Australian Sirex Management Strategy And Operations Worksheets

Produced by the National Sirex Coordination Committee
australiansirex.com.au

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National Sirex Coordination Committee

Australian Sirex Management Strategy And Operations Worksheets

Contents

The National Sirex Coordination Committee (NSCC) has developed this strategy and worksheets in order to promote an evidence-based and consistent standard for the various component operations for sirex management wherever they are applied across Australia.

A new feature of this edition of the worksheets is the ability to access supplementary **training videos** and **field checklists** which are accessed through hot-links from the relevant portion of the worksheet to their public storage location on the internet.

The NSCC is an independent self-governing committee composed of representatives of Australian plantation growers who contribute to the voluntary sirex control levy and sirex specialists.

National Sirex Coordination Committee

Strategy

Australian sirex management strategy

INTRODUCTION

Sirex noctilio, a native of Europe, is the only one of a large number of woodwasp species able to kill relatively healthy pine trees. One of the tree species most susceptible to this insect, *Pinus radiata,* from California, was introduced into Australia during the nineteenth century and now forms the bulk of this country's one million hectares of softwood plantations. After being accidentally introduced into New Zealand and causing epidemic outbreaks during 1945–1949, sirex was discovered near Hobart during 1952 and then near Melbourne during 1961.

Since then, sirex has spread throughout Tasmania, South Australia, Victoria and New South Wales. In 2009 sirex reached the southern border region of Queensland (Passchendaele). The combination of a particularly susceptible tree species and a very damaging woodwasp, brought together in drought-prone Australia is a recipe for disaster and indeed serious outbreaks have occurred in Tasmania, Victoria, and South Australia. If the control measures outlined in this document had been implemented, the impact of these outbreaks may have been greatly reduced.

Sirex control efforts in Australia were initially managed and funded by the National Sirex Trust Fund through a compulsory grower levy and government funding from 1962–1977. An initial focus on eradication was replaced by a policy of containment in parallel with research on biocontrol control options. Between 1978 and 1987 the culture and supply of biocontrol agents was funded by the Australian Forestry Council.

The National Sirex Coordination Committee (NSCC) is a group of pest management scientists drawn from Australian plantation growers who contribute to the voluntary sirex control levy, and sirex specialists. It commenced oversight of the sirex biocontrol effort in 1988, and now operates as an independent self-governing committee. Its charter includes keeping the sirex management strategy current, overseeing the technical standards for control operations, and commissioning research to improve the effectiveness of the program.

The NSCC developed the *National strategy for the control of Sirex noctilio in Australia* in 1990, first published in *Australian Forest Grower*, Winter 1990. The *Australian sirex management strategy* updates the former strategy and includes operations worksheets, training videos and field checklists which provide more detail on the essential tasks necessary for effective management of sirex.

LIFE CYCLE

In Australia, sirex normally completes one generation per year, with a small proportion of the population taking two years. Adults, which live for only a few days, have been recorded emerging from October through to May, with peak emergence occurring from January to the end of March, depending on climate. The female wasp drills her ovipositor through the bark and into the outer sapwood of trees to lay eggs (Figure 1).

Figure 1: Female sirex ovipositing into a log.

At the same time, she injects a symbiotic fungus (*Amylostereum areolatum*) and a toxic mucus/venom which together cause the death of the tree. Sirex larvae feed on the fungus as they tunnel through the wood. Mature larvae pupate close to the bark surface and adults emerge about three weeks later. However, some trees, especially if healthy and vigorous, may resist sirex attack.

Trees successfully attacked by sirex generally begin to show conspicuous dieback symptoms from April onwards. The entire crown turns light green to yellow then to reddish brown. Beads or dribbles of resin, resulting from oviposition (egg laying) holes, may be visible on the bark. As the fungus grows from the oviposition drill, fungal stains appear in the cambium as long, narrow, brown bands along the grain (Figure 2), and eventually the fungus permeates every part of the tree.

Larvae, galleries, or exit holes provide conclusive evidence of successful sirex attack. After a tree has been killed, the wood degrades rapidly and, if salvage is feasible, it should be done within four months of sirex attack.

