ADVANCES IN RESEARCH AND MANAGEMENT OF TREE PESTS AND DISEASES: EXPERIENCES FROM FABI

STUDY COMMISSIONED BY

SAWLOG PRODUCTION GRANT SCHEME (SPGS)

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Executive summary

● This report is an output of a 2-day visit I paid to the Forestry and Agricultural Biotechnology Institute (FABI) at the University of Pretoria, South Africa. The objective of the visit was to share experiences on tree health issues with scientists at FABI and provide some recommendations for improving the management of tree pests and diseases in Uganda, with particular attention to the Eucalyptus gall wasp, *Leptocybe invasa*, and potentially threatening pests. FABI is globally recognized as a centre of excellence for research and training in tree health.

● The research and training facilitates observed at FABI were very impressive as were the personnel. The Institute has well equipped laboratories for pest and disease diagnosis, with state of the art facilities for molecular analyses. A modern bio-control centre was recently established with highly qualified and experienced staff. The centre is currently focusing mainly on research and mass rearing of bio-control agents for three major pests in South Africa. These are *Leptocybe invasa*, which is already a major problem in Uganda, and *Sirex noctilio* and *Thaumastocoris peregrinus* which are a potential threat to the country.

● FABI has identified a very promising natural enemy (*Selitrichodes* sp.) of *Leptocybe invasa*, and successfully developed rearing protocols for the natural enemy. The Institute has already applied to the South African government for a permit to field release the natural enemy in South Africa following extensive research on the natural enemy at the bio-control centre. FABI is willing to provide the natural enemy for field evaluation in Uganda and Kenya. Importation of the natural enemy requires a permit from the governments of these countries. Acquisition of such permits requires a dossier, which should be developed with urgency in order to take full advantage of the good gesture from FABI. Development of a dossier essentially involves detailed compilation of the evidence on the pest and the target natural enemy. This may done in a period not exceeding 10 man days at an estimated cost of about US$ 1500, but the latter may vary considerably depending on the expert(s) involved.

● Sirex bio-control programme at FABI, especially using the parasitic nematode (*Deladenus siricidicola*) is already well established. The first field release was conducted in 2003 and good results observed 5 yeas later, indicating that the impact of biological control agents may not be

immediate. One of the main lessons learnt by FABI in the application of the nematode is that several local factors may influence the performance of the nematode, many of which can be determined by research prior to invasion of the Sirex wasp into new areas. The global spread of *S. noctilio* has been predicted, based on climatic data, to continue with Uganda as one of the suitable countries for the pest. Ugandan researchers need to collaborate with scientists at FABI to define research priorities aimed at generating local data for the bio-control of this potentially devastating pest.

● Work on the bio-control of bronze bug (*Thaumastocoris peregrines*) at FABI has focused on the egg parasite (*Cleruchoides noackae*). A Protocol for rearing the natural enemy under laboratory conditions has been developed. Extensive studies are ongoing on the biology and ecology of the natural enemy and the pest (*T. peregrinus*) in South Africa and Kenya under the supervision of scientists from FABI.

● I have proposed some research and development areas that need to be addressed for the development of effective and sustainable mechanisms for managing tree pest and disease problems in Uganda. These include the need for basic and applied research, establishment of satellite tree health monitoring sites, developing clear tree health management structure, establishment of a tree health centre, establishing and/or strengthening regional and international partnerships, building infrastructural and human capacity, dissemination of research findings and soliciting financial support. It is noteworthy that successful pest management programmes, such as those reported from FABI, require a clear vision by stakeholders that tree health is a key risk in forestry enterprises. Only then can strategies for sustainable management of current and potential tree health problems be implemented successfully. The main challenge in Uganda is that relevant public institutions such as the National Forestry Resources Research Institute (NaFFORI) and National Forestry Authority (NFA) have had very limited support and impact on tree pest and disease management. With the increasing interest in private commercial forestry in the country, the private sector may have no choice but to take the lead in pest and disease issues, as has been the case in South African forestry sector.

