International Sirex Symposium and Workshop

9 – 16 May 2007

Pretoria & Pietermaritzburg
South Africa

South African Sirex Control Programme

ICFR

Department of Science and Technology

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Welcome Note

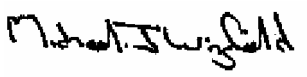
There certainly could not be a better time to be holding an International Symposium and Workshop focussed on the *Sirex* Wood Wasp. As every person attending this meeting will certainly agree, the pest has become one of the most serious threats to pines and pine forestry world-wide. Although one would not wish to be pessimistic, trends including those relating to global warming, suggest that *Sirex* invasions are set to become an increasingly difficult problem.

I had the idea to host an International Symposium and Workshop on *Sirex* early in 2006 and after a discussion with my colleagues Colin Dyer and Bernard Slippers, decided to go ahead with this idea. There was one key issue that struck me as particularly relevant. This is that many important decisions will need to be made to contend with the growing threat of *Sirex*. While an outstanding research base has been provided for us through studies on the biology and control of the pest during the height of the Australian invasion, serious research on this topic has decreased dramatically in recent years. Substantial dependence is being placed on research that might not be fully relevant today and many important questions remain to be asked AND ANSWERED, if we are going to successfully cope with new *Sirex* infestations. Here I can repeat my opening line –the time is right for researchers and managers with an interest in *Sirex* to return to the "drawing board" and to plan a course forward.

The International *Sirex* Symposium and Workshop has been planned in such a way that it should cover a wide range of objectives. We seek to have presentations on research being conducted in many parts of the world, where *Sirex* is of interest. In addition, we have included ample time for group discussion and scientific exchange. Most of this will be during relatively long periods of driving and during our visit to the world-famous Kruger National Park. We will also have an opportunity to see some of the impact of the current *Sirex* invasion in South Africa, and thus to discuss the problem in the "real world". Finally, we will engage in a day of debate on the management of *Sirex*. Here, we have chosen to focus particularly on the South African situation. This is because many problems have been experienced in controlling the pest in this country, and the local situation provides us with an outstanding opportunity to interrogate the state of our knowledge. Hopefully, this will also lead to a deeper understanding of areas of research and management that need to be pursued in the future.

I am delighted to be able to welcome a surprisingly large number of remarkable scientists from many different countries to join this important event. I am particularly glad that part of the meeting can take place at the University of Pretoria and linked to FABI, the Forestry and Agricultural Biotechnology Institute. Together with the South African Forestry Industry, the research team of the Tree Protection Co-operative Programme (TPCP) at FABI is deeply involved in finding solutions to the *Sirex* problem in South Africa. Having colleagues from around the world to join us in this quest is a special privilege. We are most grateful to you for doing so.

The Programme for our *Sirex* Workshop is jam-packed with activity. There can be no question that our aim is to achieve as much scientific benefit from this event as possible. However, I have a secondary wish. This is that every delegate enjoys the experience fully. I extend this wish especially to our colleagues from outside South Africa. Many of you will have visited South Africa before, but I also know that for some of you, this will be a first experience. We have tried hard to add many opportunities to experience the life and culture of our country. We are a young democracy, just beyond our tenth year, but one that is full of opportunity and hope. I hope that you have a wonderful meeting. Welcome to FABI. Welcome to the University of Pretoria. Welcome to the Rainbow Nation, South Africa



Michael J. Wingfield
Mondi Professor of Forest Pathology
Director: Forestry and Agricultural Biotechnology Institute (FABI), Tree Protection Co-operative Programme (TPCP) & DST/ NRF Centre of Excellence in Tree Health Biotechnology (CTHB)

Introduction

Just over 100 years has passed since the Eurasian woodwasp *Sirex noctilio*, first appeared outside its native range, in pine plantations of New Zealand. 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. *Sirex* continues to spread in South America and alarmingly, in the early 1990's appeared for the first time on the African continent, in South Africa. Just two year's ago the wasp was encountered in New York and it is now known 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. **There can be no doubt that the global spread of *Sirex* is set to continue**. Special measures and a resurgence of research effort will clearly be required to contain the negative impacts of this scourge to global forests and forestry.

The first appearance of the Eurasian woodwasp 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, have yielded impressive control of *Sirex*, particularly in areas where *Sirex* first appeared. **Control of *Sirex* 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 *Sirex*, 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.

The first appearance of *Sirex* as a non-native in the United States and Canada, where native Siricidae are also found, adds a level of complexity to our understanding of the pest and options for its management.

***Sirex noctilio* clearly represents a growing threat to world-wide conifer forests and forestry**. During the last 100 years, a great deal of knowledge has been accumulated relating to this damaging insect pest. Yet new invasions around the world are vividly illustrating the fact that **aspects of its biology and control are still poorly understood**.

The time is clearly **most opportune to hold an international symposium and workshop to share experiences** and condense recent knowledge regarding the Eurasian woodwasp. Hopefully, such a gathering will lead to a substantially increased understanding of *S. noctilio* and its threat to worldwide forestry. Perhaps more importantly, the aim of a meeting focused on *S. noctilio* should **establish a new trajectory of international collaboration regarding the pest, its biology and its management**.

Organising Committee

Bernard Slippers (FABI)
Mike Wingfield (FABI)
Colin Dyer (ICFR)
Vic Mastro (USDA APHIS)
Dick Bashford (NSCC)
Sally Upfold (ICFR)
Brett Hurley (FABI)

Programme: Thursday 10 May

07.30-08.15 REGISTRATION

	INTRODUCTORY PERSPECTIVES	
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Asia		
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08.40-09.00	The *Sirex* control program in the eastern parts of South Africa: Lessons from research efforts between 2004-2006 *Brett Hurley (S Africa)* pg 38
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	OVERARCHING THEMES AND EXPANDING FRONTIERS
11.40-12.00	Perspectives on the impending threat of *Sirex* to Africa *Gillian Allard (Italy)* pg 46
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	OVERARCHING THEMES AND EXPANDING FRONTIERS cont
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14.40-15.00	Competitive interactions among forest insect associated fungi: Implications to biology, population dynamics, and control *Kier Klepzig* USA) pg 52
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16.20-17.00	**Summary and Concluding remarks** *Mike Wingfield (FABI,S Africa)*

REGIONAL OVERVIEWS: Past and future perspective

AUSTRALIA

Sirex management in response to the Green Triangle outbreak:
Lessons for other countries
Dennis Haugen (USA)

The current status of *S. noctilio* distribution, impact and management control development in Australia
Dick Bashford (Australia)

SIREX MANAGEMENT IN RESPONSE TO THE GREEN TRIANGLE OUTBREAK: LESSONS FOR OTHER COUNTRIES

Dennis Haugen
1082 Shryer Ave, Roseville, Minnesota, USA
dhaugen@fs.fed.us

From 1987-1990, an outbreak of *Sirex noctilio* occurred in *Pinus radiata* plantations in southeastern South Australia and southwestern Victoria. Up to 80% tree mortality occurred in the most susceptible stands. The major management response was to inoculate 147,000 *sirex*-infested trees with the nematode, *Deladenus siricidicola*. Selected compartments were monitored for tree mortality, *sirex* emergence, nematode infection levels, and parasitoid levels over the next 4 years.

Monitoring showed that the mean nematode infection rate was 26% from inoculated trees. The expected rate was 90% and greater. Changes in inoculation procedures were studied and found not to be the major cause of the low infection rates. Further studies revealed a loss in nematode infectivity due to repeated laboratory culturing of the fungus-feeding form of the nematode without allowing for the infective cycle.

Evaluation of the monitoring data revealed compartments in which nematodes were already established prior to the 1987 inoculations. In hindsight, these areas already had adequate nematode levels, and further inoculations were not needed.

One outcome of this outbreak was recognition of a need for a national strategy for *sirex* management. A National *Sirex* Coordination Committee was formed under the Australian Forestry Council, and a subcommittee drafted the national strategy. This strategy was developed for the Australian situation, but many of the 12 major recommendations are applicable in other countries with some adjustments to the various parameters. In Australia, the national strategy appears to have worked; there has not been a significant *sirex* outbreak since the Green Triangle outbreak of 1987-1990.

Dennis has been working on *sirex* woodwasp for 20 years. In Australia, he was the lead entomologist in implementing a biological control program for the *sirex* outbreak during 1987-1991. Also, he was the lead author on the National *Sirex* Management Strategy for Australia. After returning to the US, he was a consultant to the US Forest Service on the Pest Risk Assessment for pine from New Zealand. He has been working with the National Forest Research agency (Embrapa) in Brazil on a *sirex* biological control program since 1997.

Dennis received his Ph.D. (Entomology & Forest Biology) from Iowa State University in 1985. He has been an Entomologist with the USDA Forest Service, North-eastern Area in the St. Paul Field Office since 1993.

NOTES

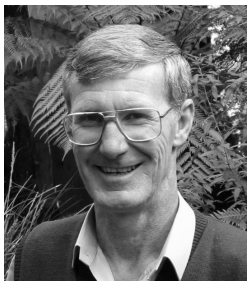
THE CURRENT STATUS OF *S. NOCTILIO* DISTRIBUTION, IMPACT AND MANAGEMENT CONTROL DEVELOPMENT IN AUSTRALIA

Dick Bashford
Forestry Tasmania, GPO BOX 207, Hobart, Tasmania, Australia
dick.bashford@forestrytas.com.au

Sirex noctilio became established in Australia in 1952 when the wasp was discovered in a plantation near Hobart, Tasmania. After a decade the wasp found in the mainland State of Victoria and subsequently spread to adjoining States throughout the *Pinus radiata* estate. The federal government, through CSIRO, funded a major research program aimed at finding biological agents suitable for introduction. A number of insect parasitoids were introduced into Tasmania for mass rearing and subsequently some of these were released in the field. The introduction of the nematode *Beddingia siricidicola* proved to be a very effective biocontrol agent, however in the late 1980's it became apparent that nematode infectivity rates were declining.

At the present time *Sirex* is still a forest pest problem in much of the *P. radiata* estate. The wasp is still increasing its distribution, there are problems with ineffective strains of the nematode, and bark beetles are impacting on the effectiveness of trap tree establishment.

The development of static trap detection of low level populations of *Sirex* is enabling cost savings to be made in both the numbers of trap trees required and early introduction of the nematode.



Dick Bashford has been involved with the *Sirex* Control Program in Australia since 1964. At that time he joined a team at a research station was established by CSIRO, at Silwood Park, England. The aim was to survey Europe for parasitoids of Sirex noctilio, rear them from logs and send cultures to Australia for mass rearing. In 1968 the station closed and he moved to Hobart, Tasmania, still with CSIRO, to join the group involved in field testing both insect parasitoids and the nematode *Beddingia siricidicola*. Between 1968 and 1980 Dick worked on a range of forest insect pest species and assisted in developing the operational control options for *Sirex* in Australia. In 1980 he joined Forestry Tasmania and has worked on a wide range of forestry pest problems as well as managing the *Sirex* control program for Tasmania. He is a member of the Australian National *Sirex* Co-ordination Committee that oversees standards for operational control of *Sirex* and administers a research program funded by a levy on growers.

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EUROPE

A review of Siricids and their fungi in Europe
Iben Thomsen (Denmark)

Genetic variation in *Amylostereum* in northern and central Europe
Jan Stenlid (Sweden)

A REVIEW OF SIRICIDS AND THEIR FUNGI IN EUROPE

Iben M. Thomsen

Forest & Landscape Denmark, University of Copenhagen, Hoersholm Kongevej 11, DK-2970 Hoersholm, Denmark
imt@life.ku.dk

Sirex noctilio and *Amylostereum areolatum* are only one of the wood wasps and symbiotic fungi, whose introduction to the southern hemisphere could cause problems. In Europe there are three other common wood wasps, of which *S. juvencus* carries *A. areolatum* and the other two (*S. cyaneus* and *Urocerus gigas*) have a symbiotic relationship with the related fungus *Amylostereum chailletii*. The latter fungus not only acts as a symbiont, but is also a wound parasite via basidiospores from fruitbodies. In contrast to *A. areolatum*, whose fruitbodies are very rare, *A. chailletii* is quite common in Europe, but has probably often been mistaken for the wound parasite *Stereum sanguinolentum*.

Studies of wood wasps and fungi of the genus *Amylostereum* have a long tradition in Europe. However, as secondary pests with no economic importance, the research has lacked the urgency which has promoted such giant leaps of understanding supplied by researchers from the southern hemisphere. Nevertheless, there are benefits to be gained from a review of the European (and North American) knowledge, especially with the aim of avoiding the misconceptions which unfortunately continue to exist.

The symbiotic fungi of wood wasps *Amylostereum areolatum* and *A. chailletii* can be distinguished by fruitbody characters (including basidiospore size) and mycelial culture characters (mainly presence or absence of oidia). Being able to identify the fungi may also help in distinguishing between species of wood wasps that look similar, or to narrow the possible number of species which could be present in wood, if no adult wood wasps can be found. Clones of *Amylostereum* (and *S. sanguinolentum*) may be detected by somatic compatibility tests.

Forest pathologist, Dr Iben M. Thomsen has been employed as senior adviser at Forest & Landscape since 2000. Her main responsibility is fungal diseases and abiotic factors which damage trees in forestry, landscape, Christmas tree production, and urban environments (park and street trees). Specific fields of interest include *Heterobasidion annosum* and *Armillaria* root rot, *Amylostereum* and wood wasps (*Sirex* sp. and *Urocerus* sp.) *Pucciniastrum epilobii* on Nordmann fir, Hazard trees in urban settings, CSNN on *Abies*. Dr Thomsen is responsible for the Danish forest health monitoring based on defoliation assessments. She has a PhD (forest pathology) and an MSc. (Forestry) from the Royal Veterinary and Agricultural University.

