conclusions

Target Pests

It was agreed that *Leptocybe invasa* and *Ophelimus maskelli* are the key target pests for SE Asia for a biological control project.

Research Program

Existing natural enemies

Thailand, Vietnam and Laos have been rearing wasps other than the pest from *L. invasa* galls. It is not known whether these are the wasps from Australia that have been released elsewhere as biocontrol agents (such as in Israel), or native species that have adapted to the new pest, such as is apparently the case in India (Kulkarni et al. 2010)

Baseline surveys are therefore required to determine if Australian biocontrol agents are already present and whether native natural enemies have also adapted to parasitising these pests. These surveys would also assess damage levels and economic loss due to gall wasps in plantations and evaluate the effectiveness of currently established biocontrol agents (native or introduced) in reducing populations of *L. invasa* in plantations.

Basic biological studies would also need to be undertaken to understand the ecology of native parasitoids if present. These studies would establish whether these native parasitoids could be manipulated to achieve better population suppression, or if further introductions are needed and guide selection of new biocontrol agents to be introduced.

Sources for new introductions

There are currently three potential sources for biocontrol agents for these gall wasps for the region.

- Prof Zvi Mendel of the Volcani Institute in Israel is the best source for the established biocontrol agents for both *L. invasa* and *O. maskelli*. Wasps can be collected from the field in Israel with ease, but individual agents would need to be sorted by the receiving institution. (*However, both Malaysia and Indonesia indicated that there may be some political issues with them receiving agents directly from Israel. This potential issue would need to be resolved early in the project*). Parasitoids which can be sourced from Israel are:

  <u>For Leptocybe:</u>

  – *Megastigmus zvimendeli* (Torymidae)

- *Megastigmus lawsoni* (Torymidae)
- *Selitrichodes kryceri* (Eulophidae)
- *Quadrastichus mendeli* (Eulophidae)

For Ophelimus:

- *Stethynium ophelimi* (Mymaridae)
- *Closterocerus chamaeleon* (Eulophidae)

- South Africa through FABI has independently identified a potentially effective new Australian biocontrol agent, a wasp parasitoid *Selitrichodes neseri* (Hymenoptera: Eulophidae: Tetrastichinae). It has yet to be released (Kelly et al. 2012), but permission has now been granted for its release from quarantine restrictions (see p. 23, below). FABI also maintains cultures of the 'Israel' agents, but has yet to receive release permission for these.
- Australia could act as a third source of agents, especially to provide greater genetic diversity and better climate matching for selected agents. For example, the *S. neseri* colony at FABI is based on a very narrow genetic base of 6 females and four males, collected from a single location in southeast Queensland.

Potential Problems/Issues

Taxonomy

Obtaining accurate identifications of wasps to determine which biocontrol agents are already present in plantations (introduced or native) in the region is already a major issue. The number of specialist morphological taxonomists available to carry out identifications for these wasps globally is very limited, and of those that can, some, such as Dr John La Salle (CSIRO) are now involved in other roles that prevent them being able to carry out such identifications in a timely manner.

Molecular barcoding techniques may therefore be better suited to quickly identifying biocontrol agents, although there are large start-up costs with establishing the molecular markers for genera and/or species for which primers are not yet established. This would potentially form part of the first part of a large ACIAR project for the region. Once barcoding for known agents has been established, identifications of what agents are present in plantations would become easier and timelier.

4.3 South Africa Project Development Meeting

4.3.1 Introduction:

Formal and informal discussions were held with representatives of FABI & IPEF over a weeklong project development visit to South Africa from 5-9 March, including a three-day field trip to inspect current pest issues in the region. FABI representatives included Prof Mike Wingfield (Director), Prof Bernard Slippers, and Dr Brett Hurley; and from IPEF Prof Carlos Wilcken (Leader Forest Protection Program).

The field trip concentrated on examining the emerging problem that *Leptocybe invasa* is posing to small growers, especially in Mpumalanga province. On the 6 March Dr Lawson, Prof Slippers, Dr Hurley and Prof Wilcken attended a meeting of small growers held at White River to update growers on the FABI research program into control of this insect, including biological control. There was considerable anxiety amongst growers about the lack of availability of resistant germplasm, chemical control methods and the lack of progress in obtaining release of biological control agents. The meeting was a strong illustration of the need to improve efforts to manage these emerging invasive pests, and of the high impact these pests can have on small growers in regional areas.