1.0 Introduction

Ugandans are experiencing a revolution in tree planting, with the private sector taking a lead in commercial forestry. Marked efforts have been spent in ensuring best practices in tree growing, especially by the Sawlog Production Grant Scheme (SPGS). For example, there has been a remarkable shift to use improved planting materials, especially for Pines and Eucalyptus. There are however, some eminent tree health problems that are a threat to tree growing in Uganda. Whereas some pests such as termites have for long been recognized in forestry in the country, there have been some recent invasions such as the Cypress aphid (*Cinara cuppressivora*) and Eucalyptus gall wasp (*Leptocybe invasa*), and more of such invasions are expected.

The lack of effective mechanisms and strategy to address tree health issues in Uganda is perhaps more worrying than the current or future tree pest and disease problems in the country as the latter should always be expected. For example, no clear management strategies are in place for serious pests such as termites and the Eucalyptus gall wasp, *Leptocybe invasa*. Similarly, strategies for rapid detection and diagnosis of new tree pest and disease problems are lacking. Some research and in-service training have been conducted on tree pests and disease problems, but these have remained largely short-term with no clear strategy for sustainability. Recently, however, a field guide for tree pests and diseases was prepared with financial support from the SPGS. The guide is expected to be published within the coming year.

As one of the measures to address the challenges above, the SPGS commissioned a visit to the Forestry and Agricultural Biotechnology Institute (FABI) at the University of Pretoria, South Africa to share some experiences and provide ways forward for Uganda. Specifically, the tasks were to: (i) visit scientists at the FABI to familiarize with their ongoing research on *Leptocybe invasa*; (ii) familiarize wit FABI's work on the potential pest and disease species that may threaten Ugandan plantations (e.g. *Thaumastocoris* and *Sirex*); (iii) recommend practical strategy for Uganda to adopt on *Leptocybe invasa* and other key pest and disease, that includes a practical 'road map' for conducting necessary research and development in Uganda to minimize the impact of the aforementioned pests and disease threats; (iv) recommend how Uganda could have formal links with FABI for future pest and disease research; and (v) prepare a concise report for SPGS.

2.0 Methods

Main activities conducted during the FABI visit were (see appendix 1 for more details):

● Round table discussions with some FABI scientists and postgraduate students

● Guided tour of FABI research facilities

● One-to-one discussion with FABI Director, some scientists, graduate students and technicians

3.0 Findings

3.1 General

● Infrastructure: The FABI square (Figure 1A) and FABI Biocontrol Centre (Figure 1B) comprising of modern and well maintained buildings. FABI owns several laboratories and greenhouses well equipped with state of the art facilities.

● Highly trained and experienced Research Assistants assigned to specific research programmes

● A core team of several highly qualified and experienced scientists

● Clear motivation of the FABI team

● Graduate training: Postgraduate (PhD and MSc.) students assigned to specific research programmes

● Regular seminar series (twice a week). I attended presentations by four graduate students and was very impressed by the high quality of the presentations and the discussions.

● Several research programmes on strategic aspects. These includes the DST NRF Centre of Excellence in Tree Health Biotechnology (CTHB), CERC-FABI Eucalyptus Protection Programme (CFEPP), Eucalyptus Pine Pathogen Interaction (EPPI), Forest Molecular Genetics (FMG) programme, Fruit Tree Biotechnology Programme, Microbial Diversity Research Programme, Molecular Plant Pathogen Interactions, Molecular and Plant Physiology

Programme, Phytobacteriology Programme, Seed Pathology Research Programme, and the Tree Protection Co-operative Programme (TPCP).