NOTES

GENETIC VARIATION IN *AMYLOSTEREUM* IN NORTHERN AND CENTRAL EUROPE

Jan Stenlid[1], Rimvydas Vasaitis[1] and Bernard Slippers[2]

[1] *Department of Forest Mycology and Pathology, Swedish University of Agricultural Sciences, Box 7026, S-75007 Uppsala, Sweden*
[2] *Department of Genetics, Centre of Excellence in Tree Health Biotechnology, Forestry and Agricultural Biotechnology Institute, University of Pretoria, Pretoria, South Africa*
jan.stenlid@mykopat.slu.se

The symbiosis between members of the fungal genus *Amylostereum* and woodwasps belonging to the genera *Sirex* or *Urocerus* is fascinating from several perspectives. It ranges from being an obligate symbiosis in some of the distribution area to having a facultative nature under other circumstances. Within the native distribution in Northern Europe, *A. chailletii* is only facultatively connected to its vector *U. gigas* while the insect is not reproducing without the fungus. By contrast, *A. areolatum* is ecologically only found in connection with insect activity and is only very rarely observed to produce fruiting bodies. These relations are mirrored by the genetic structures of the two fungal species in Northern Europe; both show signs of clonal dispersal on the scale of 10s of meters but the populations are much more variable in *A chailletii*. On a larger scale, *A. areolatum* still contains a large proportion of clonal replication while *A. chailletii* is more variable resembling other non-vector spread basidiomycetes. Interestingly, in the eastern alpine areas *A. areolatum* is known to produce fruiting bodies and correspondingly, the populations are genetically composed of a multitude of genotypes. In the epidemic areas in the southern hemisphere, lack of fruiting has a matching lack of genetic variation. An interesting question, that might be the key to our understanding of the genetic variation and corresponding aggressiveness of the symbiotic systems, is what factors, internal or external, are regulating the sexual fruiting of these fungal species.

Dr Jan Stenlid is a Professor of Forest Pathology at the Swedish University of Agricultural Sciences in Uppsala since 1995. He graduated from Uppsala University in 1980 and obtained his PhD 1986 from the Faculty of Forestry at Swedish University of Agricultural Sciences. He has conducted research on the geographic distribution and population genetics of *Amylostereum* species. Current research grants include a Joint Genome Institute project on "Whole Genome Sequencing of the conifer root rot fungus *Heterobasidion annosum*" , "FORTHREATS" an EU project on invasive pathogens in European Forests, and Swedish research grants on pathogenicity factors in *H. annosum* and characterisation of the current ash dieback.

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REGIONAL OVERVIEWS: Past and future perspective

AISA

A review of Siricid woodwasps, their fungi, and interactions within trees in Japan
Mashanobu Tabata (Japan)

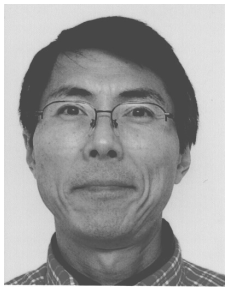
A REVIEW OF SIRICID WOODWASPS, THEIR FUNGI, AND INTERACTIONS WITHIN TREES IN JAPAN

Masanobu Tabata[1], Hiroaki Miyata[2] and Kaoru Maeto[3]

[1] *Tohoku Research Center, Forestry and Forest Products Research Institute, Morioka 020-0123, Japan*
[2] *Kochi Prefectural Forest Technology Center, Kami 782-0078, Japan*
[3] *Faculty of Agriculture, Kobe University, Kobe 657-8501, Japan*
butter@ffpri.affrc.go.jp

Adult females of *Urocerus antennatus* and *U. japonicus* cause wood discoloration of *Cryptomeria japonica* (sugi) and *Chamaecyparis obtusa* (hinoki) through the inoculation of the symbiotic fungus *Amylostereum laevigatum* as they oviposit. The discoloration of sugi and hinoki by the woodwasps and their symbiont occurs widely throughout Japan. No water conductivity was observed in the wood discolored by the invasion of *A. laevigatum*, but the inoculation of sugi trees with the fungus had little influence on stem-diameter growth and did not kill the trees. Most *U. japonicus* require one year to complete development, while a few require two years. The emergence period of *U. antennatus* is from the middle of May to the middle of August. On the other hand, that of *U. japonicus* is from the beginning of July to the middle of October.

There are four recognized species of *Amylostereum* (Stereaceae): *A. areolatum*, *A. chailletii*, *A. ferreum*, and *A. laevigatum*. All of the *Amylostereum* species occur on coniferous trees. *Amylostereum areolatum*, *A. chailletii*, and *A. laevigatum* are associated with wood decay of Pinaceae and other conifers in the Northern Hemisphere, while *A. ferreum* decays wood of *Podocarpus* spp. in Latin America. Some *Amylostereum* species are also known as symbionts of mycophagus woodwasps (horntails) [*Sirex* and *Urocerus* species (Hymenoptera: Siricinae)], which carry their fungal symbiont in the mycangia and inoculate the wood of the plant host with hyphal fragments or arthorospores as they oviposit. *Amylostereum areolatum* and *A. chailletii* are the primary symbionts of the *Sirex* and *Urocerus* woodwasps attacking Pinaceae, while *A. laevigatum* is the primary symbiont of the woodwasps attacking cedar-like tree species. *Amylostereum* species are recognized as members of the family Echinodontiaceae rather than the family Stereaceae based on morphological characteristics and DNA sequence analyses.



Dr Masanobu Tabata is a Team Leader of Tohoku Research Center at the Forestry & Forest Products Research Institute. He received a Ph.D. from the University of Tokyo. He is responsible for research on the epidemiology and management of economic diseases of conifers. The focus of his research involves the epidemiology and management of Amylostereum Rot Disease, Perenniporia Root-Rot Disease, and other Rot Diseases.

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REGIONAL OVERVIEWS: Past and future perspective

SOUTH AMERICA

The woodwasp *Sirex* noctilio in Brazil – monitoring and control
Edson Iede (Brazil)

Official Program for the detection and control of *Sirex noctilio* in Chile
Marcos Beeche (Chile)

The control of *Sirex noctilio* in *Pinus* plantations in the Arauco companies
Rodrigo Ahumada (Chile)

The woodwasp *Sirex noctilio* (Hymenoptera: Siricidae): Ecology and biological control in Argentina
Paula Klasmer (Argentina)

THE WOODWASP *SIREX NOCTILIO* IN BRAZIL – MONITORING AND CONTROL

Edson Tadeu Iede, Susete do Rocio Chiarello Penteado and Wilson Reis Filho
EMBRAPA Florestas. Estrada da Ribeira km 111, Cx. Postal 319, CEP 83.411-000. Colombo, PR, Brazil
e-mail iedeet@cnpf.embrapa.br

Until 1988, only a small number of outbreaks of native pests had been recorded in 1,8 million ha of *Pinus* plantations in Brazil. Most of these stands were planted a small number of species at high density and inadequate forest management. In 1988 an outbreak of *Sirex noctilio* Fabricius was recorded in Southern Brazil and nowadays it is present in 350.000 ha, in the Southern and Southeast. Whit the presence of the European woodwasp in the country, it is estimated that the potential losses caused by this insect may reach US$ 23,2 million annually. This resulted in an immediate change in the handling of these forest plantations, with the introduction of the Integrated Pest Management (IPM) as a part of the Forest Management Programs. In 1989, it was bred by the NATIONAL PROGRAMME OF WOODWASP CONTROL. This programme is broad in scope and also includes the early detection and monitoring of the spread through the use of trap trees (trees artificially stressed with herbicides)and ground inspections. For its control silviculture techniques are preventively used, especially the thinnings, preventing competition and providing health to plantations; and biological control, mainly with the most effective agent, the nematode parasite *Beddingia siricidicola* Bedding, a nematode that sterilizes the females and reaches 70% to near 100% of parasitism. Other parasite introduced was *Ibalia leucospoides*, an egg parasitoid that reach about 25% of parasitism. Two parasitoids *Rhyssa persuasoria* and *Megarhyssa nortoni* were introduced in 1997 and 1998, but they did not established. The biological control associated to the silvicultural control was essentials to put the *Sirex* population under control in Brazil.

Edson Tadeu Iede is a Biologist, with Masters and Doctoral degrees in Entomology, from the Federal University of Paraná. He specialised in Biological Control from the International Center for Integrated and Biological Control- University of California/ Berkeley, and is current Researcher at the National Center of Forestry Research from the Empresa Brasileira de Pesquisa Agropecuária-EMBRAPA- in Colombo, Paraná, Brazil. Edson has been the Technical Coordinator of the Woodwasp Integrated Pest Management Program from the National Fund for Woodwasp Control, from 1989-2007. He was also a Member of the Technical Panel on Forest Quarantine- FAO-2005/07 and has served on a number of other committees and working groups.

NOTES

OFFICIAL PROGRAM FOR DETECTION AND CONTROL OF *SIREX NOCTILIO* (HYMENOPTERA: SIRICIDAE) IN CHILE

Marcos Beéche Cisternas

National Coordinator, Official Program for Surveillance and Control of Sirex noctilio, Servicio Agricola y Ganadero, División Protección Agrícola, Subdepartamento Vigilancia y Control Oficial Fitosanitario

marcos.beeche@sag.gob.cl

In 1990 a National Official Program was started for the early detection of the woodwasp, *Sirex noctilio* in Chile. The objective of this surveillance program was to detect the introduction of the pest early and the possibility of an opportune control. In the beginning of 2001, *S. noctilio* was detected for the first time in Chile, in the central region of the country, at Los Andes/Guardia Vieja, infesting a radiata pine forest and many small groups of trees and urban pines. At the end of the same year, the pest was detected in the south of Chile in radiata pine plantations close to an international road linking with Argentina. When the pest was detected, the Ministry of Agriculture of Chile, through of Servicio Agricola y Ganadero (SAG) started an official control program for the pest.

As result of this program, the introduction of *S. noctilio* in Central Chile was eradicated during 2004 and the one in southern Chile is at this moment still under the official control program with the objective to suppress it. The main components of this National program are the following:

1. Surveillance Program: Using a net of trap trees at national level; Funnel traps and annual surveys of the radiata pine plantations in Central and Southern Chile. This program is developed in coordination with Chilean forestry companies.
2. Quarantine Program: Developed through the implementation of plant protection regulations and inspections of imported lumber and wood packaging material.
3. Biological Control Program: Using a complex of natural enemies of *S. noctilio* produced in SAG Laboratories: (*Megarhyssa nortoni, Rhyssa persuasoria* and *Beddingia siricidicola*) and through a memorandum of understanding between SAG and CPF companies.
4. Bilateral action: Signing and developing a bilateral agreement with the Argentinean Plant Protection Organization (SENASA) for the biological control of *S. noctilio* in the Patagonian Provinces of Neuquen, Río Negro and Chubut.
5. Biological Research: Oriented for the study of the biological life cycle of *S. noctilio* in Chile and the evaluation of the biological control parameters.

The status of the pest in the area is: Quarantine pest with restricted distribution in areas of the Ninth and Tenth regions of Chile. Furthermore, the nematode, *B. siricidicola,* was successfully established in Southern Argentina and Chile; the parasitoids wasp, *M. nortoni* and *R. persuasoria* were produced, released and established in Southern Argentina and during 2006 *M. nortoni* was released in the Tenth region of Chile.

Marcos Beéche is currently working for the Ministerio de Agricultura de Chile - Servicio Agrícola y Ganadero/SAG, as Forestry Engineer and Head of the Project for Eradication and Suppression of Forest Quarantine Pests. He is also the National Coordinator of the Official Program for Surveillance and Control of *Sirex noctilio,* and Acting Director of the Unit of Forestry Surveillance /SAG. Prior to this he was Professor of Forest Entomology- Universidad Austral de Chile (Valdivia, Chile). His main responsibilities are to study and propose quarantine regulations for the introduction to Chile of forestry products with phytosanitary risks, coordinate and supervise at national level the execution of Emergency Plans for forestry quarantine pests, coordinate and supervise the Program for the Inspection of Wood Packing materials coming from abroad, and coordinate and supervise, at a national level, issues of phytosanitary border control. Marcus is the Chilean representative in the Permanent Working Group on Forest Phytosanitary Issues of COSAVE.

NOTES

THE CONTROL OF *SIREX NOCTILIO* IN THE *PINUS* PLANTATIONS OF THE ARAUCO COMPANIES

Rodrigo J. Ahumada and M. A. Poisson
Bioforest S.A. Casilla 70-C, Concepción, Chile.
rahumada@arauco.cl

Sirex noctilio was detected at the beginning of 2001 in the central part of Chile. Its high potential to damage pine plantations is due to its capacity to attack and spread very rapidly. At present this pest is monitored under a quarantine control system regulated by the government plant health agency (SAG). The government sector and private companies have already implemented a strategy for *Sirex* control, based on early detection, biological control (nematode and parasitoids) and improvement of plantation management.

Arauco is the largest private forestry company in Chile, with more than 500.000 ha of Radiata pine, distributed along 800 km in the south of Chile. About 370,000 ha are considered to be at risk to *Sirex* attack. These Radiata pine stands are classified in different levels of risk that was supported by GIS and included various factors important for *Sirex* establishment. The main factors considered important for stand susceptibility for *Sirex* were silvicultural management, site index, age, average diameter, density, and distance of declared focus. The information generated by the GIS analysis was used to direct the monitoring and trap tree plots placement in Arauco plantations. A total of 674 plots of trap trees (6.740 trees) were established in the last season. Those plots also included trials with different herbicides in order to optimize the trap tree system.

Rodrigo Ahumada is currently the head of the Protection and Phytosanitary Division of Bioforest S.A., the research company of the ARAUCO Group. This Division includes programs of Pathology, Entomology, Forest Products, and Biological Control. Rodrigo has worked on a wide range of forestry pest and pathology problems. He also implemented and supervised the strategic planning and biological control for *Sirex* in Arauco plantations in Chile and Uruguay. Rodrigo also represents the company in the government working group on *Sirex*. Rodrigo has a Forest Engineering degree from the University of Chile and obtained an MSc in Plant Pathology from the University of Pretoria, (FABI).

NOTES

THE WOODWASP, *SIREX NOCTILIO* (HYMENOPTERA: SIRICIDAE): ECOLOGY AND BIOLOGICAL CONTROL IN ARGENTINA

Paula Klasmer
Campo Forestal General San Martín, EEA INTA Bariloche, El Bolsón, Río Negro, Argentina
vklasmer@bariloche.inta.gov.ar

The woodwasp *Sirex noctilio* has become the most damaging forest pest for the pine plantations in Argentina in the last decade. In 1985 *Sirex* had been detected in the northeastern provinces and since then the *Sirex* populations have spread into most of the commercial pine plantations of the country, causing great losses and tree mortality.