On the following day the group visited a newly planted area heavily infested with *L. invasa* and likely to require a complete replant. Figures 1 to 3 below illustrate the severity of the damage. Lack of availability of resistant germplasm meant this plantation might not be replanted for some time, resulting in a considerable loss of production for the company involved. Poor silvicultural management contributed to the high level of damage since coppice from the previous crop (a susceptible *E. camaldulensis* x *E. grandis* clone) remained, harbouring a high population of the wasp. A report of the visit appeared in the May 2012 edition of ‘Wood SA and Timber Times’ (Appendix 8)

Formal discussions on the focus and planning for an internationally coordinated biological control program for invasive Australian insect pests commenced on the 7 March with talks between Dr Lawson and Dr Wilcken focusing on the needs of Brazil and of South America more generally. March 8 started with an inspection of the FABI Quarantine laboratory and the research being conducted into biological control of *Thaumastocoris peregrinus* and *Leptocybe invasa*, as well as the associated Sirex biological control laboratory. Further strategic discussions were held in the afternoon with Prof's Wingfield, Slippers, Roux and Wilcken. The outcomes of these discussions are summarised below.

Figure 1: Seedling heavily infested with *L. invasa* galls. Seedling is beginning to lean over due to the weight of galls.

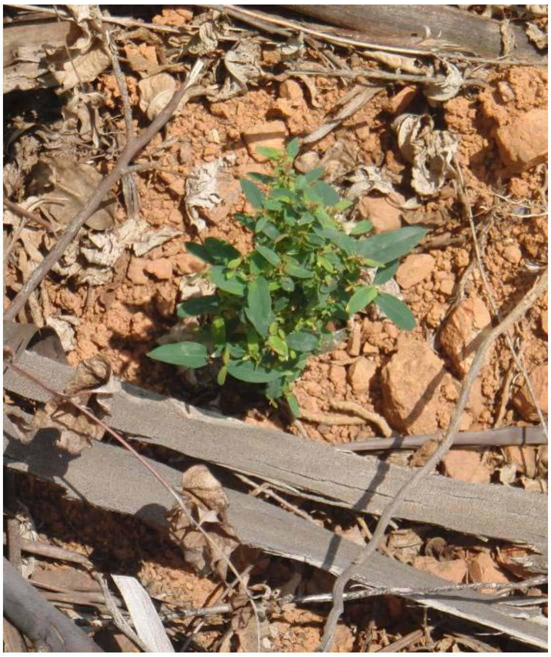

Figure 2: Small seedling already heavily infested with *L. invasa* galls.

Figure 3: Heavily infested coppice remaining on site providing a large source of gall wasps

4.3.2 South Africa and Brazil Priorities

Discussions first centred on the priority pests for each country. These are listed below in Table 1.

Common Priority Pests	Unique to Brazil
Thaumastocoris peregrinus	*Glycaspis brimblecombei*
Leptocybe invasa	*Epichrysocharis burwelli*
Gonipterus spp. complex	

Table 1: *Key priority pests for biological control in South Africa and Brazil.*

All of these species except *T. peregrinus* (and *Epichrysocharis burwelli*, but this is a much more minor pest) have established biological control agents that have been shown either to be effective elsewhere (e.g. *L. invasa* in Israel) or are already established in-country but are not achieving optimal biological control (*Gonipterus* spp. complex and *G. brimblecombei*).

There is therefore a much greater research and supply effort required for *T. peregrinus* in Australia than for the other species and this is where the most promise lies in a cooperative effort between the three countries. This does not preclude research in Australia on the other species, but it was clear that *T. peregrinus* is the number one priority for South Africa and Brazil.

4.3.3 Needs for R&D in Australia

Bronze Bug *Thaumastocoris peregrinus*

Natural enemy collections

- The primary and immediate need for both Brazil and South Africa is for continuing collections of the egg parasitoid *Cleruchoides noackae* to maintain quarantine cultures to support the specificity testing required before release permits can be granted in each country.
- Brazil will require at least 2 or 3 shipments in 2012, S. Africa a similar number. Given that Chile has already released *C. noackae* in the field and it appears to be established there, Brazil may also be able to source collections from Chile.
- Brazil indicated that the approval process there is far enough advanced now that it may be able to make direct releases of *C. noackae* into the field later in 2012. There are ongoing issues with the Governmental requirements and release approval system in South Africa, which is likely to delay any releases of the parasitoid there, however.
- Of the other countries in South America affected by this pest, Argentina through the Instituto Nacional de Tecnología Agropecuaria (INTA), is also now making preparations to import *C. noackae* via BiCEP for specificity testing later in 2012. Uruguay, which also has a significant eucalypt plantation industry (approx 700,000 ha), does not have quarantine facilities and is dependent on Brazil and Argentina to carry out specificity testing and gain release approvals.

Need for alternative biocontrol agents

There was concern expressed during discussions that there is an over reliance and expectation by industry that the egg parasitoid *C. noackae* will be the biological control solution for *T. peregrinus* around the world. There is no certainty that this will be the case. For example, the parasitoid is present in Sydney but rates of parasitism are low and are not preventing yearly outbreaks on street trees. At this time we have no indication of rates of parasitism where it has been released in the field in Chile.