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Figure 2: Exposed *Amylostereum* fungal staining at three separate oviposition sites

MANAGEMENT TECHNIQUES

Pinus radiata is highly susceptible to sirex attack, but other *Pinus* species are also attacked. Susceptible plantations are generally 10–20 years old, and unthinned stands are more susceptible than thinned stands. Trees under stress (e.g. over-stocked stands, drought, during harvesting), also appear to be more susceptible to attack. Therefore, a major preventative measure is to maintain vigorous stand growth by timely thinning and protection from fire, pests and diseases which may stress and weaken the trees (e.g. Dothistroma needle blight).

Two kinds of biological agents are used to control sirex. The parasitic nematode, *Deladenus* (*Beddingia) siricidicola,* is of greatest importance. This nematode has an extraordinary life cycle which enables it to breed up in vast numbers throughout the tree while feeding on the fungus; then it enters a sirex larva and begins reproduction as its host pupates. Nematode reproduction within the developing pupa now produces "infective" juvenile forms of the nematode. These infective nematodes subsequently enter sirex eggs within pupating female sirex, rendering entered eggs sterile (Figure 3).

When nematode-infected sirex emerge and attack other trees, they transmit/lay eggs which are now packets of nematodes instead of fertile eggs. Once a significant proportion of the sirex population becomes infected with the nematode — levels can approach 100% — the sirex population will collapse. At low sirex levels, the nematode may not be reliably transmitted between isolated sirex populations, therefore, the regular release of nematodes appears to be necessary.

Some parasitic wasps (parasitoids) have been imported and released for sirex control. The parasitoid *Ibalia* lay their eggs down the drill holes in the tree made when the sirex female laid her eggs, and into the developing sirex larvae. The parasitoids *Rhyssa*, *Megarhyssa* and *Schletterarius* drill deep into the wood to locate, paralyze and then lay their eggs on sirex larvae, and the parasitoid larvae consume and kill the sirex larvae from the outside. One native parasitoid, *Certanotus tasmaniensis,* is also active at low levels in some areas.

The combined activity of these parasitoid wasps usually kill 30–60% of a sirex population. However, parasitoid activity alone is not enough to prevent sirex from reaching outbreak levels.

CONTROL RECOMMENDATIONS

Before sirex is detected in a region:

- Consider whether quarantine measures will be effective and economically justified and invoke where appropriate.

- Train forest, logging, and sawmill personnel to recognise sirex symptoms (with annual refresher sessions) and promote vigilant forest surveillance.

- Install trap tree plots to detect whether sirex is present in susceptible plantations (i.e. 10–20 years old and more than two years past the prescribed thinning age), near mills, major transportation routes, and the leading edge of expected natural sirex dispersal. The number of plots should be proportional to the risk of sirex introduction. (Refer to Worksheet 2 for further detail).

- Review the status of plantation thinning and comply with the optimum thinning guide for first and second thinnings.

Figure 3: Microscopical image of dead infective juveniles of *Deladenus* (*Beddingia*) *siricidicola* nematodes extracted from the egg sacks of a parasitised female sirex.

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Strategy

Annual program once sirex is first detected:

- Map sirex distribution within the region (from forest surveillance and trap tree data).
- Estimate sirex-associated tree mortality in selected compartments by ground surveys along transects.
- Review the status of plantation thinning and comply with the optimum thinning guide for first and second thinnings.
- Establish trap tree plots during November to early January for later inoculation with nematodes. Select a plot density of at least one plot per 25 ha of susceptible plantation within the sirex distribution.
- Inoculate the sirex-attacked trap trees with nematodes during May–June depending on seasonal conditions. Naturally struck trees can also be inoculated.
- Release parasitoids in appropriate compartments; record and map the pertinent information (compartment, species, number of males and females released, and date).
- Determine the percentage of sirex infected with nematodes and population levels of each parasitoid species by caging logs from sirex infested trees struck in specific compartments, and then assessing emergent wasps from October through to May.
- Review data and reports of the sirex control program from the current (and previous) year and plan a work schedule for the following year.

Assessment of naturally struck trees will provide information on background levels of biocontrol agents, and assessment of inoculated trap trees will provide information on the effectiveness of the inoculations done.

After the biocontrol agents are well- established in a region and the sirex population has declined:

- Select plantations for sampling that are 10-12 years old and geographically isolated from current populations of the biocontrol agents.
- Install trap tree plots in these plantations to confirm the presence of sirex.
- Evaluate logs from these trap trees to determine the percentage of sirex infected with nematodes and the presence of parasitoids.
- Make further releases if the biocontrol agents are deficient.