Following its accidental introduction in Western Andean Patagonia, in a mixed conifer forest located close to the city of San Carlos de Bariloche (72W 41S), it has become established, together with its parasitoid *Ibalia leucospoides.* A management programme has been developed including monitoring, establishment of trap trees for early detection of the pest and biological control methods with *Ibalia leucospoides* and the parasitic nematode *Beddingia siricidicola.*

An overview of the damage, susceptible species and ecology of *Sirex* and its biocontrol agents is described, with special emphasis on silvicultural and biological control measures.

Recent research projects focus on some aspects of *Sirex* and the nematode which can improve the control strategy in the future. In this regard some questions related to the nematode, such as strains and infectivity, need to be discussed.

Paula Klasmer (Vicky) works in Forest Research at the Campo Forestal General San Martín, Estación Experimental Bariloche, Instituto Nacional de Tecnología Agropecuaria (INTA), El Bolsón, Río Negro, Argentina. She is in charge of the Entomology Lab. She is a biologist entomologist specialising in the ecology and biological control of Forest Insects. Vicky has gained considerable experience on *Sirex noctilio* since it was introduced in Patagonia (South of Argentina) by the end of 1992. She had also completed training courses in Embrapa-Brasil on *S. noctilio* and its biological control. In addition, Vicky has done research on other pests like the pine shoot moth, *Rhyacionia buoliana* and recently on insects damaging berries.

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NORTH AMERICA

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Optimized sirex surveillance technology: designing lures and traps for pest and program needs
Darek Czokajlo (USA)

RESPONSE TO THE RECENT FIND OF *SIREX NOCTILIO* IN THE UNITED STATES

Noel F. Schneeberger
USDA Forest Service, Northeastern Area State & Private Forestry, 11 Campus Blvd., Suite 200, Newtown Square, Pennsylvania 19073 USA
nschneeberger@fs.fed.us

More than 58 million hectares of potentially susceptible pine forests exist in the United States, and the risk of introduction and establishment of *Sirex noctilio* has been rated "Very High" in pest risk assessments. The insect has been intercepted by US Department of Agriculture (USDA) inspectors on several occasions since 1985; however it has not been collected in routine or targeted exotic species trapping surveys. That changed in February 2005 when a lone female specimen, taken from a trap in Fulton, New York the previous fall, was confirmed as *Sirex noctilio*.

In the spring of 2005 federal and state officials quickly mobilized to locate stressed pine stands and potential *S. noctilio* habitat around Fulton and Oswego NY. Thirteen areas were identified and infested trees were found in two sites in Oswego. A delimitation survey involving the use of more than 550 traps was subsequently implemented in July 2005 within a 200km (80 mi) radius of Oswego, NY. The trapping effort yielded 85 adult female *S. noctilio* from 55 sites in 5 counties. Delimitation surveys were expanded in 2006 covering most of New York and parts of Pennsylvania and Vermont. More than 2,000 traps were deployed within a 375 km (150 mi) radius from the known infestations. Traps were also deployed around high risk areas like ports and wood processing facilities. These efforts yielded 60 S. *noctilio* specimens in 25 counties in New York and 2 counties in northern Pennsylvania.

It is clear that *S. noctilio* is more widely established in the U.S. Plans are underway in 2007 to continue delimitation surveys beyond New York and into Ohio and Michigan, particularly along the Great Lakes. Targeted surveys around high risk ports and wood processing facilities will be increased as will routine trapping surveys in most of the states. Other work includes completion of a plan for the release of the nematode Beddingia siricidicola, evaluation of a 2006 controlled release of the nematode on 100 pine trees in New York, and further evaluations focusing on traps, lures, trap trees and non-target effects of biocontrol agents.

Noel spent the first half of his career as a field entomologist working with land managers on National Forests and on other federally-owned lands, and with forest health specialists in state forestry and agriculture agencies to plan and implement programs to monitor, manage, and control forest pests. Early in his career he worked on southern pine beetle in the southern U. S. and mountain pine beetle in the western U. S. Much of his career, however, he has spent in the eastern U. S. where he helped shape the current USDA cooperative approach to managing gypsy moth in the United States.

In his present position as the Forest Health Program Leader for the North-eastern Area State and Private Forestry he leads the development and implementation of the Forest Health Protection program on Federal, state, private and Tribal lands across a 20 state area. In recent years he has been instrumental in the planning and implementation of the Gypsy Moth Slow the Spread project and the hemlock woolly adelgid initiative; and currently leads the Forest Service's response in the north-eastern U.S. to Asian long horned beetle, emerald ash borer and *Sirex* woodwasp. His experience in working with diverse groups and agencies at all levels of government to address pest problems of common interest provides an excellent model upon which to develop and implement a coordinated and collaborative response to these new pest introductions.

A native of New Jersey, Noel holds a master's degree in forest entomology from Duke University (Durham, North Carolina) and a bachelor's degree from Wittenberg University (Springfield, Ohio). He now lives in Coatesville, Pennsylvania with his wife, Libby and teenage boys Grant and Wesley. When he isn't responding to the regular challenges posed by teenagers, Noel likes to fish and golf when he has time; and where a bad day at either is infinitely better than most other days.

NOTES

A RESEARCH UPDATE ON *SIREX NOCTILIO* FOR NORTH AMERICA

Victor Mastro, Damon Crook, Joseph Francese and Kelley Downer
USDA-APHIS-PPQ, Bldg. 1398, W. Truck Rd., Otis ANGB, MA 02542

Sirex noctilio is one of a number of new invasive pests that have significant impacts on the North American forest. Major programs are now underway to eradiate or manage the Asian longhorned beetle, emerald ash borer, sudden oak death syndrome, Asian gypsy moth, brown spruce longhorned beetle, and hemlock wooly adelgid. *Sirex*, however, is the first major pest introduced that threatens the pine resource. The North American pine resource is diverse, comprising of about 35 species in the genus, Pinus, north of Mexico. Pines are also widespread, occurring in mixed or pure stands over most of the continental United States.

The Animal and Plant Health Inspection Service (APHIS) role is to prevent introductions of exotic pests and, when introductions occur, to develop programs to eradicate or manage them. As part of this effort, APHIS and its cooperators maintain a national detection program for high-risk exotic pests. Studies were initiated to develop *Sirex* detection traps for the Cooperative Agricultural Pest Survey (CAPS) program, prior to the discovery of *Sirex* in Fulton, NY. These studies have lead to the identification of host tree volatiles that are antennally active and display behavioral activity. Additional work has also identified a contact pheromone that *Sirex* males use to recognize females. Ongoing studies are attempting to fully characterize and exploit the mate finding and host finding behavior of *Sirex noctilio* adults.

As part of developing a control program and determining what factors contribute to a tree's attractiveness, a series of tree girdling experiments are underway. Three species of pine (red, white, and scotch) have been girdled at different times prior to adult flight and with different amounts and types of herbicides. We are studying the sequence and frequency of attack by *Sirex* and other North American bark and wood infesting species.

Vic Mastro is the Laboratory Director of the Pest Survey, Detection, and Exclusion Laboratory (USDA-APHIS-PPQ-CPHST) located at Otis ANGB on Cape Cod in Massachusetts. His focus has been on developing operational technology for the exclusion, detection, and management of invasive species. His interests are behavior, population management, chemical ecology, and survey. Currently, he chairs science panels for the Asian gypsy moth, Asian longhorned beetle, emerald ash borer, and *Sirex* noctilio. The laboratory supports a number of other major APHIS activities, including the national exotic pest survey, commodity treatments, pest risk assessment, and offshore risk mitigation.

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SIRICID DIVERSITY, BIOLOGY AND TOOLS FOR IDENTIFICATION

Nathan Schiff and Dan Wilson

USDA Forest Service, Southern Research Station, Center for Bottomland Hardwoods Research, P.O. Box 227, Stoneville, Mississippi 39776 USA

nschiff@fs.fed.us

There are approximately 100 known species of siricidae worldwide. They are not commonly collected and despite their large size they are taxonomically poorly known. They are very interesting biologically because they can be a dominant pest species in the forest trophic hierarchy. They feed on the wood of trees, tremicines on hardwoods and siricines on conifers, and they digest cellulose with the aid of symbiotic wood decay fungi. They have numerous hymenopterous parasitoids and unusual nematode parasites that alternate life cycles between the wasp and its fungal symbiont. There is considerable work needed finding new species, defining their hosts, and associating their symbionts, parasites and parasitoids. Other than the pest species, *Sirex noctilio*, the biology of siricids is poorly known. A variety of techniques will be discussed including the use of genetic markers for identification of cryptic species.

Nathan Schiff is a research entomologist for the USDA Forest Service in Stoneville, Mississippi. He did his undergraduate training at UCLA and earned a Masters in Entomology in 1983 from the University of Arizona, where he studied the pink bollworm of cotton. For his doctorate from the University of Illinois (awarded 1988), he studied dietary self-selection by the corn earworm. During his Ph.D. studies, he recognized the potential of molecular biology for systematic research and retooled with a post-doc in transcriptional gene regulation of *Drosophila* at Vanderbilt University. He applied the new techniques studying population genetics of honeybees at the USDA ARS Bee Research Laboratory in Beltsville, Maryland, and moths that spread aflatoxin producing fungi in nut crops at the ARS Western Regional Research Center in Albany, California. Working for the Forest Service, Schiff has studied biological control of kudzu, the biology and ecology of an endangered shrub (pondberry), the ecology of insects associated with forest fires and a variety of insects that vector diseases of hardwoods.

Currently, he works on the biological control of *Sirex noctilio* and potential insect food sources for the Ivory-billed Woodpecker. Along with his assigned projects, Schiff has studied the systematics and biology of the sawflies (Symphyta: Hymenoptera) especially the woodborers (Siricoidea) since 1983.

NOTES

SIREX NOCTILIO DETECTION AND BEHAVIOR IN NORTH AMERICAN PINE ECOSYSTEMS

Kevin J. Dodds
USDA Forest Service, Forest Health Protection, 271 Mast Rd., Durham, NH 03824, USA
kdodds@fs.fed.us

North American pine ecosystems contain diverse groups of insects and microorganisms that develop within pine trees. These organisms complicate *S. noctilio* detection efforts and understanding the potential impact the exotic woodwasp will have in North American pine ecosystems. Survey method development and assessment of *S. noctilio* impacts on red and Scots pine are currently underway in North America and native fauna have presented unique challenges during these efforts.

Preliminary trap tree studies conducted in 2006 were successful at attracting *S. noctilio*, but Cerambycidae, Scolytidae, native Siricidae, and other insects were also found on or within trees. Bark beetles (e.g., native *Ips* spp. and the exotic *Tomicus piniperda*) and associated fungi were commonly found in trap trees and likely possess the strongest ability to influence the trap tree resource. While interactions among *S. noctilio*, *Amylostereum areolatum*, bark beetles, and associated fungi have not yet been defined, it is likely interactions occur and the outcomes could have serious implications for *S. noctilio* biological control efforts. Tools such as bark beetle anti-attractants may provide a technique to help reduce the impact of bark beetles on trap trees. Studies during 2007 will evaluate the effectiveness of green leaf volatiles and bark beetle pheromones to protect trap trees from bark beetles.

Efforts are currently underway to assess the impact and behavior of *S. noctilio* in North American pine ecosystems. Scots and red pine stands currently infested with *S. noctilio* are being located and sampled to describe stand structure, growth patterns of attacked and unattacked trees, and tree mortality. Preliminary results suggest that *S. noctilio* concentrates attacks on suppressed and/or overtopped trees. However, on several occasions, attacks on larger apparently healthy trees have been noted.

Kevin Dodds is currently a Forest Entomologist with the USDA Forest Service, Durham, NH. Prior to this he was a Research Associate at the University of Minnesota. Kevin also gained experience while working as a Research Assistant and a Technician at Oregon State University and the University of Arkansas, respectively. He has a PhD in Forest Science from Oregon State University. Kevin's current research interests lie in bark beetle biology and management, invasive species management, Cerambycidae, Buprestidae, chemical ecology, trapping and survey methods.

NOTES

AN OVERVIEW OF THE *SIREX NOCTILIO* SITUATION IN CANADA

Peter de Groot

Natural Resources Canada, Canadian Forest Service, Great Lakes Forest Centre, 1219 Queen St East, Sault Ste. Marie, Ontario, Canada, P6A 2E5

pdegroot@NRCan.gc.ca

After the discovery of *Sirex noctilio* in the United States in 2004, Canada began an active survey to determine if this insect was also in Canada. Surveys began late in August of 2005 where it was discovered in six locations as far as 435 km apart. Subsequent surveys in 2006 in Ontario extended the known range to cover an area of approximately 60,000 km^2. Most of the work undertaken to date has been to detect and delimit the known infestation, and surveys will be extended in 2007. Research studies have been initiated to determine if the nematode, *Beddingia siricidicola* is present in Canada, to investigate the fungi associated with *Sirex noctilio* and develop molecular-based diagnostic assays, to develop improved methods of detection, and to learn more about the interaction of *Sirex noctilio* with native natural enemies and other insect and fungal associates. An update of the survey, research, and plant pest regulatory activities will be presented.

Peter de Groot is a research scientist with the Canadian Forest Service and an adjunct professor of forest entomology with the Faculty of Forestry at the University of Toronto. Peter holds a Diploma in Forestry, a Bachelors of Science in Forestry, and a PhD in Forest Entomology. Known for his love of field research, Peter has worked in forest entomology research for the past 32 years and has worked in many different areas including research on viruses, bacteria, pesticides, chemical ecology, taxonomy, cone and seed production and insect biology and ecology. Although a forest entomologist, Peter considers himself as a forester first with a strong motivating interest in forest protection. Peter has published nearly 70 peer-reviewed scientific papers, seven authoritative field guides, 11 book chapters and reviews, dozens of technical reports and over 40 presentations/posters in just the last 5 years. Since 2000, Peter has worked on five invasive insects in Canada, including *Tomicus piniperda, Tetropium fuscum, Agrilus planipennis, Anaplophora glabripennis*, and more recently, *Sirex noctilio*. He is involved with many science panels and advisory groups and currently leads the Sirex Science Panel for Canada. .