Outbreaks of *T. peregrinus* were not recorded in Sydney prior to the early 2000's (Noack & Coviella 2006; Noack & Rose 2007), so it is possible that the pest is an introduction into Sydney from elsewhere in Australia. We also do not know if *T. peregrinus* is the primary host of *C. noackae*. If it is not the primary host this may help explain the low rates of recorded parasitism. From these discussions several potential research themes were developed.

- Identifying area of origin in Australia of the Sydney population using molecular ecological techniques (see Section 7).
- Conducting targeted collections of *T. peregrinus* from areas so identified (including the native ranges of the most commonly attacked trees in Sydney, *E. scoparia* and *E. nicholi*) and rear out, identify and assess potential alternate biological control agents.
- Target South Africa and Brazil climate-matched areas to identify more appropriate parasitoid biotypes.
- Search for natural enemies of the closely related emerging pest species (*T. safordi*) in northern NSW and southeast Queensland.

Predictive modelling of pest populations

Development of a Dymex® predictive population model for *T. peregrinus* was discussed, particularly in relation to the needs of Brazil, but with potentially much wider application. Research carried out in Brazil has collected the basic biological data (developmental temperature thresholds for all life stages, temperature induced mortality, adult longevity etc.) that is required to drive such a model. Australia, through DAFF- Queensland, has expertise in developing and refining these models for plantations pests, and so such collaboration could be highly beneficial

This population model could be used, e.g. to:

- Develop risk models for different climatic conditions in plantation regions at varying spatial scales, as well as for regions currently not invaded, particularly SE Asia, India and China.
- Predict the levels of egg parasitism and overall mortality required to maintain populations below damage thresholds

Blue gum gall wasp *Leptocybe invasa*

Brazil

Brazil currently has a permit to import and release the Israel sourced parasitoids (see section 4.2.5 above for the list of those available. In addition, they have also recently reared out a native parasitoid wasp from galls and are examining its potential as a biocontrol agent. Brazil is also considering use of the new biocontrol agent *Selitrichodes neseri* discovered by South Africa (see below). Studies on the biology of *L. invasa* including work on its distribution and control in nursery conditions are currently being carried out by students and postdocs.

South Africa

South Africa also has a permit to import Israel sourced parasitoids and currently maintains cultures of these. In addition, it is maintaining a culture of a newly identified parasitoid from southeast Queensland, *S. neseri*, which shows considerable promise as a biological control agent and compares more than favourably under laboratory conditions with the Israel material. Specificity testing has been completed for this wasp, an application for release submitted in November 2011, and which has just been approved (see: http://www.forestry.co.za/good-news-about-leptocybe-biological-control/)

Eucalyptus snout beetle, *Gonipterus* species complex

Both Brazil and South Africa (and other countries such as Portugal) may require further collections of the long-established egg-parasitoid *Anaphes nitens* (and discovery of new parasitoids?) from the correct species in the *Gonipterus* species complex in Australia, and from better climate-matched biotypes. Given the difficulty in identification of the *Gonipterus* complex (morphologically based on the male genitalia) a molecular bar-coding approach to research on this species may also be preferred.

Importation and release in receiving countries should be relatively straightforward since *A. nitens* is already established and should therefore need no further specificity testing.

Red Gum Lerp Psyllid, *Glycaspis brimblecombei*

Glycaspis brimblecombei is a major issue for Brazil and other countries in South America at present, and it is also an emerging problem in other areas such as Mauritius and southern Europe (Italy, Spain, Portugal and France). The principal need is for better climatic matching of biotypes of the parasitoid *Psyllaephagus bliteus* to areas in Brazil where *G. brimblecombei* is causing problems. There may also be a need to search for new parasitoids.

4.3.4 General Discussion

Information sharing (via BiCEP Website)

Enhanced information sharing and communication between researchers and industry in and between affected countries was seen to be an absolutely essential part of project development and for delivering the best biological control outcomes. The BiCEP website (www.bicep.net.au) has been generally well received, but needs a more cooperative approach to providing a greater amount of more timely content. Information on all pests needs updating urgently. It was suggested that a page(s) on current proposed research programs worldwide on the key pests be provided.

It was also considered that the BiCEP website should have a role as a biosecurity network through sharing of information on emerging native new encounter pests and pathogens on eucalypts around the world as well as issues such as native natural enemies that are adapting to introduced eucalypt pests in different countries/regions. The website should house a database with reference to voucher collections of these different agents of international concern or interest.

It was suggested that the project development process should include a budget component for participants to meet once/year. The next most obvious target for such a meeting would be in conjunction with the 4th International Symposium on Biological Control of Arthropods (ISBCA) to be held in Chile from March 4-8, 2013.

Industry and Government Funding

Brazil

In Brazil IPEF widely encompasses the industry across a spectrum of growers (pulp, solid wood and biofuels) and also includes some of the major Uruguayan growers, and so is the key central clearing house for cooperation regarding biological control of eucalypt pests in South America. It has an increasing international profile in forest health R,D&E through Prof Carlos Wilcken who leads the PROTEF (Forest Protection) program.