These recommendations are summarised in the illustration on page 7.

IMPLEMENTATION

Quarantine

Where sirex has not been detected within a state, the state agency responsible for biosecurity would be expected to take the lead on maintaining quarantine and monitoring for detections in the vicinity of likely entry pathways. As sirex has historically travelled less than 50 km per year, the biggest risk is transport of sirex-infested logs into new areas. Sirex can even emerge from air dried timber and CCA-treated products (copper-chrome-arsenate preservative applied under vacuum/pressure).

Cooperation

Each plantation grower also needs to implement appropriate actions to protect its plantations. As sirex does not recognize boundaries, coordination of responses between growers within the one region is both desirable and sensible.

Training

Sirex awareness amongst forestry staff and timber processors is important regardless of whether sirex has not yet been detected or has been present for many years.

Education and training can use materials such as these worksheets, embedded videos and other resources available at australiansirex.com.au.

Good reporting needs to be encouraged and everyone in the supply chain should know where to report sirex observations.

Operations

The attached Operations Worksheets provide detailed explanation of the key operational and management components of a successful sirex management program which will minimize the economic loss to plantation owners.

Worksheets:

1. Monitoring sirex population
2. Installing trap trees
3. Nematode handling and inoculation
4. Evaluation of biocontrol agents
5. Breeding nematode-free sirex
6. Rearing of sirex parasitoids
7. Determination of nematode infectivity
8. Panel trap installation

Field checklists have also been prepared to assist briefing of field crews for the major tasks.

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Field Checklists:

1. Trap tree plot establishment
2. Monitoring trap tree plots
3. Felling and inoculation of trap tree plots
4. Billet collection and emergence monitoring

These checklists are available at australiansirex.com.au.

Research

The NSCC is commissioning research projects to underpin ongoing successful biocontrol of sirex. As sirex moves across Australia, it will encounter different climatic regimes, insect interactions and other host *Pinus* species, any of which may introduce an unexpected change to a component of the complex interactions which make up this effective program.

Ongoing research and monitoring are essential, as previous experience has demonstrated that without continued vigilance, the effectiveness of biocontrol programs can wane unnoticed until a major outbreak occurs.

Current research projects are reported on the NSCC website: australiansirex.com.au.

Further assistance

Enquiries regarding any aspect of sirex management can be directed to the NSCC, and this is best done by email to nscc@australiansirex.com.au which available as a link on the NSCC website contact page.

Links to reference documents which provide further explanation of the sirex and its interactions with the plantation host and with its biocontrol agents can also be found on the NSCC website.

Training videos

A range of comprehensive short-format videos have been made. These videos cover all aspects outlined within this *Australian Sirex Management Strategy and Operations Worksheets* document including sirex history, objectives, research and control methodologies, and are available on the following vimeo channel:
https://vimeo.com/channels/1309879

- Sirex 01: Where did sirex come from?
- Sirex 02: Sirex life cycle overview
- Sirex 03: Sirex life cycle
- Sirex 04: Finding parasites to control sirex
- Sirex 05: Nematode life cycle overview
- Sirex 07: Managing the spread of sirex
- Sirex 08: Common causes of tree death
- Sirex 09: Recognising sirex signs
- Sirex 10: Trap tree overview
- Sirex 11: Recording details of trap trees
- Sirex 12: Selecting trap trees
- Sirex 13: Principles for establishing trap trees
- Sirex 14: Preparing trap trees with drill
- Sirex 15: Preparing trap trees with axe or spear
- Sirex 16: Felling trap trees
- Sirex 17: Preparing nematodes in gel solution
- Sirex 18: Inoculating trap trees
- Sirex 19: Inoculation hole quality
- Sirex 20: Punch maintenance
- Sirex 21: Dissecting sirex wasps
- Sirex 22: Naturally struck trees

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Summary of major tasks necessary for effective management of sirex wasp

Before detection of sirex

Quarantine

Training of staff

Stand thinning and **health**

Reconnaissance including aerial survey, panel trapping and trap tree establishment

After detection of sirex

Training of staff

Stand thinning and **health**

Map and **monitor** tree mortality

Introduce nematodes by establishing and inoculating trap trees

Release parasitoids

Determine nematode inoculation **effectiveness**

After sirex population crash

Maintenance of staff skills

Stand thinning and **health**

Monitor susceptible plantations by aerial survey and trap trees

Release further biocontrol agents if required

Evaluate plantation and trap tree logs to determine nematode parasitism and parasitoid levels

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Monitoring sirex populations

Work Sheet 1

OBJECTIVES

- To determine the distribution and the severity of infestation of sirex throughout a given area of plantation and to detect changes from year to year.