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SIRICID-FUNGAL-NEMATODE INTERACTIONS IN CANADA

Isabel Leal[1], Richard C. Hamelin, Marie-Josée Bergeron, Peter de Groot, Chuck Davis, & Quing Yu
[1] *Research Biologist, Pacific Forestry Centre, Canadian Forest, Victoria, Canada*
Ileal@pfc.cfs.nrcan.gc.ca

This project involves the development of molecular tools for the *Sirex noctilio* wood wasp complex that includes an exotic fungal associate*, Amylostereum areolatum,* and its potential biological control *Beddingia siricidicola.* The development of molecular assays will support the diagnostic and monitoring efforts on the fungus and the nematode associates in Canada. Wood was collected from a survey of *Sirex* infested pines in Ontario in 2006, and used to recover nematodes by Baermann extraction followed by morphological identification of nematodes. We did not find *B. siricidicola*, but we isolated *Beddingia wilsoni*. Wood was also collected in late fall from areas that had had recent wild fires in British Columbia. We identified some *Beddingia* nematodes in some of these wood samples and we are presently growing them on the native *A. chailletii.* We are also rearing insects from log bolts of the same trees. Cultures of *Beddingia* nematodes will be established from emerged adult siricid insects. In addition, we have sequenced DNA from isolates of *A. areolatum* and *A. chailletii* for 3 mitochondrial and 4 nuclear regions. Mitochondrial genes and the ITS region provide lineage identification and are present in multiple copies, which can yield very reliable assays for diagnostic, while nuclear genes are usually more polymorphic and can provide additional information, such as origin of strains and levels of recombination. Multiple polymorphisms have been found, which will be exploited for discriminating species and strains. We are presently identifying cultures of fungi isolated from the wood of the Ontario survey. We are planning to compile these results from multitrophic interactions to develop a better understanding of the patterns of spread and colonization of this complex.

Dr Isabel Leal obtained her PhD from the University of Victoria (Department of Biochemistry and Microbiology) in 1994. Since 1994, when she joined the Canadian Forest Service (CFS) at the Pacific Forestry Centre (PFC), she has been working on studies of molecular characterization and genetic diversity studies of pests, and pathogen-host interactions. Dr. Leal through her research affiliation with the forest invasive alien species research group at PFC, has developed two molecular diagnostic methods (conventional PCR and real-time PCR), that can effectively determine the presence of pinewood nematode (PWN) in wood, and that are highly-sensitive and species-specific. These methods are critical for PWN detection for global phytosanitary purposes and have become part of the IPPC (International Plant Protection Convention) diagnostic protocol for PWN. Dr. Leal is also working on the molecular identification of wood decay and blue-stain fungi present in export quality green lumber produced in Canada. She is currently involved in a collaborative effort with other member of CFS on the development of molecular diagnostic tools for the identification and monitoring of a species recently introduced into Canada, *Sirex noctilio*, its fungal associate *Amylostereum areolatum* and the potential biological control, *Beddingia siricidicola*.

NOTES

ESTABLISHMENT OF *BEDDINGIA SIRICIDICOLA* FOR BIOLOGICAL CONTROL OF *SIREX NOCTILIO* IN THE UNITED STATES: QUESTIONS, ISSUES, AND CHALLENGES

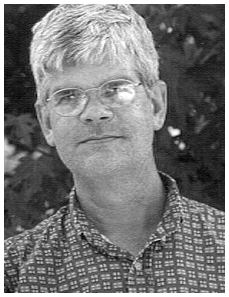
David Williams, Victor Mastro and Kelley Downer

USDA, APHIS, CPHST, Pest Survey, Detection & Exclusion Lab, Building 1398, Otis ANGB, MA 02542, USA
david.w.williams@aphis.usda.gov

Sirex noctilio was first identified in the United States in the spring of 2005. Rearing of adults from infested pine billets and dissection of larvae during 2005 and 2006 revealed that *S. noctilio* was already under attack by native parasitoids, including *Ibalia leucospoides* and *Rhyssa lineolata*. However, entomopathogenic nematodes rarely have been encountered in our surveys to date and have been identified only as *Beddingia* species. *Beddingia siricidicola*, in particular the Kamona strain from Australia, is highly pathogenic and density dependent in action and is considered the most effective natural enemy of *S. noctilio* in pine plantations of the southern hemisphere. Clearly, Australian *B. siricidicola* may be a very useful tool for managing *S. noctilio* populations in the United States. However, several questions and issues arise as we consider the establishment of *B. siricidicola* in the pine forests of North America.

Ecological questions include the effects of intra-tree competition by other boring insects, physiological differences between pine species, and diversity of forest habitats on nematode establishment and dispersal. Strain of *Amylostereum areolatum* is also important because the Australian and American strains have different growth characteristics, which in turn influence growth and reproduction rates of *B. siricidicola*. Climatic patterns are very different between Australia and the United States, particularly with respect to the length and severity of winter. Release strategies and prospects for establishment will depend upon these and other factors. In response to some of these questions, a controlled trial release was carried out in the fall of 2006 in New York State to test application techniques and evaluate nematode overwintering.

A critical issue in the decision to release nematodes is their potential effect on non-target boring insect species. Of particular concern are several native North American siricid species that feed on dead or dying pines. The possible susceptibility and vulnerability of those species to *B. siricidicola* are discussed.



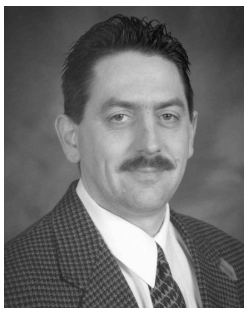
David Williams is an entomologist with the USDA Animal and Plant Health Inspection Service (APHIS) on Cape Cod, Massachusetts. He completed an A.B. in Anthropology at Indiana University and an M.S. in Entomology at North Carolina State University. He earned a doctorate in Entomology in 1981 at the University of California at Berkeley. After a postdoctoral position with Texas A & M University investigating natural control of cotton boll weevil in Yucatan, Mexico, Dave returned to California where he worked for five years as a systems analyst and modeler with the UC Statewide IPM Project in Berkeley and Davis. Relocating East to Pennsylvania in 1987, he was a research entomologist with the USDA Agricultural Research Service and then the USDA Forest Service, carrying out research in diverse fields, including biological control, climate change, theoretical and spatial ecology, and invasive species. Dave joined APHIS in the summer of 2003. In addition to his work on *S. noctilio* biological control, he has carried out research on emerald ash borer, including the application of remote sensing technologies to its survey and foreign exploration for its natural enemies in South Korea.

NOTES

OPTIMIZED *SIREX* SURVEILLANCE TECHNOLOGY: DESIGNING LURES AND TRAPS FOR PEST AND PROGRAM NEEDS

Darek Czokajlo
APTIV, Inc., Portland, Oregon, USA
darekc@aptivinc.com

APTIV has been designing and field testing optimized surveillance technology for invasive forest pests since 1998. Our research and product development program has two aims: 1) delivering the greatest accuracy in pest detection, especially at low pest densities; and 2) ease of use, so more program resources and time can be focused on detection instead of logistics. Lures and traps have been developed for a wide range of exotic species. Recent results from the US and Australia demonstrate that the APTIV Intercept Panel Trap is superior in capture of Siricid wasps including *Sirex noctilio*. Intercept Panel Traps are optimized to maximize both trap capture and user convenience (durability, storage, logistics and handling) in large scale trapping programs.



Dr. Darek Czokajlo is a Senior Scientist and Owner of APTIV Inc., and has worked within this group (IPM Tech, Advanced Pheromone Technologies, IPM Development Company) since 1998 with a focus on chemistry, controlled release formulation, prototype development and forest products. After graduating with a Masters in Forestry from the Agricultural University of Warsaw, Poland, Czokajlo worked as a forest ranger. In 1998 he completed Ph.D. in chemical ecology of insects and forest entomology, specializing in the chemical communication of bark beetles and other forest coleopterans from State University of New York, College of Environmental Science and Forestry in Syracuse. He has experience with behavioural research techniques, including the use of EAG and wind tunnels. He is a key researcher within APTIV and also directs all product manufacturing and formulation. APTIV undertakes research, development, manufacture and sales of innovative semiochemical tools - the foundation of modern IPM. The company consistently sets new standards worldwide for technical leadership, quality and product efficacy. APTIV products are designed with the user in mind.

NOTES

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REGIONAL OVERVIEWS: Past and future perspective

AFRICA

An overview of the national *Sirex* control strategy in South Africa
Colin Dyer (S Africa)

Monitoring the introduction, development and damage of *Sirex* infestation levels in KwaZulu-Natal
Philip Croft (S Africa)

The *Sirex* control program in the eastern parts of South Africa: Lessons from research efforts between 2004-2006
Brett Hurley (S Africa)

Silvicultural measures to reduce the impact of *S. noctilio* in KwaZulu-Natal: Challenges and opportunities
Grant Boreham (S Africa)

Validation for mass inoculations with *Beddingia siricidicola*, despite apparent low inoculation generated parasitism rates
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Influence of *Sirex* infestation on P*inus patula* TMP pulp properties
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The potential threat of *Sirex noctilio F*. to Zimbabwe's forestry industry
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Clement Chilima (Tanzania)

AN OVERVIEW OF THE NATIONAL *SIREX* CONTROL STRATEGY IN SOUTH AFRICA

Colin Dyer
Institute for Commercial Forestry Research (ICFR), PO Box 100281, Scottsville 3209, Pietermaritzburg, South Africa
colind@icfr.unp.ac.za

Sirex noctilio was first recorded in South Africa in 1994 on *Pinus radiata* stands in the Western Cape. Its spread was slow along a fairly narrow band of *P. radiata* plantations in the winter rainfall areas. In 2000 it was detected on *Pinus patula* in the Eastern Cape and by 2002, it had reached the KwaZulu-Natal Midlands where it has reached epidemic levels of infestation. Almost half of this area under pine plantation has been affected by *Sirex*. In 2007, the extent of *Sirex* infestation was estimated to be affecting over 1.5 million trees in 30 000 hectares. The mean level of infestation is 6%.

In the winter and uniform rainfall areas where *P. radiata* is grown, inoculations with *Deladenus siricidicola* were done in the mid 1990s. This was coupled with introduction and release of *Ibalia leucospoides* and *Megarhyssa nortoni.* With the exception of *Megarhyssa nortoni*, which failed to establish, the combination of *Deladenus siricidicola* and *Ibalia leucospoides* appear to have stabilised the *Sirex* population in the winter and uniform rainfall areas. In addition, most of these plantations are managed on saw timber regimes.

The South African *Sirex* Control Programme only began operating at an industry level in 2002, once *Sirex* had reached the summer rainfall areas. The response from industry was to follow the Australian (and other) examples and deploy the available biological control agents (i.e. inoculation with the Kamono strain of *Deladenus siricidicola*). Extensive research trials were conducted to understand the relatively low success that has been achieved in the summer rainfall areas. In 2007, the industry embarked on commercial-scale inoculations centred around the KwaZulu-Natal Midlands and the Eastern Cape, based on evidence of natural spread of the nematodes from previous inoculations. In addition, *Ibalia leucospoides* has been released in these areas in limited numbers since 2006.

The Control Programme operates under the auspices of the forest industry association (Forestry South Africa) which represents all timber growers in South Africa. It is structured into a national steering committee with representation from timber growers, technical experts and government. A number of task teams addressing specific aspects of the Control Programme have been set up. The Control Programme is focused on four aspects: Biological Control, Chemical Control, Monitoring and Awareness, and Silviculture for forest hygiene. All of these are underpinned by research programmes geared towards developing a knowledge base on *Sirex* and its management in South Africa.

Colin Dyer is currently the Director of the Institute for Commercial Forestry Research in Pietermaritzburg, South Africa. He obtained a PhD in Plant Systematics from the University of the Witwatersrand in South Africa. After working at the South African Forestry Research Institute and the CSIR as both researcher and research manager, he took up the directorship of the ICFR in 1998. Colin also serves on the boards of several forestry research and science organisations and is the South African representative on IUFRO's International Council. Colin is also the Chairman of the South African *Sirex* Control Programme.

NOTES

MONITORING THE INTRODUCTION, DEVELOPMENT AND DAMAGE OF *SIREX* INFESTATIONS IN KWAZULU-NATAL

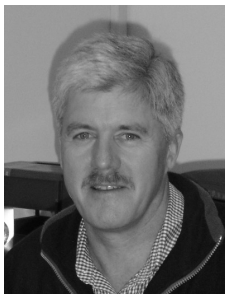
Philip Croft

Institute for Commercial Forestry Research (ICFR), PO Box 100281, Scottsville 3209, Pietermaritzburg, South Africa
Philip@icfr.unp.ac.za

Sirex was accidentally introduced into South Africa in 1994 and has spread along the winter rainfall areas of the Southern Cape. It then moved up along the Eastern Cape which experiences summer rainfall. Here the wasp populations have exploded far exceeding anything found in the Cape Province. The drier winters of KwaZulu-Natal allow the *Sirex*-infested, predominantly, *Pinus patula* trees to dry out to low levels of moisture. This has adversely influenced the success of biological control with nematodes.

Sirex has spread from southern KwaZulu-Natal to just north of Mooi River, south of Dundee and back to Greytown. There have been no reports of *Sirex* beyond this point. The population density in KwaZulu-Natal is extremely high and we measure the *Sirex* population density in terms of pine tree mortality.

A *Sirex* Monitoring Working Group has established several methods of recording the mortality annually. These methods range from GIS interpretation of infra red photography to visual assessment and enumeration type plot measurements. This then supports the planning and execution of the control programme in terms of nematode production and other control measures. The ultimate result of the monitoring is the production of a map depicting the spread and intensity of *Sirex* across South Africa. Future spread of *Sirex* can be monitored and assessed by knowing the present status and looking for possible new infestations in predetermined transport routes or prevailing wind direction.