South Africa

FABI and the TPCP represent the vast majority of players in the South African plantation forest industry and as the pre-eminent forest health R,D&E providers in southern Africa provide linkages to other developing southern African nations, in particular Kenya, Uganda, Tanzania and Zimbabwe which have significant forest industries threatened by *T. peregrinus* and *L. invasa* in particular.

Leveraging Industry Funds

Thought was given to the necessity to make the best use of industry support for the proposed BiCEP R,D&E through strategic leveraging of this funding against governmental funding. It was indicated that in Brazil there were State and Federal programs that may be amenable to this kind of international collaboration. In South Africa the National Research Foundation and direct funding through the National Government's Forest Sector Transformation Charter were also considered potential (but in the Government case somewhat difficult to access) sources of leveraging.

Leveraging was seen as crucial in ensuring project sustainability for a program that may be required to run for a period greater than four years.

Project structure & focus

Two approaches to project development were discussed.

- A long-term program looking at a number of different pests simultaneously. South Africa indicated that its industry may not want to invest in something that appears to be too open ended. In addition, it was thought that priorities and conditions may change quickly, requiring rapid responses within such a program.
- A pest-by-pest project approach. In the first instance, *T. peregrinus* would be the highest priority for both Brazil and South Africa.

Timeframes

ACIAR Project

It was anticipated that, due to lead-in project development times and funding constraints, an ACIAR project focussed on biological control of eucalypt pests would not be able to start until the 2013-14 Australian fiscal year, with a project length of 4-5 years.

Industry funded project(s)

For Brazil, the IPEF General Assembly met in April 2012. A brief of the proposed project was developed for presentation at this meeting and subsequently endorsed unanimously. The Brazilian financial year runs on the calendar year and full project proposals need to be submitted by 31 October 2012 for funding from January 2013 (although some industry members expressed a wish for an earlier start).

For South Africa, a similar brief was developed for the Tree Protection Cooperative Programme (FABI) Board held on 9 May 2012. Supportive feedback was received from this meeting via Prof Mike Wingfield, with qualifications on the need for equitable funding arrangements and development of tightly defined project deliverables

Other Ideas & Issues discussed

A number of other specific ideas related to biological control and international collaboration were briefly raised at the meeting. These included:

- Establish a database of molecular barcodes of eucalypt pests and their natural enemies worldwide. FABI is ideally positioned with its molecular expertise and international network of collaborators to carry out both the barcoding and database hosting.
- Analyse the factors responsible for the invasions of Australian eucalypt pests in order to help prevent further introductions. Some preliminary work on this subject has already been done by DAFF (Nahrung and Swain 2012 (submitted) and Murphy et al. (in prep)). Genetic characterisation of populations of the key Australian eucalypt pests around the world (as referred to above) and of populations of these insects in Australia would also greatly assist in this regard.
- Investigate establishment of 'sentinel' plantings of currently used Brazil/South Africa germplasm in Australia for assessment of resistance/tolerance to the native Australian suite of eucalypt pests and diseases.

  There are practical and budgetary restrictions with such a plan due to quarantine import restrictions on seedlings and tissue cultures in Australia. Under current AQIS entry conditions, such material must be held in a post-entry quarantine facility for a minimum of two years, which may be prohibitively costly to fund and adds a significant delay in getting material deployed and tested in the field.
- Given the difficulty in gaining access to specialist taxonomists, it was suggested that as part of this project activity a community or network of researchers around the world capable of identifying eucalypt insect parasitoids be established.
- Certification for sustainable forest management schemes such as the Forest Stewardship Council (FSC) limit the use of chemical insecticides for pest management. The question was raised as to whether it may be possible to establish a linkage between BiCEP and FSC to promote the use of biological control in FSC certified eucalypt plantations?

  At present, the FSC position on biological control is somewhat ambivalent. For example, in the draft Australian FSC Forest Management standards, Criterion C 6.6 states "Management systems shall promote the development and adoption of environmentally friendly non-chemical methods of pest management and strive to avoid the use of chemical pesticides…" Indicator 6.6.11LL goes on to require "The enterprise implements a documented 'integrated pest management' (IPM) strategy designed to minimise the likelihood of serious pest problems occurring through an ecological management approach…" whereas criterion C6.8 states "Use of biological control agents shall be documented, minimized, monitored and strictly controlled in accordance with national laws and internationally accepted scientific protocols. Use of genetically modified organisms shall be prohibited". The relevant Indicators for this criterion are: Indicator 6.8.3 "If biological control agents are used, the enterprise can demonstrate that such use is in strict compliance with national laws…and internationally accepted scientific protocols". Indicator 6.8.4 "If biological control agents are used, comprehensive records of use are maintained by the forest manager, and the impacts of such use are closely monitored".