- To enable planning and the implementation of an appropriate management response. To do this we need to be able to detect sirex when it first enters the plantation and then monitor the population through reliable assessment of the level of associated tree mortality.

KEY FACTORS

1. Early detection of sirex.
2. Capacity to survey often large areas of plantation quickly, economically and reliably (i.e. aerial survey).
3. Accurate, reproducible sampling of specific blocks (i.e. ground survey).
4. Survey timing.

TRAP TREES

Trap tree sites (see Worksheet 2) will assist in the detection of sirex at the earliest stages, often 2-3 years before dying trees become evident within the plantation estate.

In plantations where sirex is suspected but has not been detected, trap trees should be established at enough locations to provide a representative sample of the area. Sites should be close to all-weather roads. These sites also desirably provide initial release sites for control nematodes if appropriate.

Note: Trap trees are only receptive for one sirex flight season. New sites will be required annually.

STATIC TRAPPING

Cross-vane panel and Lindgren funnel traps baited with pinene component lures can also be used for early sirex detection. Static traps with lures are cost effective compared to the establishment of trap trees. Static traps can also be reused and quickly moved between desired monitoring sites. A range of Australian and International companies supply these traps and lures (Figure 4).

AERIAL SURVEY

Aerial surveys are most useful for covering large areas and stratifying plantation compartments by the frequency of dead and dying trees. Verification of the cause of mortality must be made subsequently by detailed ground survey. Survey from fixed-wing aircraft does not appear to accurately quantify tree mortality, particularly at the critical levels below 5%. Use of a helicopter provides the advantage of slower speeds, and greater maneuverability including the ability to hover.

Figure 4: Cross-vane panel trap (with extended hood).

Aerial survey for early detection:

Early detection of sirex is best achieved with trap trees (see above). In the absence of trap trees, aerial survey can be used to locate suspect trees or areas for further investigation with any dead or dying trees being noted. In the early stages of infestation, sirex are most likely to kill suppressed trees not readily visible from the air.

Aerial survey without follow-up ground survey can thus be misleading. Clumps of dead trees are unlikely to be caused by — but may contain some — sirex and should be investigated.

Aerial survey as part of a control program:

In areas where sirex presence is confirmed aerial survey should be used to determine the distribution and relative intensity of new sirex induced death. Stratification of a plantation by compartment for later ground survey sampling is the objective. Stratification should be made at the following infestation classes for current year deaths.

Table 1-1: Classification of sirex infestation

Annual tree deaths	Severity - Infestation
0%	Nil
<1%	Light
1-3%	Moderate
>3%	Severe

GROUND SURVEY

Ground survey is used to sample representative areas (compartments) to verify reliability of aerial estimates and to confirm whether tree mortality is sirex related. It provides a more accurate estimate of the proportion of trees within a stand killed by sirex. Sample compartments should be selected using the following criteria:

1. Sirex susceptibility (age >10 years),

Monitoring sirex populations

Work Sheet 1

likely time to first thinning, presence of other stress causing agents or events.

2. Aerial assessment.
3. Representative of the surrounding compartments.
4. Sirex history of the area.

The number of compartments sampled will depend upon logistics but should be sufficient to provide full coverage of plantation variation.

The surveys should be carried out by appropriately trained personnel. The method involves sampling either on repeatable or randomly selected representative transects. The method described below has been found to provide reliable and reproducible results using randomly selected transects.

Method

All trees within two rows are counted while walking between those rows through the compartment. A hand-held counter is essential for rapid and accurate counts. Dead or dying trees are recorded on a Sirex Survey Record Sheet and tallied according to the observed cause of death and the tree's dominance classification. These forms can be processed later onto summary sheets or recorded on a suitable computer spreadsheet or data base system. The data are usually processed to provide % death attributable to sirex on a compartmental or age class basis.

The composition of survey crews is flexible and may be from one person in low infestation level stands, to a three-person crew in heavily infested stands. A three-person crew (two observers and a recorder) has the advantage of covering a broader band of trees (4-6 rows) within a single transect. (The recorder could also act as an observer in low infestation stands).