Philip Croft has a Diploma in Forestry from the Saasveld Forestry College, George. From 1986 to 1990 he was employed as a silvicultural forester by the Dept. of Forestry in S.A. and worked in KwaZulu-Natal and Mpumalanga provinces. In 1990, Philip joined Mondi, and was responsible for forestry operations including silviculture and harvesting of Pine, Eucalyptus and Wattle at plantation level in KwaZulu-Natal. In 2000 his focus changed to forestry planning, both long term harvesting planning and annual planning operations, and also to providing technical support to silvicultural operations in Mondi Shanduka Newsprint, where he first encountered *Sirex*. Philip was made chairman of the *Sirex* Technical Working Group, and then this year, he was seconded to Forestry South Africa for a 3 year period as the Industry *Sirex* coordinator based at the ICFR, Pietermaritzburg. His current areas of interest in *sirex* population reduction include chemical control of *sirex*, monitoring of infestations annually, inoculation trials, creating *sirex* awareness amongst foresters, and developing a National monitoring network across all forestry companies.

NOTES

THE *SIREX* CONTROL PROGRAM IN THE EASTERN PARTS OF SOUTH AFRICA: LESSONS FROM RESEARCH EFFORTS BETWEEN 2004-2006

Brett P. Hurley[1], Bernard Slippers[1], Hardus J. Hatting[1], Philip K. Croft[2] and Mike J. Wingfield[1]

[1] *Department of Genetics, Forestry and Agricultural Biotechnology Institute (FABI), University of Pretoria, Pretoria, South Africa*

[2] *Institute for Commercial Forestry Research, Pietermaritzburg, 3209, South Africa*

brett.hurley@fabi.up.ac.za

Soon after the first detection of *Sirex noctilio* in Cape Town in 1994, biological control agents were introduced in an effort to control this alien invasive pest. These biocontrol agents were released between 1995 and 1999 and included the parasitic nematode, *Deladenus siricidicola*, and the parasitic wasps *Ibalia leucospoides* and *Megarhyssa nortoni*. The latter insect did not become established. When *Sirex* spread to the Eastern Cape and KwaZulu-Natal provinces of South Africa, these biological control agents did not spread with it. In 2004 and 2005, efforts were made to re-introduce *D. siricidicola*, considered to be the primary biological control agent. Success from these releases was very poor, with less than 10 % parasitism recorded from inoculated trees. The influence of various factors on inoculation success was consequently examined. Inoculation technique and nematode viability were not found to be the cause of the poor success. The section of the tree that was inoculated, time of inoculation, and emergence period of the wasps were found to influence inoculation success. Inoculation success was higher in the bottom and middle section of the tree, and in the earlier inoculation periods, where moisture content of the wood was higher. However, there was no correlation between moisture content and parasitism, and high moisture content did not guarantee high levels of parasitism. Thus, other barriers besides moisture content and nematode source appear to hinder inoculation success. These barriers could include strain incompatibilities between the wasp, nematode and symbiotic fungus, competition between the symbiotic fungus and bluestain fungi, as well as various other factors. The influence of these barriers on inoculation success and the background establishment of the nematode, need to be investigated to determine the feasibility of using *D. siricidicola* as a biological control agent in the eastern parts of South Africa. Furthermore, the introduction into South Africa of other known biological control agents of *S. noctilio* is urgently needed.

Brett Hurley has worked as a Forest Entomology Field Extension Officer in the Tree Protection Cooperative Programme (TPCP) of the University of Pretoria, since 2001 on a part-time basis and since 2003 on a full-time basis. During this period, Brett was responsible for monitoring the spread of the *Sirex* woodwasp in South Africa. It was from this work that *Sirex* was discovered to have moved out of the Cape peninsula and into the Eastern Cape and KwaZulu-Natal province. In 2003, Brett was sent to Australia to learn from the *Sirex* programme already established there, and was responsible for the re-introduction of the nematode *Deladenus siricidicola* in South Africa. Brett is currently enrolled for his PhD at the University of Pretoria, where he is investigating the establishment and molecular ecology of the biological control agents for the *Sirex* woodwasp. Apart from this, Brett continues to manage the rearing of *Sirex* biocontrol agents and is involved in various research projects related to the *Sirex* programme, including the development of more effective monitoring tools.

NOTES

SILVICULTURAL MEASURES TO REDUCE THE IMPACT OF *S. NOCTILIO* IN KWAZULU-NATAL: CHALLENGES AND OPPORTUNITIES

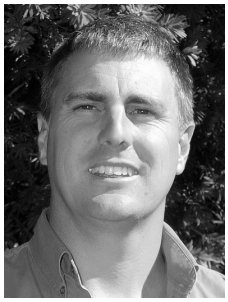
Grant Boreham
Sappi Shaw Research Station, P O Box 473 Howick, 3290 South Africa
Grant.boreham@sappi.com

Approximately 54% of South Africa's 1.3M ha of commercial forests is established with pine species, with over 30% of this pine resource managed for pulpwood production. The major species include *Pinus patula*, *P. elliottii*, *P. taeda*, and the *P. elliottii x caribaea* hybrid with *P. patula* being the most widely planted. If the pine plantations of Swaziland are included then over 90% of all pine pulpwood area is ahead of the Sirex front and currently non-infested. Thinnings are not standard practise in pulpwood stands and maximizing fibre per hectare remains a primary objective.

A total of four thinning treatments were established at each of four trial sites in the KwaZulu Natal midlands in 2005. The treatments included a systematic 3rd row thinning, two selective thinning treatments, and a control (no thinning). Two of the sites were located within the *Sirex* front, one site on the front and one site ahead of the front. A total of 120 permanent monitoring plots were established within all the treatments across all four trial sites in October 2006. Detailed field observations and measurements including growth and yield, *Sirex* population numbers, tree moisture and resin yield were collected.

Where *Sirex* has established, its activity is restricted to suppressed trees within either the unthinned or 3rd row treatments with larger sized trees producing higher numbers of adult emergences. Selective thinning, which removes suppressed and damaged trees, is more successful in reducing the risk of *Sirex* infestation than systematic third row thinning. Thinning improved stem moisture, particularly within the more susceptible, smaller diameter classes. In unthinned stands, larger stems have higher stem moisture than smaller diameter stems. Resin yield was very low from most of the stems measured, and this technique will need to be refined if resin yield is seen to have an impact on tree resistance to *Sirex* attack. The size of *Sirex* adults decreased with increasing height up the stem, with no adults emerging in the top 30% of the tree.

Based on these preliminary results an additional trial will be implemented to test various levels of phytosanitary thinning and the impact on *Sirex* establishment and development over time in pine pulpwood stands.



Grant Boreham has been employed by Sappi Forests as a Research Officer in the Land Management programme since 2003. His responsibilities include silvicultural research, growth and yield, site/species matching, monitoring sustainability, and minimising risks on Sappi's landholdings. Since *Sirex* was first detected in pine plantations in Southern KwaZulu Natal Grant has been involved in projects to increase the understanding of the impact of silvicultural practises such as thinning on *Sirex* population levels in Sappi's pulpwood stands.

NOTES

VALIDATION FOR MASS INOCULATIONS WITH *BEDDINGIA SIRICIDICOLA*, DESPITE APPARENT LOW INOCULATION GENERATED PARASITISM RATES

Marcel Verleur
Sappi Forests, P O Box 13124 Cascades 3202, South Africa
Marcel.verleur@sappi.com

Inoculation trials on Sappi landholdings with *Beddingia siricidicola* during 2004 - 2006 resulted in the following average adult female parasitism rates:

2004 = 2.1%, 2005 = 9.3%, 2006 = 8.5%

Sappi Forests embarked on a mass inoculation program during 2007, with the intention to inoculate 50,000 trees between February and May 2007. How is this justified in the light of apparent ineffective inoculations?

Results from the 2005 and 2006 Sappi inoculation trials indicated that parasitized adults mostly emerge from the bottom third of inoculated trees. The levels of parasitized females emerging from the bottom third of sample trees were as follows:

2005 treatments = 19.9%, 2006 felled treatment = 22.9%, 2006 standing treatment= 25.9%

During 2006 un-inoculated *Sirex* infested trees were sampled within a 500 m radius of sites where inoculations during 2005 yielded the highest levels of adult parasitism. The average larval scarring observed was as follows:

Bottom third = 41%, Middle third = 25%, Top third = 25%.

This indicated that parasitism generated from inoculated trees was able to result in natural parasitism in the next generation. Subsequent sampling of these same trees in emergence drums yielded the following adult parasitism:

Bottom third = 31%, Middle third = 13%, Top third = 12%.

Expressed as parasitized females only the result is as follows:

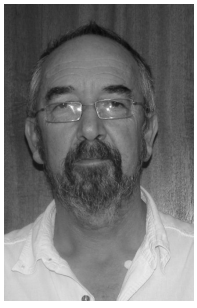
Bottom third = 54%, Middle third = 28%, Top third = 21%

The difference in parasitism levels between total adults vs. females only, is explained by a simple analysis of all the emergence results from 2005 and 2006. It would seem that females predominantly occur towards the bottom of the trees and males in the middle:

Given the huge potential losses ahead of the *Sirex* front there is a demand for a solution driven approach. Operational decisions are often based on assessing results and evaluating opportunities for success on the balance of probability in an ongoing manner. Embarking on mass inoculations during 2007 follows the same precedent:

1. Higher levels of parasitism occur in the bottom third of trees
2. Parasitism from inoculated trees transfers to natural parasitism in the next generation
3. Females seem to predominantly occur in the bottom third of trees

Therefore mass inoculations targeting the bottom third of trees is justified.



Marcel Verleur is currently Manager Special Projects (Silviculture) at Sappi Forests. He has a BSc in Entomology and Botany from the University of Pretoria and is registered for an MSc on the Bio-Control of *Sirex noctilio* on Sappi landholdings through the Nelson Mandela Metropolitan University. Marcel has been with Sappi Forests since 1983 during which time he gained experience as a Forester, Forestry Manager, Development Manager and Business Development Manager.

NOTES

INFLUENCE OF *SIREX* INFESTATION ON *PINUS PATULA* TMP PULP PROPERTIES"

Marius du Plessis[1], N J Le Roux[2], S Gardner-Lubbe[2], J Swart[3] and T Rypstra[3]
[1]Mondi Business Paper, P O Box 39, Pietermaritzburg 3200, South Africa
[2]Department of Statistics and Actuarial Science, Stellenbosch University, Private Bag X1, Matieland, 8000.
[3]Department of Forest and Wood Science, Stellenbosch University, Private Bag X1, Matieland, 8000.
[1]Marius.duplessis@mondibp.com

The infection of trees by the wood wasp *Sirex noctilio* and its associated fungus, *Amylostereum areolatum* and the influence thereof on the wood and pulp properties *Pinus patula* was investigated. Various tree classes representing different levels of physiological growth stress are compared with one another. The infection and association between the wood wasp and the fungus is responsible for the dying of trees on a large scale in the Midlands of KwaZulu-Natal. Together with the above stress agents, fire damage to *P. patula* trees was also considered as a possible cause of the deterioration of chemical properties. Chemical analyses to determine the cellulose and lignin contents as well as the levels of extractives were conducted by using accepted Tappi standard methods. The thermo mechanical pulping process was used to produce pulp suitable for analysis. The results indicated only negligible differences between tree classes with respect to cellulose and lignin contents. In contrast, highly significant differences were observed for solvent-borne and water-borne extractives. It is evident from the results that *P. patula* trees engage a defence strategy to counter the effects of the infestation and the resulting physiological stress. The results of the chemical analyses lead to the suggestion that trees should not be harvested any younger than the intended rotation age and at the time of harvesting all the biomass, including the infected wood, should be send to the pulp processing facility. The usefulness of a biplot to simultaneously display various tree classes and several chemical properties is illustrated.

Marius du Plessis has a Saasveld Diploma, a BSc Forestry and an MSc Agriculture (Forestry). Research interests include the chemical Kraft pulp processes, genetic improvement of species used in the pulping processes, the contribution and influence of individual species and site to process and pulp quality, laboratory and pilot scale standards setting, testing methods and having some fun making paper. Marius is married to Eureka, and has 3 sons. When he is not making paper, he enjoys caravanning, camping, DVD-ing and Googling.

NOTES

THE POTENTIAL THREAT OF *SIREX NOCTILIO* F. TO ZIMBABWE'S FORESTRY INDUSTRY

Member Mushongahande

Research and Training Division, Zimbabwe Forestry Commission, Harare, Zimbabwe

Zimbabwe is a land-locked country in Southern Africa covering more than 39 million hectares. Of the 39 million hectares 108214 ha (or 0.3%) of the total area is under commercial plantations which are mainly found in the Eastern Highlands. According to the 2004/05 plantation forestry statistics, the distribution of commercial tree species is as follows: pines 71771ha (66.32%), eucalyptus 26274ha (24.28%), wattle 10009ha (9.25%) and popular 160ha (0.15%). Of the commercial plantations 61816ha are privately owned while 38326ha are owned by the state.

Zimbabwe's economy depends heavily on natural resources for employment creation, generation of foreign currency and sustenance of livelihoods. The Forestry sector contributes about 3% of the Gross Domestic Product (GDP) largely from exotic plantations and commercial indigenous timber. According to the employment statistics of 2004/05 the formal forestry sector in Zimbabwe employed a total of 14253 people and many more were employed in the downstream industries.

Major threats to the exotic forest plantations in Zimbabwe include fires, baboon damage (especially in pines), droughts, floods, both indigenous and invasive alien insect pests and diseases. Since the establishment of exotic plantations in Zimbabwe, exotic invasive insect pests were either accidentally introduced or spread into our country. This has been made worse by the increase in international trade and globalization which increased the permeability of Zimbabwe's borders to invasive forestry insect pests such as *Sirex noctilio*. Of major concern in Zimbabwe's timber industry is that all commercial pine species are susceptible to *S. noctilio*. The country shares borders with South Africa, Zambia, Botswana and Mozambique. Even though *Sirex noctilio* has not been sighted in Zimbabwe, it will not be long before it spreads into the country.

Member Mushongahande has worked as research assistant for the SADC/ICRISAT, Pearl Millet Regional Breeding Programme, before completing a MSc. Agriculture (Crop protection) at the University of Zimbabwe in 1994. After this he worked at the University of Zimbabwe as research assistant on grain product projects. Member was appointed in 1995 as Forest Entomologist at the Zimbabwe Forestry Commission, Research and Training Division, where he now serves as Forest Protection Programme Leader. In this role he is responsible for the formulation, establishment, analysis and results adoption of forestry protection experiments in Zimbabwe and giving advice on forest protection to the Zimbabwe forestry sector and the public.