● Impressive number and quality of publications from FABI staff

● FABI's very close links with commercial tree growers in South Africa

● Global strategic research partnerships

3.2 Biocontrol programmes

3.2.1 Leptocybe invasa

The Eucalyptus gall wasp, *L. invasa* has become a global pest of Eucalyptus in the last decade. There has been intensive research especially from Australia, Israel and South Africa to implement biological control measures against the pest. Ongoing studies at FABI include assessment of Eucalyptus germplasm susceptibility, genome sequencing, global population movement, biology of *L. invasa* and its natural enemies. Three natural enemies of *L. invasa* were imported from Israel to FABI viz. *Quadrastichus mendeli*, *Selitrichodes kryceri* and a *Megastimus* species. FABI has had difficulties in mass rearing these natural enemies. Only few individuals have emerged from *L. invasa* galls infested under greenhouse conditions. In contrast, a natural enemy new to science (proposed name *Selitrichodes neseri*) was recently collected by a South African scientist from Australia, successfully mass-reared (over 15,000 individuals) and the biology and host preference studied extensively at FABI. The insect has demonstrated high level of parasitism on *L. invasa* larvae (up to 72%) under greenhouse condition. It is expected that this species can have even higher level of parasitism if established under field conditions. Several host specificity tests conducted on this species at FABI have demonstrated that it is specific to *L. invasa* as the host. With these impressive results, FABI has applied to the South African government for a permission to release the natural enemy in the field for the control of *L. invasa*.

FABI expressed interest in providing the natural enemies of *L. invasa* for field trials in Uganda and Kenya at no cost. Of particular interest is the very promising *Selitrichodes neseri*. The two

countries need to acquire permits for the importation of the natural enemies. Acquisition of such permits requires development of dossiers on the pest and the target natural enemy. In the case of Uganda, the dossier is submitted to the Plant Protection Department at the Ministry of Agriculture, Animal Industry and Fisheries.

Another important requirement for the importation of such natural enemies is the need for basic facilities for rearing the natural enemy prior to field release. This includes for example a greenhouse for raising and infesting Eucalyptus seedlings with *Leptocybe invasa*, an insectarium space for releasing the natural enemy on *L. invasa* infested seedlings, and laboratory plastic and glassware (Figures 2A-D). Some of these facilities already exist at Makerere University and the National Forestry Resources research Institue (NaFORRI), and may require minor modifications and/or repair.

3.2.2 Thaumastocoris peregrinus

The bronze bug, *Thaumastocoris peregrines*, is a small (about 3 mm long) sap-sucking insect in the family Thaumastocoridae (Hemptera: Heteroptera). It lays black eggs in clusters (Figure 3A) and the eggs develop into nymphs and later adults (Figures 3 B-D). The insect is native to Australia. In the last decade *T. peregrinus* has rapidly established as a pest of some Eucalyptus species (Figure 3E) in several countries including Australia, Brazil, Argentina and Uruguay. More recently (2010), the insect was reported at the Namanga area in Kenya and has since spread in many parts of the country (Mutitu, Pers. Com.). It is possible that the insect has already spread unnoticed to Uganda and Tanzania, the countries neighbouring districts where the pest has been detected in Kenya. There is an urgent need to alert tree growers about the looming bronze bug invasion. This could be done through press releases, newsletters and/or as a circular of urgent information from the Uganda Timber Growers Association (UTGA) to its members.

Two species of mymarid wasps (*Cleruchoides noackae* and a *Stethyrium* species) have been confirmed to be egg parasites of *T. peregrinus*. FABI recently imported *C. noackae* into South Africa and studies on the biology and parasitism of this biological control agent is undergoing at the FABI Biocontrol Centre. *Cleruchoides noackae* is a solitary egg parasite with very promising potential for biological control. Additional data are being collected by a FABI PhD student on the population dynamics of *T. peregrinus* in relation to environmental factors in

various parts of Kenya. A Protocol for rearing *C. noackae* under laboratory conditions has been developed at FABI (Figures 4A-D).

3.2.3 Sirex noctilio

The woodwasp (*Sirex noctilio*), which is native to Eurasia and northern Africa, was first recorded outside its native range, in pine plantations of New Zealand in the early 1900s. This alien invasive pest, together with its *Amylostereum areolatum* fungus symbiont, gradually spread, first to Australia and later, in the 1980's to South American countries. In the early 1990's it appeared for the first time on the African continent, in South Africa. More recently, the insect was reported to be established in eastern North America. In every country where *S. noctilio* has become established, it has resulted in considerable damage and cost to local economies. It has been predicted that the global spread of *S. noctilio* will continue with eastern Africa as one of the suitable regions for the pest. Distribution pattern of *S. noctilio* in Southern Africa indicates that the pest is moving northwards, with the latest invasion reported in 2011 in Swaziland. Several species of pine are known to be susceptible to *S. noctilio*, including *P. patula*, *P. caribaea* and *P. oocarpa* which are widely planted in Uganda. The need for research for such an important pest can not be overemphasized.