The number of trees to be surveyed to obtain an accurate assessment of a compartment will vary but should take into account variations of aspect, topography and aerially observed distribution of sirex-killed trees within a compartment. Two or three transects of 250-500 trees each (accounting for 2-3% of total trees in the compartment) using a three-person crew gives reliable and reproducible results.

Survey Timing

Surveys should be undertaken from mid-May through to the end of July depending on seasonal conditions. Symptoms of recent infestation e.g. resin 'pin' bleeds or balls down tree stems (Figure 6), are usually most apparent and easiest to confirm during this period, while earlier surveys run the risk of missing sirex struck trees.

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Figure 5: Clean perfectly centric emergence holes (up to 10 mm diameter) are a key indicator to the presence and incidence of sirex in the area being monitored.

Figure 6: Extensive resin bleeding 'pin bleeds', indicates multiple sirex strike and presence of developing sirex larvae within.

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Work Sheet 1

Monitoring sirex populations

Sirex ground survey record sheet

PLANTATION BLOCK... ... ...

DATE... ... ...

COMPARTMENT ... ...

AREA... ... ...

YEAR PLANTED ... ...

TRANSECT NUMBER ... ...

TOTAL STOCKING ... ...

STOCKING RATE (/ha) ... ...

Dead / Dying trees due to sirex				**Dead from other causes**	
Recent deaths (Coppery needle colour, resin bleeding, cambial staining)		Old deaths (Emergence holes present)			
Suppressed	**Dominant**	**Suppressed**	**Dominant**	**Suppressed**	**Dominant**
Totals:					

REMARKS:

TOTAL TREES SURVEYED:

TOTAL DEAD: SIREX; RECENT OLD OTHER

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Trap tree plot establishment

Work Sheet 2

OBJECTIVES

1. To establish a network of trees attractive to sirex attack during the peak of the flight season.
2. To detect the presence of sirex in an area.
3. To provide an efficient means of introducing sirex biocontrol agents.
4. To monitor population levels of sirex and its biocontrol agents where sirex is already established but population levels are low.

KEY FACTORS

- Location of trap tree plots in accessible locations within plantations susceptible to sirex attack.
- Technique used to poison the trap trees.
- Timing of trap trees poisoning to ensure that the trees are attractive to sirex during the peak emergence time (summer months).

SITE SELECTION

Trap trees are of greatest value in areas where sirex levels are low or where naturally struck trees are difficult to locate or access. Trap trees should be located in plantations susceptible to sirex attack (unthinned plantations 10-20 years old, particularly where routine thinning has been delayed by two or more years, unthinned plantations subjected to drought/moisture stress, or where fire or other pests and diseases have damaged plantations).

Size of trap tree plots may vary (ideally 10 trees) depending on the purpose, access and availability of suitable trees within the plot. Plots can be used in three ways:

1. **Detection plots**: in areas where sirex has not been found
2. **Inoculation plots**: in areas where sirex has been detected
3. **Monitoring plots**: in areas where sirex populations have collapsed.

The distribution of trap tree plots is determined by considering the density of sirex present in the plantation (refer Table 2-1). Sites should be near to all-weather roads for ease of access, but not adjacent to open areas or plantation margins. If trap trees are later felled for biocontrol inoculation, excessive exposure (heat) can reduce the survival of parasitised female sirex within.

Plots may be set up as line plots or as a group of scattered trees, preferably within a 10-15 m radius of the plot centre point. Select trees of approximately 10-20 cm Diameter at Breast Height Over Bark (DBHOB). Issues such as ease of felling and minimising damage to the surrounding stand should be considered.

Each tree should be distinctively marked and numbered for later identification. Plot locations must be marked on maps for subsequent monitoring. Avoid using trees on the boundary edge of the plantation as they tend to grow more vigorously and consequently are harder to stress with herbicide. Also, once felled, the logs will dry out more rapidly, reducing the duration of favourable conditions for sirex.

Table 2-1: Selection of trap tree plot density.