  Biological control therefore appears to be supported by FSC, but with the riders that use must comply with national and international regulations (such as the International Plant Protection Convention ISPM 03 Guidelines for the export, shipment, import and release of biological control agents and other beneficial organisms and that releases and field effectiveness are well documented.

- Promote student and researcher linkages and exchanges. Brazil's "Science without Borders" program could be a key established program that could be targeted initially. Australia has now signed on to this scheme as a partner country.

5 Communication Activities

5.1 BiCEP Communication Strategy

The main objectives of the BiCEP communication strategy were to:

- Establish an online presence (**website**) to enable communication and dissemination of information relating to the biological control of Eucalypt pests, amongst researchers and interested organizations and individuals from around the world.
- Develop a publicity **flyer** to raise awareness of the BiCEP project amongst Australian and International researchers

5.2 BiCEP website

The website (http://bicep.net.au/) was developed by an external private contractor, Mr John Blundell, using a privately hosted WordPress website.

The main focus of the website is to:

- Coordinate and rationalize research into the biological control of Eucalypt pests, initially *Thaumastocoris peregrinus*
- Provide updates on new emerging pests, progress of testing of biocontrol agents, and effectiveness of released agents in establishing and providing control.
- Share information on testing, rearing, release and distribution procedures relevant to different biocontrol agents.

The **BiCEP banner and flyer** (Appendix 9) were developed by the DAFF Queensland Communication team. The flyer was prepared specifically for distribution during the International Union of Forestry Research Organisations (IUFRO) conference in Uruguay in October 2011.

The target audience included:

- Australian and International researchers and organisations including Australian Centre for International Agricultural Research (ACIAR), Forestry and Agricultural Biotechnology Institute (FABI) (South Africa), Forestry Science and Research Institute (IPEF) (Brazil), National Food Safety and Quality Service (SENASA) (Argentina), Forest Science Institute of Vietnam (FSIV (Vietnam), Forestry Research and Development Agency (FORDA) (Indonesia)
- State and local government agencies (e.g. DPI-NSW; Sydney local councils and tree resource centre)
- Forest Plantation Industry representatives

As at 20 July 2012, the website had 1,304 views since it went live in early November 2011 (the total includes site development). The busiest day (January 6, 2012) had 66 views.

6 Shipments of Bronze Bug biocontrol agents

6.1 Shipments 2011-12

Country	Shipping date	SER Number	Collection location	Notes
South Africa	12/09/2011	N26324	Sydney	
	11/01/2012	N26325	Nowra	No suitable populations in Sydney
	16/04/2012	N26326	Nowra	No suitable populations in Sydney
	30/04/2012	N26327	Sydney	
Brazil	12/09/2011	N18435	Sydney	
	08/11/2011	N18436	Sydney	
	11/06/2012	N28338	Sydney	
	06/08/2012	N28339	Sydney	

Table 2: *Shipments of* T. peregrinus *parasitoids 2011-12. Note: Argentina – shipments arranged for 26-28/05/2012 but unable to proceed due to new guidelines on imports into Argentina.*

6.2 Permit Status

Country	Contact	Export Permit valid to:	Import Permit valid to:	Notes
South Africa	Brett Hurley	18/08/2013	30/06/2013	New import permit applied for April 2012
Brazil	Carlos Wilcken	01/01/2015	31/12/2012	
Argentina	Eduardo Botto	21/08/2014	28/10/2012	

Table 3: *Export permit status for* T. peregrinus *shipments*

6.2.1 Shipping/Permit Contacts

SOUTH AFRICA

Dr Brett Hurley

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University of Pretoria
Pretoria 0002
SOUTH AFRICA
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BRAZIL

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ARGENTINA

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Instituto de Microbiológia y Zoología Agrícola (IMYZA)
Centro de Investigaciones en Ciencias Veterinarias y Agronómicas (CICVyA)
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7 Molecular ecology of Thaumastocoris peregrinus

7.1 What we know currently

Both mitochondrial and nuclear markers have now been successfully used to examine *Thaumastocoris peregrinus* populations in the native range of Australia as well as invasive pest populations in South Africa and South America.

Analysis of a 547 bp fragment of the mitochondrial barcoding gene COI of individuals from Sydney, Brisbane, and various South African, Brazilian and Uruguayan localities (Nadel et al. 2010) revealed the presence of 2 haplotypes in South Africa and 1 in South America. Each of these 3 invasive haplotypes were found among the 7 present in Sydney individuals, while one of them was among the haplotypes found in Brisbane individuals. It has been speculated that the invasion has taken place via long distance dispersal from Sydney, possibly human mediated. No mitochondrial sequencing of non-urban populations has been undertaken thus far.