The first appearance of *S. noctilio* in the southern hemisphere led to a period of intensive research on this pest. Substantial attention was given to control options that included the discovery and deployment of various biological control agents such as the wasp parasitoid *Ibalia leucospoides* and the parasitic nematode *Deladenus siricidicola*. These agents, together with silvicultural practices to reduce stress in plantations and stop the spread of the wasp (e.g. on-time thinning), have yielded impressive control of *S. noctilio*, particularly in areas where *S. noctilio* first appeared. Control of *S. noctilio* in areas that it has more recently invaded has yielded variable and sometimes disappointing results. This could be attributed to factors relating to pine hosts new to *S. noctilio*, climatic conditions different to those where biological control has been effective, mismatch of biotypes of the wasp, its fungal symbiont or its parasites, or indeed a great number of other factors.

In South Africa, FABI has been in the forefront in implementing control measures for *S. noctilio*. The wasp parasitoid *I. leucospoides* and the parasitic nematode *D. siricidicola* have been

released in the country. The innoculation with the latter was first conducted in the country in 2003, and it took about 5 years for good results to be observed. Variations have been reported in the effectiveness of the nematodes between the Western cape (with winter rainfall) and the KwaZulu Natal regions (with summer rains). This emphasizes the need for careful analysis of environmental and tree conditions on a case-by-case- basis prior to introduction of the nematode.

Currently, FABI has section of its modern Biocontrol Centre designated for working on Sirex. The centre is well equipped with facilities and personnel for rearing the *D. Siricidicola*. The main activities observed during the visit included diagnosis of field samples of *S. noctilio* for nematode parasitism and mass rearing of nematodes for field release (Figures 5A-D).

A very useful book on *S. noctilio* has recently been published by Springer with contributions FABI scientists- *The Sirex Woodwasp and its Fungal Symbiont: Research and Management*. Editors B. Slippers, P. de Groot and M.J. Wingfield. I strongly recommend this book to institutions involved in commercial pine production in Uganda.

4.0 Research and development strategy for Uganda to adopt on tree pests and diseases

● Basic research: Successful management of any pests requires good understanding of the biology and ecology of the pest and its hosts. Whereas such information may be generated by researchers in other regions or continents, information based on local situations may be necessary for the data to be relevant for local application. Basic data, for example, on the number of pest generations per year, periods of peak pest populations in relation to the dynamics in the local environmental conditions, chemical properties of host plants in different locations are necessary fundamentals for developing solutions to tree pests and diseases.

● Applied research: This should be conducted with the aim of developing effective and economically and environmentally sound pest and disease control measures. For example, research is necessary to generate data for optimum silvicultural practices, resistant germplasms, judicial application of pesticides and biological control of threatening pests and diseases. The control options for study here should be determined according to particular pest and disease problems at hand. For invasive pests such as *L. invasa* which is already establish and causing

severe damage to trees in Uganda, biological control is the most sustainable option and should be a priority for integration with other control methods. Control of *L. invasa*, for example, now urgently requires research and development efforts to be directed towards importation and field release of the promising natural enemy, *Selitrichodes neseri*, from FABI. The biological control trials can be designed to incorporate variations in environmental conditions and other control options (e.g. different Eucalyptus germplasms and silvicultural practices) in order to develop optimum integrated strategies for managing the pests.

● Satellite monitoring sites: Potentially threatening pests such as *Sirex notilio* and *Thaumastocoris peregrinus* may be recognised when their populations have exploded. Immediate identification of such problems would be necessary for timely management interventions. I propose establishment of pest and disease monitoring satellite sites in the different regions of the country in which nursery and plantation managers could be involved in periodically reporting pest and disease situations at such sites to tree pest and disease specialists at a focal point, for example, Makerere University. This can provide a rapid monitoring and analysis of pest and disease dynamics in various parts of the country.