NOTES

THE THREAT OF *SIREX NOCTILIO* AND OTHER ALIEN INVASIVE SPECIES IN AFRICA

Clement Chilima
FISNA Secretariat, Forestry Research Institute of Malawi, P.O Box 270 Zomba, Malawi

Forestry resources are very important for the socio-economic welfare of African Countries and there is recognition that the resource and international market need to be protected from the impact of alien invasive species for the good of the continent.

The paper describes the threat of alien invasive species to forest resources in Africa and the weak capacity of most African countries to deal with these threats through the application of sanitary and phytosanitary system (SPS) measures. resource limitations, inadequate trained personnel, poor awareness and lack of regional harmonisation are cited as the main reasons for the poor situation.

The paper proposes that that African countries should be better linked through regional networking on IAS, build their capacity, harmonisation their SPS activities and improve awareness of IAS issues at all levels. The paper introduces and describes the existing networking initiatives through the Forestry Invasive Species Network for Africa (FISNA) and seeks support from all African countries.

DISCUSSION NOTES

OVERARCHING THEMES AND EXPANDING FRONTIERS

Perspectives on the impending threat of *Sirex noctilio* to Africa
Gillian Allard (Italy)

The role of parasitoids in management of *Sirex*:
Looking back and looking ahead
Alan Cameron (USA)

Key biological factors in the management of *Sirex noctilio*: A review
Dolly Lanfranco (Chile)

Opportunities for *Sirex* research in the genomics era.
Jeffrey Dean (USA)

The genetics of recognition in *Amylostereum areolatum*
Magriet van der Nest (S Africa)

Competitive interactions among forest insect associated fungi: Implications to biology, population dynamics, and control
Kier Klepzig USA)

Climate change and the threat of forest insect and their associated fungi
Diana Six (USA)

Spread and establishment of *S. noctilio* and *A. areolatum* in new environments
Bernard Slippers (S Africa)

The pathway approach to minimising the threat of invasive forest pests: *Sirex* as an example.
Simon Lawson (Aust)

PERSPECTIVES ON THE IMPENDING THREAT OF *SIREX NOCTILIO* TO AFRICA

Gillian Allard
Forestry Department, Food and Agriculture Organization of the United Nations

Gillian Allard, Forestry Officer (Forest Protection and Health), Forestry Department, Food and Agriculture Organization of the United Nations, has worked since 1997 in the FAO forest protection and health programme, which aims to safeguard the health and vitality of forests, forest ecosystems and trees outside forests. She has global responsibility for insects, diseases and woody invasive species. In this capacity she has worked in more than 30 countries, providing technical support to member countries to strengthen capacity through field projects to address specific forest health problems. Project activities range from emergency operations in Mongolia and DPR Korea to control outbreaks of the Siberian caterpillar to investigating diebacks in the Seychelles, Saudi Arabia and Libyan Arab Jamahiriya. Gillian provides technical support to recently developed information exchange networks and working groups on forest invasive species in Asia and the Pacific, North America and Africa. She is also participating in the development of further forest invasive species networks for the Near East and for the Southern Cone countries of South America.

Prior to joining FAO, Gillian worked in Africa for 12 years, including five years as Regional Coordinator for CABI on a cypress aphid project based in Nairobi, Kenya, where she coordinated activities in 11 countries in east and southern Africa.

THE ROLE OF PARASITOIDS IN MANAGEMENT OF *SIREX*: LOOKING BACK AND LOOKING AHEAD

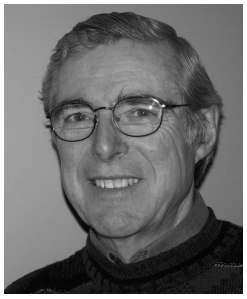
E. Alan Cameron
Department of Entomology (Emeritus), Penn State University, University Park, PA 16801 U.S.A.
eajabaka@comcast.net

Effective management of *Sirex noctilio* begins and ends with the application of good silvicultural practices. The addition of one or more species of hymenopterous parasitoids, and of a nematode, have significantly reduced or eliminated the adverse economic impact of this insect in exotic pine plantation forestry in Australia and New Zealand.

Rhyssa persuasoria and *Ibalia leucospoides* were introduced from England to New Zealand in the 1920's; Ibalia was reintroduced in the 1950's when rigorous thinning and pruning were also undertaken to improve the health of overstocked and stressed stands. In the 1960's, *Megarhyssa nortoni nortoni* from California, USA, was released. The nematode *Beddingia (Deladenus) siricidicola*, was discovered and exploited. Healthy stands, along with the biological agents, have reduced populations so *Sirex* is no longer a forest problem in New Zealand. Rhyssa spp. from India and California, and *Megarhyssa, Ibalia leucospoides ensiger*, and *Schletterarius cinctipes* from California, were released in Australia in the 1960's; silvicultural treatments were intensified; nematodes were widely introduced. Populations were largely controlled, especially in Tasmania. Where proper thinning is undertaken as stands mature, control is generally maintained by the biological agents.

S. noctilio was discovered in South America – Uruguay, Brazil, Argentina, and Chile – in the 1980's. *I. leucospoides* arrived in Brazil and Argentina on its own and established readily in some areas. In Brazil, *R. persuasoria* and *M. nortoni nortoni* were introduced; establishment has not been recorded. *B. siricidicola* has been introduced in Brazil and Argentina with some success. Silvicultural improvements are being undertaken in plantations; *Sirex* populations have been greatly reduced. In South Africa, *S. noctilio* was first recorded in Cape Province in 1994. *M. nortoni nortoni* was introduced but not established. More recently, *Sirex* has become a major and increasing problem in KwaZulu-Natal. Other than the nematode, introduction of biological controls has not been attempted.

In the future, rigorous silvicultural management to maintain healthy stands, primarily through thinning but not ignoring pruning, will provide the foundation for any success in management of *Sirex* with biological agents in pine plantations.



While with the Commonwealth Institute of Biological Control (1960-65), Alan Cameron provided a number of species of parasitoids of Siricidae to Australia and New Zealand from western North America. Following graduate studies at the University of California, Berkeley, (1965-70), Alan joined the faculty of the Department of Entomology at Penn State University, from which he retired in 2000, as their forest entomologist. His primary teaching and research area was forest pest management, but he also conducted research in behavior, biocontrol, chemical ecology, and ecology. Major contributions were made in understanding the behavior of the gypsy moth and the limits on the use of its synthetic pheromone, disparlure; spray technology, including field testing of new products and formulations for forest pest management; and pear thrips biology and the consequences of its attack on sugar maple forests. His program supported a number of graduate students and post-doctoral research associates.

Cameron has contributed over 150 entomological publications, including co-editing Diagnosing Injury to Eastern Forest Trees, for which he received a USDA Certificate of Appreciation (1987). He received a second USDA certificate (1994) for his contributions to gypsy moth research at the USDA-ARS European Biological Control Laboratory in Montpellier, France. Alan has also received a number of recognitions from professional societies for both scientific accomplishments and professional service. He was a 20-year member of the Speakers' Bureau of the American Chemical Society. Alan currently serves as Editor-in-Chief of *Environmental Entomology*. He has served on the Entomological Society of America Governing Board, as Eastern Branch President, and was a Board Certified Entomologist. Cameron was named an Honorary Member of the ESA in 2001.

NOTES

KEY BIOLOGICAL FACTORS IN THE MANAGEMENT OF *SIREX NOCTILIO*: A REVIEW.

Dolly Lanfranco[1] and Cecilia Ruiz[2]

[1] *Instituto de Silvicultura, Facultad de Ciencias Forestales, Universidad Austral de Chile*
[2] *Campus Isla Teja. Casilla 567, Valdivia, Chile*
dlanfran@uach.cl

The case of *Sirex noctilio* represents complex interspecific interactions and many important biological factors which influence decision-making must be considered in the management of this forest pest. This presentation considers the forest, the pest, the biocontrol agents, and the role of man in favoring, mitigating, improving and solving this problem.

With respect to the trees, the species susceptibility, monospecific condition, plantation age, silvicultural management, and health will be analysed, among other factors.

In relation to *Sirex* we will consider factors unique to the species such as: survival; mating; sexual rate; offspring; and others related to its population dynamics and the monitoring of its behaviour with its host and its symbiotic fungus.

Biocontrol agents (parasites and parasitoids) used as regulators of the pest are hindered by numerous technical factors, such as poor implementation, which interfere with these biological control mechanisms. Assuming that the most effective agents are currently being used, basic aspects of their biology such as their adaptation to the environment, survival, mating, offspring, and measures to facilitate their action are not usually being incorporated into management programs for this pest.

Finally, way of monitoring and controlling the quality of the processes and procedures involved in all of the above-mentioned factors will be discussed in order to achieve a good level of pest management within the context of the management of the forest.

Dolly Lanfranco Leverton is currently based at the Instituto de Silvicultura, Facultad de Ciencias Forestales, at Universidad Austral de Chile, Valdivia – Chile. She describes herself as a biologist, zoologist and entomologist with expertise in the taxonomy and systematics of Hymenoptera (Ichneumonidae). Her research interests lie in the biological control of forest pests, with recent projects in the biology, ecology and control of *Rhyacionia buoliana* and other insect pests. Currently she is involved in research in Ichneumonidae of the remnant evergreen coastal forests in Valdivia, Chile. Dolly has considerable experience and training in areas related to *Sirex* having worked at the CSIRO-Australia, Embrapa-Brasil and the Pacific Forestry Centre, Victoria, Canada. She has also completed courses in Integrated Forest Pest Management, Biological Control, Forest Health and Forest Ecosystem Management and the Evolution of Phytophagous Insects.

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DISCUSSION NOTES

OPPORTUNITIES FOR *SIREX* RESEARCH IN THE GENOMICS ERA

Jeffrey F.D. Dean
Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA 30602, USA
jeffdean@uga.edu

Considering the frequency with which potential pathogens contact prospective hosts it is surprising how infrequently disease states actually become established. The interplay of genes and gene responses that permit or resist establishment of the disease state can be subtle, but genomic tools and technologies can potentially enable quick identification and monitoring of critical genetic components. The availability of complete genome sequences for a nematode (*C. elegans*), the honeybee (*Apis mellifera*) and several species of basidiomycetes (e.g. *Phanerochaete chrysosporium* and *Cryptococcus neoformans*), as well as increasing amounts of gene sequence information for pines (*Pinus* sp.), provide ample material with which to begin exploration of the fundamental genetic interactions governing individual members of the *Sirex: Amylostereum* pathocomplex. For example, genomic tools could be used to examine genetic signals in *Beddingia siricidicola*, a nematode parasite of *Sirex noctilio*, that control the developmental transition from mycophagous to parasitic behavior. This information could better inform efforts to isolate more aggressive parasitic lines. Similarly, transcriptional profiling to determine the response of *Amylostereum areolatum* arthrospore germination to various fatty acids might indicate whether the waxes in which *S. noctilio* encases the arthrospores contribute to early growth of the fungus in the pine host. An association genetics study using a large collection of single nucleotide polymorphism (SNP) markers in loblolly pine (*Pinus taeda*) is currently being tested as an approach to identify resistance genes for the pitch canker causative agent, *Fusarium circinatum*. Resistant genotypes from that study could be tested for cross-resistance to *A. areolatum*. Alternatively, available *P. taeda* cDNA microarrays could be used to follow gene expression profiles in species of pine displaying different levels of resistance to *Sirex* attack in an effort to identify the responsible metabolic pathways. These and other possibilities for using genomic tools to study important features of this pathocomplex will be considered.

Dr Jeffrey F. D Dean is currently a Professor at the Daniel B. Wardell School of Forestry and Natural Resources, University of Georgia in Athens. Georgia, USA. Prior to this, he was Director of the Plant Center at the University of Georgia, from 2002 to 2005. Jeffrey has a Bachelor of Science degree from Stanford University and obtained a PhD in Biochemistry from Purdue University. Current research initiatives include a project for the USDA Forest Service, Agenda 2020 Program entitled: "Assessing the Impact of Intensive Forest Management Practices on Wood Formation and Quality at the Level of Gene Expression." He is also working on the Georgia Traditional Industries Program in Pulp & Paper, entitled: "*Sirex noctilio*: Genetic Approaches to Managing a Newly Introduced Insect Pest of North American Pines and Conifers."

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THE GENETICS OF RECOGNITION IN *AMYLOSTEREUM AREOLATUM*

Magriet A. van der Nest[1], Bernard Slippers[1], Jan Stenlid[2], Brenda D. Wingfield[1] and Michael J. Wingfield[1]

[1]Forestry and Agricultural Biotechnology Institute (FABI), Department of Genetics, University of Pretoria, Pretoria, 0002, South Africa; [2]Department of Forest Mycology and Pathology, Swedish University of Agricultural Biotechnology Institute, Uppsala, Sweden.
magriet.vandernest@fabi.up.ac.za

Amylostereum areolatum is a filamentous homobasidiomycete with a typical basidiomycete life-cycle. Basidiospores germinate to produce monokaryotic hyphae with a single nucleus per cell. The hyphae of sexually compatible monokaryons can fuse to form fertile dikaryons, which have two nuclei per cell. The hyphae of vegetatively compatible dikaryons can also fuse to form new dikaryons having a mosaic of nuclei. *Amylostereum areolatum*, however, differs from model homobasidiomytes that have been studied, by the fact that it has a close symbiotic relationship with the woodwasp, *Sirex noctilio*. The woodwasp symbiont facilitates efficient spread of asexual arthrospores. This has resulted in the presence of clonal populations of the fungus over large distances and that have persisted for long time periods. It has previously been suggested that this association could also influence the diversity and evolution of the genes determining mating and vegetative incompatibility. We studied the genetic mechanisms that control the outcome of these fungal-fungal interactions of *A. areolatum*. Our results confirmed that *A. areolatum* has a tetrapolar heterothallic mating system, where sexual compatibility is determined by two mating-type (mat) loci (loci A and B), each with multiple sub-loci. The mating compatibility studies also demonstrated that both the mat loci are multi-allelic. The outcome of interactions between dikaryons is controlled by the vegetative incompatibility (vic) loci. Results of our vegetative incompatibility studies showed that self recognition in this fungus is controlled by at least two multi-allelic vic loci. Linkage mapping further demonstrated that both the mat and vic loci are unlinked. These data provide a useful foundation upon which to understand the biology of *A. areolatum* and its interaction with *S. noctilio*. They will also facilitate an understanding of their patterns of spread around the world as well as considerations of the likely consequences of further introductions.