Ten nuclear microsatellite DNA markers have been generated (Gray et al. 2010) and successfully trialled in 113 individuals from 11 localities, including 2 from Sydney, 6 from inland NSW, 1 from Qld, and 1 from each of South Africa and Argentina (Gray et al. 2008). All populations were found to be genetically differentiated from one another. F-statistics indicated that the South African samples are most similar to those from Sydney, while the Argentinian samples are the most divergent group of all.

Although both mtDNA and microsatellite markers indicate an affinity between invasive *T. peregrinus* and those from Sydney, it is possible that the individuals in Sydney have themselves invaded from another area.

7.2 What we need to know to support biological control

The next step is to perform genotyping of individuals from populations throughout the range of *T. peregrinus* to elucidate the source population of the invasive lineages in South Africa and South America. This will facilitate discovery of potential natural enemies of *T. peregrinus.*

The pilot study (due to commence now in August 2012) will involve mtDNA sequencing of representative individuals examined in the microsatellite study, and both mtDNA and microsatellite genotyping of individuals spanning the range of *T. peregrinus* in Australia.

8 A Centre for Biological Control Of Eucalypt Pests (BiCEP)

8.1 Background

There are currently more than 20 million hectares of eucalypt plantations established worldwide. The productivity of these plantations and the expansion of plantation area to meet world demand for wood fibre is increasingly under threat from a suite of destructive native Australian eucalypt insect pests that have been rapidly moving around the globe. The most serious of these recent invasive pests impacting on the productivity of plantations are the bronze bug (*Thaumastocoris peregrinus*) and the gall wasp (*Leptocybe invasa*). Currently there are no effective control methods for these insects so new management methods are urgently required to protect plantations from ongoing losses.

In addition to these pests, further introductions of new Australian-origin pests are highly likely in the future, facilitated by increasing world trade and movement of people. To illustrate this, a review conducted by the DAFF forest health team suggests that the number of new introductions of Australian insect pests overseas has risen almost exponentially since 2000 and this trend is likely to continue over the longer term. In addition, once established in one country, movement of these pests between countries and continents is now much more rapid through a 'beachhead effect' and globalised trade. For example, since its initial establishment overseas, *L. invasa* has spread within a period of 10 years to all continents where eucalypts are grown. There is therefore an increasing worldwide necessity to establish cooperative mechanisms among eucalypt growers to address the ongoing issue of how to effectively and sustainably manage these emerging pests. As the original source of both the host tree and the pests, Australia has a unique and critical role to play if this challenge is to be successfully managed globally.

Classical biological control is a well-established, highly effective method for controlling exotic pests and has a proven track record. However, biological control efforts directed at eucalypt pests around the world have until now been fragmented, uncoordinated and not as effective as they potentially could be, especially given the speed at which these pests move around the globe. Establishment of a centre in Australia to carry out R&D to support worldwide biological control programs, in conjunction with research into other management techniques, would help address these needs.

Australia faces significant issues in managing endemic pest insects in its eucalypt plantation estate (currently around 1 M ha) and there is also a growing need for biologically based control methods for these pests. As in most countries, Australian growers are now certified by Forest Stewardship Council and/or the Australian Forestry Standard, which limit their ability to manage pests through the use of conventional broad-spectrum insecticides. The key forest pest R&D issue for Australian eucalypt plantations is therefore to develop and deploy alternative and sustainable management practices for key pests that are not reliant on chemical usage. Enhancing natural pest regulation mechanisms in plantations is one potential solution to this problem. Since endemic eucalypt herbivores have a co-evolved suite of natural enemies that already provide some regulation of populations, there is potential to manipulate these parasitoids and predators so as to maintain pest populations below damaging levels. The Queensland and Australian part of the project would focus on the R&D required to exploit this potential.

The forest health team in Queensland is well-qualified to take on a central research and coordination role for eucalypt insect biological control R,D&E, with team members having strong backgrounds in biological control and general forest entomology and ecology, as well as considerable experience working with international partners in forest health overseas, particularly in the Asia-Pacific region. Over the past few years the team has also developed very strong collaborative linkages with the Tree Protection Cooperative Programme (TPCP) of the Forestry and Agricultural Biotechnology Institute (FABI), University of Pretoria, in South Africa, and the Forestry Science and Research Institute of Brazil (IPEF). FABI is recognized internationally for its excellence in forest health research, while IPEF is the pre-eminent industry-focused forestry research organization in South America. Both these R&D organisations link strongly with the majority of the industry in each region. The team also has a long history of leading and collaborating in forest health projects in the Asia-Pacific region through ACIAR and AusAID.

8.2 Scale of the problem

Australian insect pests are now major problems in all regions around the world that grow eucalypts commercially. These problems are currently most severe in South America (particularly in Brazil, the worlds largest commercial grower), southern Africa (especially South Africa, which has that region's largest resource and most highly developed industry), and Southeast Asia (which has a rapidly expanding resource, particularly in China, Vietnam, Laos and Indonesia) where there is limited capacity to address these threats. Table 1 illustrates the global distribution of the 5 key eucalypt pests, and for Australia their pest status.