● Tree health management structure: Currently no specific tree health management structure exists to spearhead tree health research and development agenda for the predominantly private sector lead commercial forestry in Uganda. There is a need to constitute a platform that includes the various stakeholders involved in forestry in the country to define and monitor the research and development agenda on tree health issues. Such a platform could be initiated as a small and focused committee under the Commercial Forestry Research Team (COMFORT), which already has membership drawn from several key commercial forestry stakeholders in Uganda. Such a committee could be tasked to, for example, identify, prioritize and cost key areas of tree pest and disease research.

● Tree protection centre: It is imperative that a research and development focal point for rapidly recognising tree health problems and developing appropriate control actions be established in Uganda to directly handle tree health concerns from tree growers. A leaf on this can be borrowed from the Tree Protection Cooperative Programme (TPCP) at FABI, which South Africa Forestry, the equivalent of Uganda Timber Growers Association (UTGA), was instrumental in establishing. Establishment and operation of such a centre in Uganda is feasible, especially if the

centre is affiliated to research and/or training institutions such as Makerere University which already have some basic research facilities and tree health scientists.

● Partnership: The need for regional and international partnerships for effective management of tree health problems cannot be overemphasized. Over the years, Ugandan tree health scientists have had several informal links with scientists from some key forestry research institutions in Africa and beyond. Such links should be strengthened through development of a clear strategy for partnership on tree health problems. Memoranda of understanding (MOUs) with partner institutions are necessary for formality, but MOUs are relevant only if the partnership in functional. During my visit to FABI, the management and some scientist expressed the desire for partnership to rollout the services of the TPCP programme into other African countries. Such services could include for example, joint research, training and diagnosis of tree pest and disease problems. This presents a very good opportunity for Uganda, and the tree protection centre I suggested earlier would be paramount in such a partnership.

● Infrastructural capacity for research: Laboratories for tree pest and disease diagnoses exist at Makerere University and NaFORRI. However, these laboratories lack some essential facilities for research on pest and disease problems. Again, formation of a tree health centre would help to mobilise and concentrate such facilities at one point for the country. Deliberate efforts are necessary to raise resources to obtain basic research facilities, and this should be a priority area for all stakeholders in order that management of tree pest and disease problems are based on research evidence specific to local conditions. The starting point here could be compilation of a list of essential basic research facilities which are not available. This can be easily done by the tree health scientists in Uganda. The next step would be developing strategies for generating the necessary resources, which could be done by the national tree health committee I suggested earlier.

● Research personnel: A few experienced tree health scientists are available in Uganda. However, apparently no well trained and experienced tree health technician exists in Uganda. Technicians are a necessity in conducting field and laboratory research. Research and training institutions such as Makerere University have some general forestry technicians. In the short term, two of such technicians could be retooled through short courses and frequent field and laboratory engagements to support the tree health scientists in research. In addition, reliable field

-based assistants will be necessary especially when pest and disease monitoring activities are required. Nursery and plantation managers from different regions of the country could be strategically selected and trained for this. Training of technicians and field assistants could be done under collaborative arrangements with FABI.

● Dissemination: Synthesis, simplification and transfer of tree health information among researchers, tree growers, policy makers and other stakeholders are important in the development and implementation of sustainable pest and disease management measures. Tree health scientists at Makerere University, and the SPGS and UTGA have in the last few years made some efforts on this, but there is a need to strengthen this initiative. Important dissemination channels include stakeholder seminars, clients meetings, leaflets and brochures, newsletters, and short training on tree health problems.

● Funding: Substantial financial support is required for tree pest and disease management solutions for long term sustainability. This calls for commitment from all forestry stakeholders in the country. A number of potential funding sources exist, but charity has to commence from home. There is a need to lobby for support within UTGA membership, SPGS and Ugandan government. At the regional level, it is necessary to carry out inventory of Forest companies in East and Central Africa and lobby them for supporting tree health initiatives. This will require effective partnerships among institutions in the different countries. Development of joint tree health project proposals with regional and international partners is another avenue for funding, but this is often short-lived. Scientists from FABI, Makerere University and the Kenya Forestry Research Institute (KEFRI) have expressed enormous interest in spearheading this.