Annual tree deaths	Infestation level	Plot density recommended
<1% 1-3% 3%	Light Moderate Severe	2 plots/100 ha 4 plots/100 ha 4 plots/100 ha plus 10-20% naturally struck trees

TREE INJECTION

Sirex are attracted to pines under stress, therefore, trap trees are injected with herbicide. This creates artificial stress and will cause them to decline and eventually to die. These trap trees will then be attractive to sirex over most of the flight season. If stressed too early, or too much herbicide is used, trees will likely become susceptible to ips bark beetle attack which will inhibit sirex strike. Ips will reduce trap tree effectiveness by hastening tree mortality and introducing a competitive blue stain fungus into the stem. The optimum time for preparing trap trees is mid-December to mid-January, as this will make the trap trees attractive to sirex over most of the peak flight period.

Trees are prepared by trimming the branches to make the butt accessible. Herbicide is injected using a drench gun into 20 mm deep angled holes made by a battery powered drill with 10 mm drill bit. Alternatively, an axe may be used to create an injection point, or a tree injector spear such as an INVjector may be used. It is important that the herbicide be injected slowly into the sapwood and not into the bark of the tree, so hole depth will need to be adjusted based on the thickness of the bark.

Trap tree plot establishment

The preferred herbicide for trap tree plot establishment is Dicamba 500 g/L a.i., diluted with water to obtain a final solution of 200 g/L a.i. The recommended injection rate for the Dicamba is 1 ml of chemical applied to injection points every 10 cm around the stem.

ASSESSING RESULTS

Trees should be examined for signs of decline due to the herbicide applications and sirex attack. This can be done during summer and/or autumn and must be done at the time of felling in winter. The most distinguishable symptoms of sirex attack, especially during winter, are fine resin 'pin' like flows down tree stems or fine hollow resin beads on the stem arising from oviposition points, and narrow bands of tea-coloured brown staining on the cambium layer just beneath the bark, mainly along the grain of the timber. The stain bands surround sirex oviposition points and are caused by the growing sirex fungus *Amylostereum areolatum*. These fungal stains are distinctive and easily detected when a sample of bark is removed (Figure 2).

All trap trees in each plot should be felled into a shaded position to minimize drying and prepared for inoculation or monitoring assessment. Felled trees can be assessed for sirex by a single mid-bole chainsaw cut. Cutting at this position has a higher probability of exposing sirex if present (galleries, larvae and associated staining) (Figure 7). Logs can be slightly raised to prevent ground contact, and end-coated with a timber sealant to slow drying (Figure 8).

Raising the logs provides aeration, slowing decay and the establishment of competing fungi. With the logs having no ground contact nematode-sterilised sirex are able to emerge around the entire circumference of the tree stem. If the trap tree appears healthy it should still be cut down as it may have sirex within, with symptoms less obvious due to late seasonal strike.

Figure 7: Mid-bole cut exposing numerous sirex galleries.

Figure 8: Felled trap tree end coated to slow drying.

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Work Sheet 2

Trap tree plot establishment - datasheet

TRAP TREE PLOT NUMBER.....

Plantation Block.....

Compartment.....

Year Planted.....

Lat.....Long.....

Are naturally struck trees present in area? [3]
0 / 1 / 2 / 3

Herbicide used: .....

Herbicide dilution:.....

Last Thinning Year
Thinning Type T1 / T2 /.....

Compartment sketch with plot location

	Poison Rate	Assessment 1 Fol[1]	Ips[3]	Sirex[2]	Assessment 2 Fol[1]	Ips[3]	Sirex[2]	Felling Assessment Fol[1]	Ips[3]	Sirex[2]	Inoculate	Blue stain[3]	Exit hole count
Date													
Crew													
Tree 1											Y / N		
2											Y / N		
3											Y / N		
4											Y / N		
5											Y / N		
6											Y / N		
7											Y / N		
8											Y / N		
9											Y / N		
10											Y / N		
11[4]											Y / N		
12[4]											Y / N		

[1] G = Green, GY = Green/Yellow Y = Yellow, B = Brown/Red, D = Dead grey
If foliage is green on the bottom and yellow on the top, complete the box like this: 

[2] Report symptoms seen: R = resin beads, S = sirex stain, O = Ovipositing sirex or parasitoid, G= galleries, L = larva
[3] Report amount seen: 0 = nil, 1 = a little, 2 = moderate amount, 3 = lots
[4] Optional extra rows for un-inoculated trees (mainly used in NSW).