Pest	South America	Africa	Asia	Europe	North America	Australia (Pest Status)
Bronze Bug *Thaumastocoris peregrinus*	+	+	-	+	-	+**
Blue gum chalcid *Leptocybe invasa*	+	+	+	+	+	-
Eucalyptus gall wasp *Ophelimus maskelli*	-	-*	+	+	-	-
Red gum lerp psyllid *Glycaspis brimblecombei*	+	-*	-	+	+	-
Eucalyptus snout beetle *Gonipterus* spp. complex	+	+	-	+	+	+***

Table 4: *Current distribution of the 'big five' eucalypt pests around the world and pest status in Australia.*

* - G. brimblecombei *and* O. maskelli *are established in Mauritius, a potential gateway to Africa.*

** - *Pest of street trees in Sydney. The related* T. safordi *is an emerging pest of* Corymbia citriodora *ssp.* variegata *plantations in subtropical eastern Australia.* T. peregrinus *was recently recorded (May 2012) on urban street trees in New Zealand.*

*** - *Pest of* E. globulus *plantations in W.A., Green Triangle and Tasmania.*

8.3 The Need for Biological Control R&D

8.3.1 Overseas Biological Control R&D

The key pests identified in Table 4 fall into three main categories in regard to needs for biocontrol R&D. These are shown in Table 5.

Category	Pest	Agents known	Released and/or Established	Effectiveness
1	Bronze Bug *(Thaumastocoris peregrinus)*	Y*	N**	Unknown
2	Blue gum chalcid (*Leptocybe invasa*)	Y	Y	Good, but unknown in industrial scale plantations. Not yet released in Asia, Africa, or S. America
2	Eucalyptus gall wasp (*Ophelimus maskelli*)	Y	Y	Good, but unknown in industrial scale plantations. Not yet released in Asia.
3	Red gum lerp psyllid (*Glycaspis brimblecombei*)	Y	Y	Good, but not in all climatic zones. Need better biotype matching or alternative agents.
3	Eucalyptus snout beetle *Gonipterus spp. complex*	Y	Y	Good, but not in all climatic zones. Cryptic host species may have caused parasitoid biotype mismatches

Table 5: *Biological control status of the 'big five' eucalypt pests.*

** - One commonly occurring egg parasitoid* (C. noackae) *is known. ** - released in Chile without extensive specificity testing.*

These categories and the R&D required for them can be briefly summarized thus:

Category 1:

Pests for which there are no currently known effective biological control agents (e.g. *T. peregrinus*). R&D required: Field discovery, collection and preliminary evaluation of biocontrol agents in Australia. Preliminary host specificity testing and support for release programs overseas.

Category 2:

Pests for which discovery work has been done and for which biocontrol agents are now available outside Australia (e.g. the gall wasps *L. invasa* and *O. maskelli*). R&D required: Identification of natural enemies already present in SE Asia. Support for regional host specificity testing and release programs of agents and evaluation of regionally suited biotypes

Category 3:

Longer established pests for which fine-tuning is required (e.g. *Glycaspis brimblecombei*, *Gonipterus* complex). R&D required: Field collection and evaluation in Australia required for regionally suited biotypes. Field release and testing.

The R&D required to support global biological control programs for these key pests will be funded by plantation companies, governments and ACIAR and would be carried out by the DAFF/USC forest health team and other Australian collaborators (incl. the University of Sydney, NSW-DPI, the University of Tasmania and Latrobe University).

8.3.2 R&D to support enhancing biological control in Australian eucalypt plantations

The R&D effort in Australia would be targeted at providing alternative, innovative and environmentally sustainable management options for the key insect pests in eucalypt plantations in the subtropics of eastern Australia. As alluded to above, plantation companies are increasingly constrained in management options by forest certification schemes. The proposed research would place Queensland at the forefront of clean, green forest production systems and would concentrate on the following research themes:

Enhancing the effectiveness of natural enemies in plantations.

- Research a specific host/parasitoid/plantation/landscape interaction using *Paropsis atomaria* leaf beetle as the model system to determine if the system can be manipulated to enhance natural population regulation.
- Test herbivore-induced plant volatiles as a means of manipulating natural enemies in plantations. Link to potential carbon co-benefits project development with CSIRO.

Understanding host-natural enemy interactions in an emerging plantation pest.

- Study the biology and ecology of the emerging pest the winter bronzing bug (*Thaumastocoris safordi*) and its natural enemies in CCV plantations in SEQ and N-NSW with a focus developing biological management options. Link to *T. peregrinus* management in overseas plantations.