Magriet van der Nest is currently a PhD student at FABI. Her research interests focus on fungal-fungal interactions. For her project she is aiming to enhance our understanding of how vegetative and sexual compatibility shape the population structure, diversity and evolution of the white rot fungus *Amylostereum areolatum*.

NOTES

COMPETITIVE INTERACTIONS AMONG FOREST INSECT ASSOCIATED FUNGI: IMPLICATIONS TO BIOLOGY, POPULATION DYNAMICS, AND CONTROL

Kier D. Klepzig[1], Richard W. Hofstetter, Matthew P. Ayres and Bernard Slippers
[1]USDA Forest Service, Pineville, LA, USA
kklepzig@fs.fed.us

Most phloem and xylem colonizing insects in trees are associated with one or more symbiotic fungi. The effects of these fungi on their insect partners are context dependent and range from mutualistic to antagonistic. These relationships influence all levels of processes within the insect-tree interaction. Effects on larval development and adult size and physiology translate to effects on fecundity. Variable fecundity impacts population dynamics. Likewise, any attempts to interfere with the biology of these systems through the use of biological controls (especially microbes) are likely affected by existing symbiont interactions. We review the state of the knowledge of these interactions in a few aggressive insects as well as our approach to studying similar aspects of the *Sirex* symbiotic system.

Kier got his BS (Reclamation/Biology) in 1986 from the University of Wisconsin-Platteville. He followed that with a MS (1989) and PhD (1994) in Entomology and Plant Pathology from the University of Wisconsin-Madison. His research, then and now, focuses on symbiotic interactions between bark beetles and fungi. Kier taught Urban Forestry at Southern University in Baton Rouge, LA. In 1995 he accepted a position as a Research Entomologist with the Southern Pine Beetle Unit in Pineville, LA. After 3 years, Kier was selected as Project Leader of the unit. Kier has authored over 50 publications and delivered over 90 scientific presentations. Recently he was named Project Leader for the newly created Insects, Diseases and Invasive Plants unit (SRS-4552). Kier is heavily involved in international research with projects in Mexico and South Africa.

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CLIMATE CHANGE AND THE THREAT OF FOREST INSECTS AND THEIR ASSOCIATED FUNGI

Diana Six

Department of Ecosystem and Conservation Sciences, University of Montana, Missoula, Montana 59812 USA
diana.six@cfc.umt.edu

Some of our most important forest insects possess intimate associations with symbiotic fungi. These include bark beetles, ambrosia beetles, and *Sirex* woodwasps. For these insects, fungal partners are critical to development and survival and can have significant effects on population dynamics. Both insects and fungi are very sensitive to changes in environmental conditions, especially those involving temperature. An important ecological consequence of global warming is predicted to be an acceleration of activity and impacts of insects and pathogens in forests. Such effects are already being observed in many areas of the world, including the current outbreak of mountain pine beetle in British Columbia. This outbreak is of unprecedented size and has resulted in a substantial expansion of the beetle's geographic range. The beetle is expected to kill over 80% of the pine forest in this Canadian province by the end of the decade. While many studies are focusing on how to best document and predict the effects of climate change on insect populations, little effort is being expended to understand how temperature may indirectly affect host insects through its effects on critical symbionts. In some cases, insect hosts and their symbionts may be similarly affected by climatic change (either positively or negatively) while in other cases, hosts and symbionts may be affected asymmetrically, effectively decoupling the symbiosis.

Dr. Six received her masters and doctoral degrees from the University of California, Riverside, after which she conducted postdoctoral research at the University of California, Berkeley. She has been a Professor of Forest Entomology/Pathology at the University of Montana since 1997. Her research focuses primarily on bark/ambrosia beetle-fungus symbioses, bark beetle ecology and management, and ecological impacts of biological invasions. This work has recently expanded to include the effects of climate change on forest insect and fungal systems.

NOTES

THE SPREAD AND ESTABLISHMENT OF *SIREX NOCTILIO* AND *AMYLOSTEREUM AREOLATUM* IN NEW ENVIRONMENTS

Bernard Slippers[1], Magriet A. van der Nest[1], Rimvis Vasiliauskas[2], Brett P. Hurley[1], Jan Stenlid[2] and Michael J. Wingfield[1]

[1] Department of Genetics, Forestry and Agricultural Biotechnology Institute (FABI), University of Pretoria, Pretoria, 0002, South Africa
[2] Department of Forest Mycology and Pathology, Swedish University of Agricultural Biotechnology Institute, Uppsala, Sweden.
bernard.slippers@fabi.up.ac.za

Siricids are frequently intercepted in packaging material and other forms of unprocessed wood. They are well suited to this mode of long range anthropogenic dispersal, because they are attracted to fresh wounds, are common at sites where wood is being harvested and subsequently occur in low grade timber often used for packaging. Their accidental movement is also enhanced by the fact that their larvae are cryptic and well protected deep inside infested wood. Their predisposition to spread in wood, coupled with the often weakly implemented quarantine regulations and the large volume of trade between the Northern and Southern Hemisphere, makes it surprising that only two Siricids, *Sirex noctilio* and *Urocerus gigas*, have spread to the latter region. Furthermore, our research into the population diversity of *S. noctilio* and its fungal symbiont, *Amylostereum areolatum*, indicates that these organisms were most likely introduced only once or a limited number of times from the same origin, after which they spread between countries in the Southern Hemisphere. These findings suggest that, while Siricids might be easily introduced to new environments, they do not establish as easily as might be supposed. Results of our research also illustrate the threat of invasive pests moving between countries of similar latitude, compared to that between the Northern and Southern hemisphere. As for other invasive organisms, barriers to establishment could include the presence of host plants in a given area, extreme seasonal or other environmental differences, barriers to the establishment of the symbiont or the presence of Allee effects due to small initial population sizes. An already established population of a pest such as *Sirex* in a new environment would, however, increase the chances of future establishments, as it might alleviate Allee effects and because a successful fungal genotype would already be present. Such additional introductions could seriously threaten biocontrol programs due to incompatibility between host-parasite genotypes and because it adds a layer of complexity to the control programs. In order to reduce the threat of new introductions and slow the outward spread from already established populations, renewed attention should be given to monitoring and eradication as an artificial measure to induce Allee effects, as has recently been shown for other invasive insects. This should be especially considered around potential points of introduction and around range margins of already established *Sirex* populations.

Bernard has a PhD in Plant Pathology from the University of Pretoria. He specializes in plant protection, mycology and insect-microbe interactions. A special interest is the ecology and evolution of pests and pathogens influenced by humans, i.e. when these organisms are introduced into new environments, or when pathogens and pests adapt to environmental changes caused by humans as in agriculture and forestry. Bernard first worked on the *Sirex-Amylostereum* symbiosis during his M.Sc. (completed in 1998), and subsequently returned to the topic during a postdoc at the Swedish University of Agricultural Research in 2003. Bernard is a senior lecturer in the Department of Genetics at the University of Pretoria, where he works within the Tree Protection Co-operative Programme (TPCP) in FABI. The *Sirex* research program, including research on the wasp, fungus and natural enemies, are among his main responsibilities. In this capacity he also serves on the South African National *Sirex* Steering Committee.

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THE PATHWAY APPROACH TO MINIMISING THE THREAT OF INVASIVE FOREST PESTS: *SIREX* AS AN EXAMPLE

Simon Lawson
Department of Primary Industries & Fisheries, Queensland, Australia
Simon.lawson@dpi.qld.gov.au

Pest risk analysis (PRA) and the compilation of lists based on these analyses has been the most common strategy for determining key invasive species threats and for developing strategies to prevent their introduction. With the huge expansion in world trade it has become apparent that while this is still a valid approach to targeting serious, known forest pests such as the pinewood nematode, there are limitations to its effectiveness. The *Sirex* wood wasp is a case in point: Before its introduction from Europe to New Zealand in the 1940's, it is unlikely that this now serious worldwide forestry pest would have appeared on any pest list, with siricid wasps generally not considered significant forestry pests. More recently the rapid spread worldwide of a number of eucalypt pests such as the blue gum chalcid (*Leptocybe invasa*) (which had not even previously been described in its native Australia), have illustrated the need for a different approach to minimising the spread of invasive species, based on identifying high risk pathways and implementing measures that minimise the risk of species spreading along these pathways. Two of the highest risk pathways for the introduction of forest invasive species are via timber packaging and nursery planting stock. For timber packaging, a new set of rules covering treatment and certification, ISPM-15, has now been implemented worldwide, and draft protocols for nursery stock are being developed. The latter uses a systems approach, imposing strong controls, regulation and auditing throughout the production system. Both these approaches implicitly focus on non-regulated (or unknown) pests as well as quarantine and regulated pests.

Simon Lawson is team leader for forest health research in the Department of Primary Industries & Fisheries, Queensland, Australia, and has over 26 years involvement in applied forest entomological research in Australia and internationally, including nine years in Japan. His research focus over the last ten years has been in developing effective, sustainable management methods for insect pests of eucalypt plantations in the subtropics of Australia, with an emphasis on the chemical ecology of key pests such as cossid moth and longicorn beetle stem borers. Prior to this his research focussed on the control and management of *Ips* spp. bark beetles in Australia and Japan, and on the biological control of the insect vector of pine wilt disease in Japan. He also has a strong interest in forest biosecurity issues and leads an international project with collaborators in Fiji and Vanuatu developing early detection methods for invasive pests and diseases at ports and other high risk sites.

NOTES

List of Delegates

Name	Organisation & Country	E-mail
Mr Rodrigo Ahumada	Arauco, Chile	rahumada@arauco.cl
Dr Gillian Allard	FAO, Italy	Gillian.allard@fao.org
Dr Dick Bashford	Forestry Tasmania, Australia	Dick.bashford@forestrytas@com.au
Mr Marcos Beeche	Official Program for Surveillance & Control of *Sirex noctilio*, SAG, Chile	Marcos.beeche@sag.gob.cl
Mr Grant Boreham	SAPPI Forests, S Africa	Grant.boreham@sappi.com
Mr Andre Brink	SAPPI Forests, S Africa	Andre.brink@sappi.com
Dr Alan Cameron	Eajabaka Enterprises, USA	eajabaka@comcast.net
Mr Stuart Charlton	Singisi Forest Products, S Africa	stuartc@hansmerensky.co.za
Dr Clement Chilima	Forestry Research Centre, Malawi	cchilima@frim.org.mw
Mr Philip Croft	ICFR, S Africa	Philip@icfr.unp.ac.za
Dr Darek Czokajlo	APTIV, USA	darekc@aptivinc.com
Prof Jeffrey F.D. Dean	University of Georgia, USA	jeffdean@uga.edu
Dr Peter De Groot	Canadian Forest Service, Canada	pdegroot@NRCan.gc.ca
Dr Kevin J. Dodds	USDA Forest Service, USA	kdodds@fs.fed.us
Mr Marius du Plessis	Mondi Business Paper, S Africa	Marius.duplessis@mondibp.com
Prof Colin Dyer	ICFR, S Africa	colind@icfr.unp.ac.za
Dr Lori G. Eckhardt	Auburn University, USA	eckhalg@auburn.edu
Mr Michael Edwards	Forestry South Africa, S Africa	trees@global.co.za
Mr Roger Godsmark	Forestry South Africa, S Africa	roger@forestrysouthafrica.co.za
Mr Derian Echeverri	FABI, University of Pretoria, S Africa	Derian.echeverri@fabi.up.ac.za
Ms Raquel Muñoz Godoy	SAG, Chile	
Mr Hardus Hatting	FABI, University of Pretoria, S Africa	Hardus.hatting@fabi.up.ac.za
Dr Dennis Haugen	USDA Forest Services, USA	dhaugen@fs.fed.us
Mr Bianca Hinze	FABI, University of Pretoria, S Africa	Bianca.hinze@fabi.up.ac.za
Mr Brett Hurley	FABI, University of Pretoria, S Africa	Brett.hurley@fabi.up.ac.za
Dr Edson T. Iede	EMBRAPA, Brazil	iedeet@cnpf.embrapa.br
Dr Arnulf Kanzler	SAPPI Forests, S Africa	Arnulf.kanzler@sappi.com
Dr Paula Klasmer	INTA, Argentina	vklasmer@hotmail.com
Dr Kier Klepzig	IDIP–Insects, Diseases, Invasive Plants, USA	kklepzig@fs.fed.us
Dr Paal Krokene	Norwegian Forest & Landscape Institute, Norway	Paal.krokene@skogoglandskap.no
Prof Dolly Lanfranco L.	Universidad Austral de Chile,	Chiledlanfran@uach.cl
Dr Simon Lawson	DPI&F Queensland, Australia	Simon.lawson@dpi.qld.gov.au
Dr Isabel Leal	Canadian Forest Service, Canada	ILeal@pfc.cfs.nrcan.gc.ca
Mr Keneilwe Mabena	DWAF, S Africa	mabenaK@dwaf.gov.za
Prof Seif Madoffe	Sakoine University of Agriculture, Tanzania	madoffe@giant.suanet.ac.tz
Dr. Aaron Maxwell	AQIS, Australia	Aaron.maxwell@aqis.gov.au
Ms Lorraine McNamara	Global Forest Products, S Africa	Lmcnamara@gfp.co.za
Dr Andrew Morris	SAPPI Forests, S Africa	Andrew.morris@sappi.com
Dr Sari Mohali	Universidad de los Andes, Venezuela	msari@ula.ve
Mr Member Mushongahande	Forest Research Centre, Zimbabwe	member@frchigh.co.zw
Mr Ryan Nadel	FABI, University of Pretoria, S Africa	Ryan.nadel@fabi.up.ac.za
Mr Keith Paterson	Mondi Shanduka Newsprint	keithpaterson@mondishanduka.co.za
Mr Ntuthuzelo Herald Ponoyi	DWAF, S Africa	ponoyiN@dwaf.gov.za
Mr Mario Zapata Quiroga	Official Program for Surveillance & Control of *Sirex noctilio*, SAG, Chile	
Mr Carlos Rodas	Smurfit Kappa Cartón de Colombia, Colombia	Carlos.rodas@smurfitkappa.com.co
Prof Jolanda Roux	FABI, University of Pretoria, S Africa	Jolanda.roux@fabi.up.ac.za
Ms Kathleen Ryan	Canada	kathleaner@gmail.com
Dr Nathan Schiff	USDA Forest Services, USA	nschiff@fs.fed.us
Dr Noel F. Schneeberger	USDA Forest Services, USA	nschneeberger@fs.fed.us
Mr Obote Shakacite	ZAFFICO, Zambia	zaffico@kitwe.microlink.zm
Prof Diana Six	The University of Montana, USA	Diana.six@ctc.umt.edu
Dr Bernard Slippers	FABI, University of Pretoria, S Africa	Bernard.slippers@fabi.up.ac.za
Prof. Jan Stenlid	Swedish University of Agricultural Sciences	Jan.stenlid@mykopat.slu.se
Dr Masanobu Tabata	Forestry and Forest Products Research Institute, Japan	butter@ffpri.affrc.go.jp
Dr Iben Thomsen	Forest and Landscape Denmark, University of Copenhagen , Denmark	IMT@kvl.dk
Ms Sally Upfold	ICFR, S Africa	sally@icfr.unp.ac.za
Ms Magriet van der Nest	FABI, University of Pretoria, S Africa	Magriet.vandernest@fabi.up.ac.za
Mr Marcel Verleur	Sappi Forests, S Africa	Marcel.verleur@sappi.com
Dr David Williams	USDA APHIS, USA	David.w.williams@aphis.usda.gov