5.0 Formal links with FABI for future pest and disease research

Scientists from FABI have been instrumental in raising the profiles of tree pest and disease problems in Uganda, especially through consultancy visits, training and publications. Although no specific formal strategy for future collaboration between FABI and scientists in Uganda apparently exists, scientists from FABI have been working closely with those in Uganda on various aspects of tree health. This Partnership can be formalized and strengthen in various ways as discussed earlier and outlined below:

● Memorandum of understanding between FABI and some institutions involved in commercial forestry research in Uganda. Apparently, there already seems to be a MoU between Makerere University and the University of Pretoria which cold be binding for FABI and Makerere University. There is a need to confirm this from the authorities at the two Universities.

● Development of joint research proposals to solicit for funding

● Training, especially of technical staff and postgraduate students

● Staff exchange visits for scientists to familiarize themselves with tree health situations, and research and management actions in the two countries.

● Rolling out the TPCP programme at FABI into Uganda

● Exchange of information and some research materials e.g. samples of pathogens, insect pests and bio-control agents.

6. Conclusions

My visit to FABI was very successful. FABI is a well established institute, which can immensely benefit the commercial forestry sector in Uganda. In particular, opportunities exist for research and training that should be exploited under a partnership arrangement. Implementation of biological control of *Leptocybe invasa* using the promising natural enemy at FABI presents the immediate challenge that scientists in Uganda and FABI should jointly handle. But this will be very difficult for the scientists to achieve without the necessary support.

7.0 Acknowledgements

I gratefully acknowledge the full financial support from the SPGS for the visit. I thank Prof. Bernard Slippers for organizing my visit very well, and Eston Mutitu for guiding me superbly throughout the visit. I will forever remember the excellent hospitality accorded to me by FABI staff and students- thank you to you all.

Appendix 1: Programme for FABI Visit

Date	**Activity**
28/11/2011	Arrival
	Tour of FABI Square (offices, laboratories, seminar rooms and greenhouses)
	Meeting with Prof. Michael Wingfield
	Dinner
29/11/2011	Visit to FABI biocontrol centre for *Leptocybe invasa* and *Thaumastocoris peregrines* activities
	Round table discussion with selected FABI scientists and postgraduate students
30/11/2011	Visit to FABI biocontrol centre for *Sirex noctilio* activities
	Meeting with Prof. Jolanda Roux
	Wrap up meeting with Prof. Bernard Slippers
1/12/2011	Seminar
	Departure for Uganda

Figure 1: Some of FABI's infrastructure at a glance: (A) an aerial view of FABI facilities at the main campus of the University of Pretoria; (B) The quarantine block at FABI Biocontrol centre.

Figure 2: Some of the facilities and personnel involved in the rearing the natural enemies of *Leptocybe invasa*: (A) FABI staff explaining how Eucalyptus seedlings are raised and infested by *L. invasa* in a greenhouse;(B) Eucalyptus seedlings with leaves sleeved for release of *S. neseri*, the natural enemy of *L. invasa*; (C) Piles of plastic containers used for rearing *L. invasa* natural enemies; and (D) Emerged insects from *L. invasa* galls kept in glass tubes for microscopic identification of species and sexes.