8.4 Benefits to Australia

8.4.1 Enhancing sustainability of forest production systems

- Australia already has an enviable international reputation for sustainable production of high quality food and fibre. Developing biologically based management methods for pests of forest plantations would enhance the ability of the Australian plantation industry to meet its obligations under the certification schemes that operate to ensure plantation forests are managed sustainably.

8.4.2 Building capacity in forest health and biosecurity R&D

- This project offers a unique opportunity to build on Australia's current strength in forest health research capacity. With the demise of the CRC Forestry and restructures in other State agencies, national strength in forest health capacity has dwindled dramatically. The forest health team within DAFF is one of the largest remaining in Australia, and the only one with a strong tropical and subtropical focus and experience.

8.4.3 Over the horizon surveillance.

- New pests and pathogens of eucalypts overseas are constantly emerging (e.g. myrtle rust). This project will establish an active ‘over the horizon’ surveillance network in the world’s major eucalypt growing regions to proactively assess and manage risk of invasion by exotic pests and pathogens. Such a network will assist in identifying pests as they emerge and assist in the rapid development and deployment of management responses.

9 Conclusions and recommendations

This Small Research and Development Activity provided a significant opportunity to review the status of biological control of Australian invasive eucalypt pests worldwide, engage with collaborators (current and potential) and evaluate the contribution Australia could make to improving management of these pests by assisting in implementing and/or refining biological control programs, particularly in developing countries where plantation forestry contributes strongly to regional and rural economies and communities.

9.1 Conclusions

There are five major Australian invasive eucalypt pests (the ‘big five’) causing severe damage to plantations of Eucalyptus worldwide. These are:

- The Bronze Bug (*Thaumastocoris peregrinus*)
- Blue gum chalcid (*Leptocybe invasa*)
- Eucalyptus gall wasp (*Ophelimus maskelli*)
- Red gum lerp psyllid (*Glycaspis brimblecombei*)
- Eucalyptus snout beetle (*Gonipterus* spp. complex)

The bronze bug, blue gum chalcid, gall wasp and, to a lesser extent, the red gum lerp psyllid are rapidly expanding their worldwide distribution, while long established pests such as the eucalyptus snout beetle still pose threats in some environments.

In particular, the blue gum chalcid and bronze bug pose specific new and key challenges to forest growers around the world and especially in the developing world. There is limited capacity in many countries to develop integrated pest management (IPM) approaches that include genetic, silvicultural, chemical and biological approaches to regulating populations of these pests below levels that cause significant damage and loss of productivity.

Given that these are all exotic, invasive pests, classical biological control will be an important part of ongoing, sustainable management of these pests worldwide. A major difficulty with biological control programs in the developing world is that, while in the long-term introduced biological control agents provide a ‘free’ pest control, the R&D and testing required to get biocontrol agents released and established in the field can be quite costly. It is in this area of assistance with start-up costs and capacity building that assistance from aid agencies such as ACIAR can be of most benefit.

9.2 Recommendations

1. Consideration should be given to establish a ‘Centre’ in Australia to address the demonstrable need for improved global coordination of approaches to effective biological control of Australian eucalypt pests.

2. Such a ‘Centre’ could be supported by both government agencies such as ACIAR with a focus on developing countries with the greatest need, and by the international eucalypt plantation industry, especially by those countries that already have well-developed, mature plantation industries (e.g. Brazil, Argentina, Uruguay and Chile in South America, South Africa, China, and Europe). Significant synergies and cost-savings could be achieved by such an approach.

3. As part of this ‘Centre’, priority should be given to establishing a regional, large-scale ACIAR project in SE Asia focussed on biological control of the blue gum chalcid, where the need for immediate support is most required. This would form the core of a larger centre.

4. Initially a limited number of industry partners, represented by IPEF in Brazil and the TPCP in South Africa, should form part of this ‘centre’, with a focus on the bronze bug. Once this core ‘Centre’ is established, other industry partners from Europe, China and other countries would be invited to take part, widening collaborations and synergies.

10 References

10.1 References cited in report

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10.2 List of publications produced by project

See the BiCEP website (http://bicep.net.au) and flyer (Appendix 9).

11 Appendixes

11.1 Appendix 1:

Dr Simon Lawson presentation “Eucalypt insects - pests at home and abroad: the growing need for a coordinated approach to biological control” at the International Union of Forest Research Organisation Forest Health Joint Meeting "Pathogens, insects and their associations affecting forestry worldwide" in Uruguay in November 2011

11.2 Appendix 2:

Vietnam Pest Status

11.3 Appendix 3:

China Pest Status

11.4 Appendix 4:

Indonesia Pest Status

11.5 Appendix 5:

Malaysia Pest Status

11.6 Appendix 6:

Thailand Pest Status

11.7 Appendix 7:

Lao Pest Status

11.8 Appendix 8:

May 2012 edition of ‘Wood SA and Timber Times’

11.9 Appendix 9:

The BiCEP flyer.