Name	Organisation & Country	E-mail
Prof Mike Wingfield	FABI, University of Pretoria, S Africa	Mike.wingfield@fabi.up.ac.za

FIELD VISIT

15 MAY 2007

Sirex Field Day Programme

Hard hats will be provided and need to be worn in-field

08h00	Meet at the Ascot Inn Conference Centre
08h10	Travel to 1st field stop at Pinewoods, Sappi Forests
09h15 - 10h15	Visit to Pinewoods, Sappi Forests Aspects to be covered include: ❖ Clear-felling and salvage operation following *Sirex*-infestation ❖ Saw Timber stand on Singisi Forest Products land ❖ Demonstration of inoculation process
10h15	Travel to 2nd field stop at Good Hope, Mondi Shanduka Newsprint (MSN)
10h45 -12h30	Visit to Good Hope. MSN Aspects to be covered include: ❖ Presentation on Pine Forestry in South Africa (Keith Paterson, MSN) ❖ Industry inoculation trials (Philip Croft, *Sirex* Technical Coordinator) ❖ Chemical spray trial (Philip Croft, *Sirex* Technical Coordinator)
13h00 - 14h00	LUNCH at Mt Shannon Cottages (MSN)
14h00	Travel to 3rd field stop at Pinewoods, Sappi Forests
15h00 - 15h30	Visit to Pinewoods, SAPPI Aspects to be covered include: ❖ Presentation on release of *Ibalia* parasitoids wasps (Marcel Verleur, Sappi Forests)
15h30	Travel to last field stop at Linwood. MSN
16h00 - 16h45	Visit to Linwood, MSN Aspects to be covered include: ❖ Emergence Cages (Philip Croft, *Sirex* Technical Coordinator)
16h45	Return to Ascot Inn Conference Centre
18h00	Braai at Ascot Inn Conference Centre sponsored by the South African Sirex Control Programme

Information on the *Sirex* Field Stops

1. Geology and Soils:

The geology and the soils of this region vary from one area to another. The most dominant lithology throughout the region is Southern Mudstone, Southern Shale and Sandstone. Soils are mostly characterised by fine to medium sandy clay loam, humic topsoil, underlain by yellow or red apedal subsoil. Dominant soil forms are Inanda, Magwa and Kranskop. Clay contents in most areas vary between 25-35% in topsoil horizons and attain values of between 45 and 60% in subsoil horizons. Significant riparian areas occur with associated soil forms of Tukulu.

2. Topography

Linwood & Good Hope

The Topography is varied, ranging from gentle slopes to extremely steep in places. Isolated scarps also occur. There are a number of wetlands present in this area with peat soils being common (Champagne) and organic variants of the Katspruit and Westleigh forms.

3. Hydrology and Aquatic Systems

Linwood & Good Hope

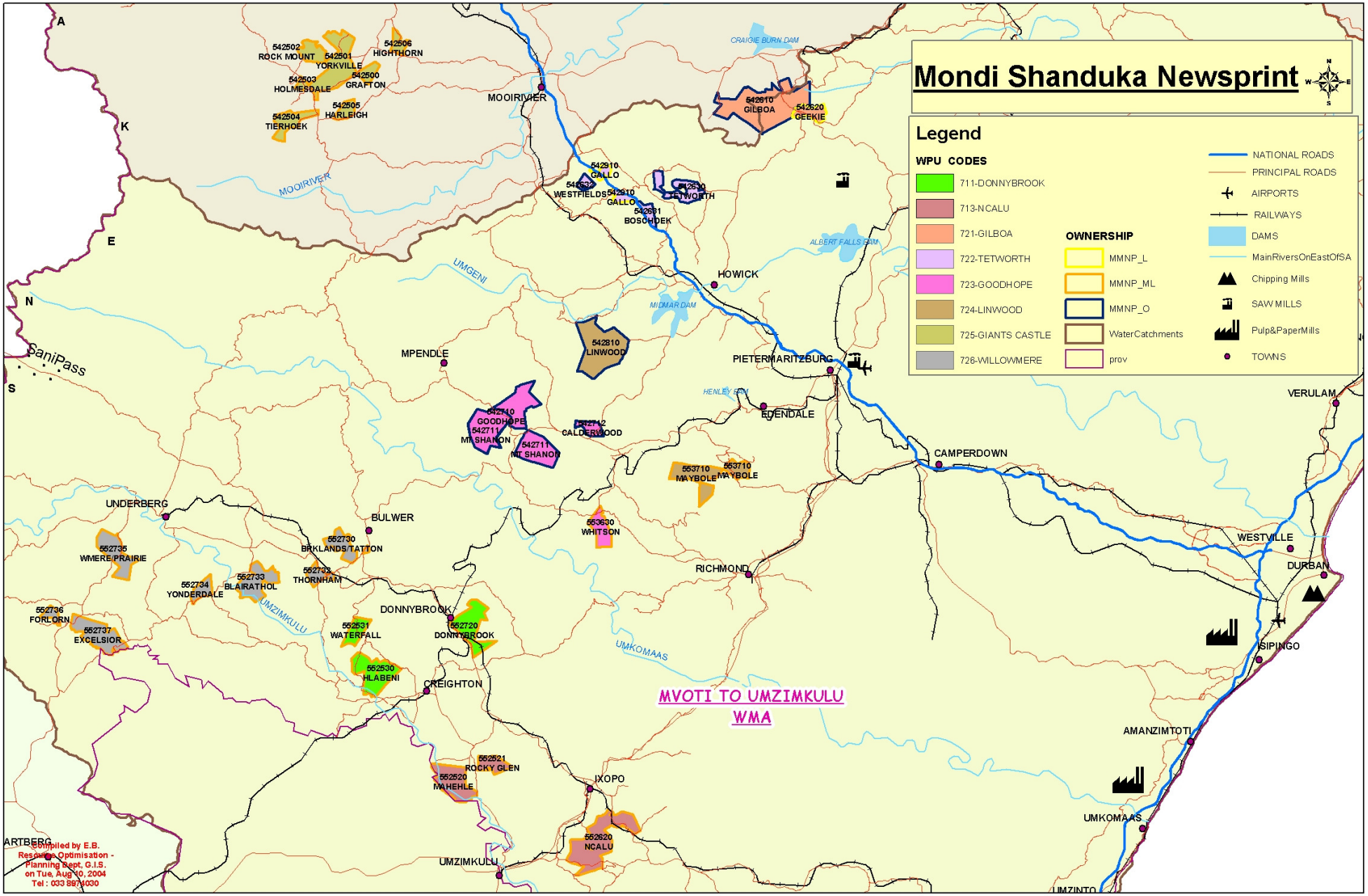
These farms lie within the 'U' and 'V' primary drainage regions and the U20 and V20 secondary drainage regions. The mean annual precipitation is 980 mm, the median annual simulated runoff is 144 mm and the lightening flash density is 8 lashes. Km^2.annum-1. The average depth to groundwater is < 20 m and the annual groundwater recharge 75 mm.

Precipitation

Linwood, Good Hope	Median A - Pan Evaporation (mm)	Median Max. Temperature (^oC)	Median Min. Temperature (^oC)	Median Rainfall
JANUARY	172.59	25.24	14.21	147.39
FEBRUARY	150.32	25.09	14.19	127.61
MARCH	144.1	24.35	13.02	115.16
APRIL	122.55	22.57	10.04	52.55
MAY	104.04	20.33	6.67	16.22
JUNE	92.52	18.25	2.5	4.3
JULY	102.74	18.45	3.58	6.65
AUGUST	131.29	20.01	5.62	15.76
SEPTEMBER	148.05	21.92	8.26	41.67
OCTOBER	156.96	22.39	10.01	82.41
NOVEMBER	155.98	23.09	11.64	116.51
DECEMBER	177.03	24.94	13.28	144.87

4. Altitude

- The altitude on Linwood rises from 1110 m to 1600 m.
- Good Hope ranges from 1380 m to 1520 m and
- Brooklands has a range from 1490 m to 1780 m.


Mondi Shanduka Newsprint
Legend
WPU CODES
711-DONNYBROOK
713-NCALU
721-GILBOA
722-TETWORTH
723-GOODHOPE
724-LINWOOD
725-GIANTS CASTLE
726-WILLOWMERE
OWNERSHIP
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NATIONAL ROADS
PRINCIPAL ROADS
AIRPORTS
RAILWAYS
DAMS
MainRiversOnEastOfSA
Chipping Mills
SAW MILLS
Pulp&PaperMills
TOWNS
542502 ROCK MOUNT
542501 YORKVILLE
542506 HIGHTHORN
542503 HOLMESDALE
542500 GRAFTON
542505 HARLEIGH
542504 TIERHOEK
MOOIRIVER
CRAIGIE BURN DAM
542610 GILBOA
542620 GEEKIE
542910 GALLO
542632 WESTFIELDS
542630 TETWORTH
542601 BOSCHDEK
ALBERT FALLS DAM
UMGENI
HOWICK
MIDMAR DAM
542810 LINWOOD
MPENDLE
PIETERMARITZBURG
HENLEY DAM
EDENDALE
VERULAM
542740 GOODHOPE
542711 MT SHANON
542712 CALDERWOOD
CAMPERDOWN
553710 MAYBOLE
UNDERBERG
BULWER
553630 WHITSON
552735 WMERE/PRAIRIE
552730 BRKLANDS/TATTON
552732 THORNHAM
552733 BLAIRATHOL
552734 YONDERDALE
WESTVILLE
DURBAN
RICHMOND
552736 FORLORN
552737 EXCELSIOR
UMZIMKULU
DONNYBROOK
552531 WATERFALL
552720 DONNYBROOK
ISIPINGO
UMKOMAAS
552530 HLABENI
CREIGHTON
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AMANZIMTOTI
552521 ROCKY GLEN
552520 MAHEHLE
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UMKOMAAS
552620 NCALU
UMZIMKULU
UMZINTO
SaniPass
Compiled by E.B.
Resource Optimisation - Planning Dept, G.I.S.
on Tue, Aug 10, 2004
Tel : 033 8974030

SIREX WORKSHOP

16 MAY 2007

ASCOT INN, PIETERMARITZBURG

WELCOME & INTRODUCTION TO THE WORKSHOP

On behalf of the South African *Sirex* Control Programme, it is a pleasure to welcome you to a one day workshop on *Sirex* management to be held on Wednesday 16 May 2007 in Pietermaritzburg, KwaZulu-Natal.

Sirex noctilio clearly represents a growing threat to the South African Forestry Industry, and indeed to world-wide conifer forests and forestry. During the last 100 years, a great deal of knowledge has been accumulated relating to this damaging insect pest, and yet new invasions around the world vividly suggest that aspects of its biology and control are still poorly understood. The purpose of the workshop is to access some of the leading *Sirex* experts in the world to comment on, and guide our approach to managing *Sirex* in South Africa.

The objectives of the workshop are:

- To present a consolidated view of *Sirex* worldwide and effective measures to control it (summary from the preceding international symposium);
- To present a review of the South African control programme, and assess this programme relative to others around the world; and
- To try to understand the relatively low success of the currently available tools to control *Sirex* in South Africa.

The workshop will be run in three sessions, focusing on:

- A brief update of the South African Control Programme and the current state of knowledge on *Sirex* and its management globally;
- A facilitated discussion around key questions that have arisen from the implementation of a control programme in South Africa;
- Identification of key issues that need to be addressed for the control of *Sirex* in southern Africa.

The outcomes from the Workshop will provide inputs into the control programme for southern Africa.

I look forward to engaging with you in this forum where we, as stakeholders in forestry, can focus our expertise and experience on effectively managing this pest in southern Africa.

Prof. Colin Dyer
Chair: South African *Sirex* Control Programme
Director: Institute for Commercial Forestry Research

PROGRAMME

08:30 – 10:00	**Session 1** The South African *Sirex* Control Programme – what we know *Facilitator: Colin Dyer*	
	How have we tackled the *Sirex* threat in South Africa? Strategy used since 1994, elements of the control programme, long- and short-term approaches	Colin Dyer
	Short-term plan – commercial-scale inoculations, *Ibalia* releases, monitoring and awareness, silviculture for forest health.	Philip Croft
	Long-term plan: development of new genotypes for biological control.	Bernard Slippers
	What do we know about *Sirex*? – a synthesis of the latest thinking from the Symposium	Mike Wingfield
10.00 – 10.30	TEA	
10:30 – 12:30	**Session 2 – part 1** Key questions and discussion on the future direction for the South African *Sirex* control programme. *Facilitator: Sally Upfold*	
12.30 – 13.30	LUNCH	
13.30 - 15.00	**Session 2 – part 2** Key questions and discussion on the future direction for the South African *Sirex* control programme. *Facilitator: Sally Upfold*	
15:00 – 16:00	**Session 3** Synthesis and strategy development. *Facilitator: Andrew Morris*	