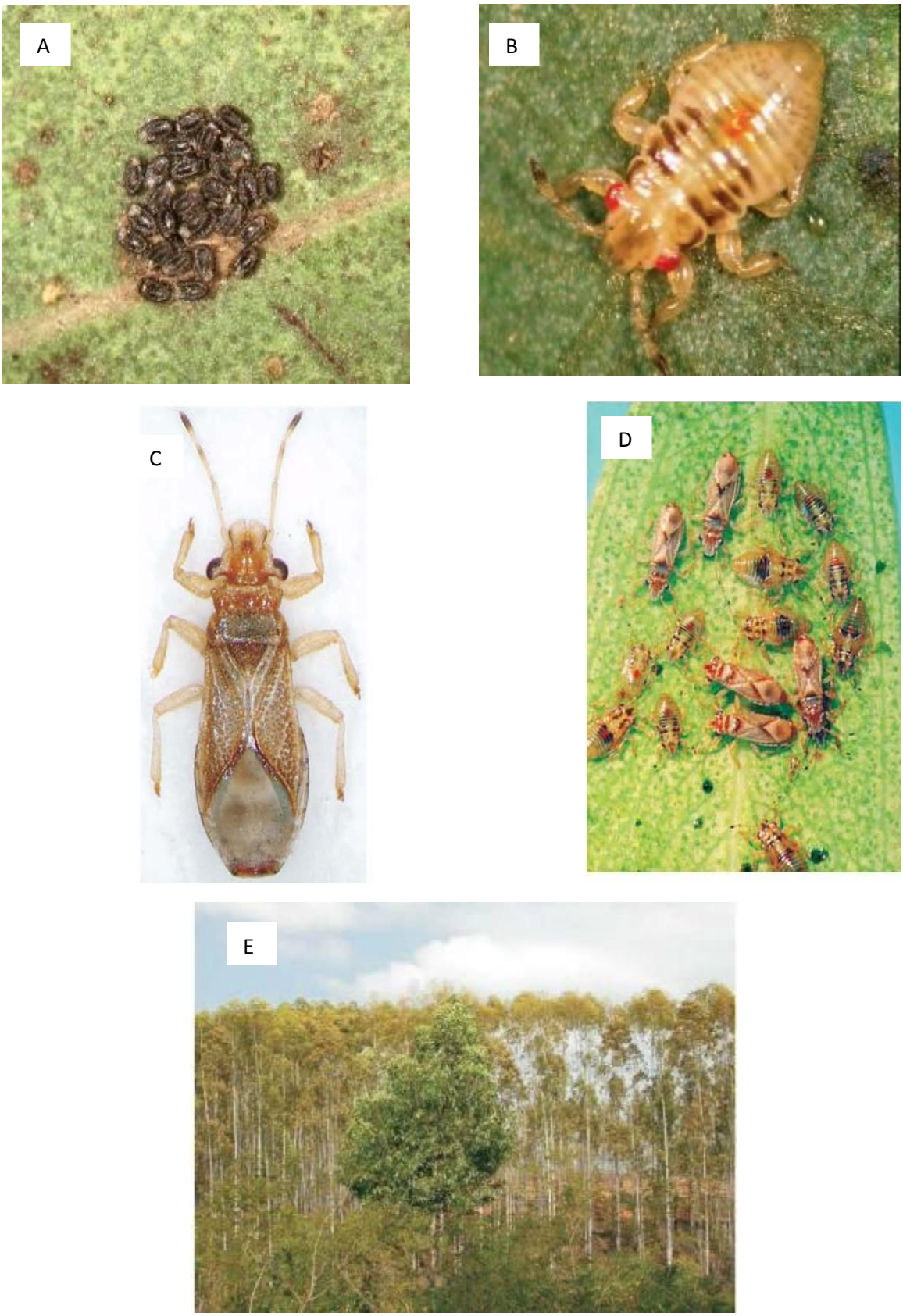

Figure 3: *Thaumastocoris peregrinus* and its infestation on Eucalyptus: (A) *T. peregrinus* eggs; (B) *T. peregrinus* nymph; (C) Adult *T. peregrinus*; (D) Adults and nymphs of *T. peregrinus* on a Eucalyptus lef; (E) A Eucalyptus stand infested by *T. peregrinus*. Source: FABI publications

Figure 4: Rearing of *Cleruchoides noackae*,the natural enemy of *Thaumastocories peregrineus*: (A) Mr. Mutitu, A PhD student at FABI, describing how samples of *T. peregrinus* are kept on Eucalyptus foliage using a bouquet; (B) A FABI staff preparing samples of *T. peregrinus* eggs for inoculation with the natural enemy. (C) Mr. Mutitu describing the plastic tubes used for rearing *C. noackae*; (D) Microscopic examination of *C. noackae* that have emerged from *T. peregrinus* eggs.

Figure 5: Some work on *S. noctilio* at FABI Biocontrol centre: (A): Sirex male and female pinned on a board for diagnosis of nematode infection; (B) Sirex field samples being delivered at FABI Biocontrol centre; (C) FABI staff sorting sirex samples according to sex; and (D) Cultures of nematode (*D. siricidicola*) reared for field release.