Billet Collection details: (record extra billets on the back of the sheet)

	CutDate	RemoveDate	Tree	BarCode	Tree	Barcode 2	Tree	Barcode 3	Tree	BarCode 4
Uninoculated										
Inoculated										

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Nematode handling and inoculation

Work Sheet 3

OBJECTIVE

To inoculate sirex infested trees with the biocontrol nematode *Deladenus siricidicola,* so that >90% of emerging sirex are infested with the nematode.

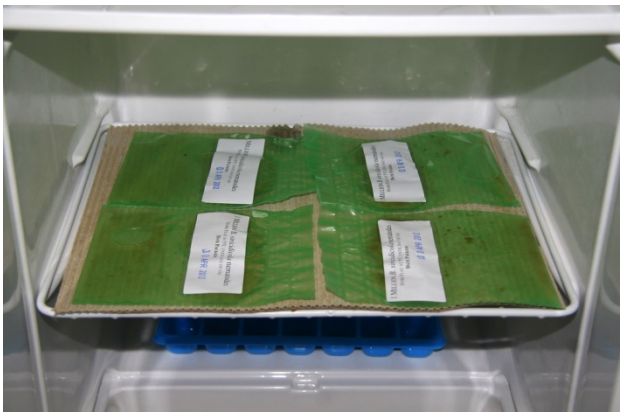
KEY FACTORS

1. Fresh nematodes transported and stored under optimal conditions.
2. Inoculation of approximately 2,000 nematodes per inoculation hole (1 ml of nematode/gel slurry).
3. Correct storage, transport and handling of nematode gel mix.
4. Inoculation of sirex-infested trees at the optimum time of the year.
5. Clean cutting of tracheid's (wood cells) using a very sharp punch to enhance nematode movement into the wood.

NEMATODE HANDLING

Nematodes are transported in sealed plastic satchels containing 1 million nematodes in 20 ml of water. These should be separated by corrugated card to allow oxygen access, and packed flat in insulated boxes with freezer blocks included and kept between 5-15° C at all times (Figure 9).

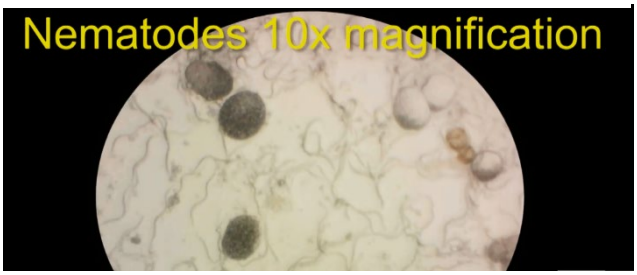
Figure 9: Satchels of 1 million nematodes stored on corrugated cardboard in fridge (Note: do not freeze).



The optimum storage temperature is 5 Celsius. At higher temperatures, less oxygen is dissolved and available in the water, with this increasing the probability of nematode mortality. Nematodes should be used as soon as possible after they are received. Under optimum conditions they should be able to be kept refrigerated for up to 5 days.

Samples of nematodes should be checked under a microscope or hand lens prior to mixing, to ensure they are alive (Figure 10). When stored in a refrigerator, a maximum/minimum thermometer can be included to ensure the acceptable temperature range is maintained.

Figure 10: Healthy nematodes can be observed moving under a hand lens.



GEL MIXING

The aim is to produce a gel mix where are nematodes evenly mixed throughout the gel.

Recipe:

1. Pour 500 ml **tap** water into a mixing bowl or sauce bottle (clear bottle if available).
2. Mix in one sachet (approximately one million nematodes) and stir or shake, ensuring that the nematodes are evenly distributed through the water.
    a. **Bowl:** While stirring the water/ nematode mix, gradually add one sachet of dried polyacrylamide gel (approximately 5 g). Continue to stir for at least 2-3 minutes by which time the preparation will have become a thick viscous gel slurry, which then can be added to the sauce bottle.
    b. **Sauce bottle:** Empty the entire contents of the dried polyacrylamide gel satchel into the sauce bottle, cap and shake immediately by constantly "up-ending" the bottle. Within a minute or so the gel will solidify to a slurry and be ready for use (colder temperatures extends time needed to jellify).
3. Once the gel starts to thicken, several drops of vegetable dye can be added. A uniform colour following further stirring or shaking provides a visual indication of a thorough mix.

A mix of this volume is sufficient for approximately 500 inoculation holes (10 trees at 50 holes each).

Nematode handling and inoculation

Work Sheet 3

POLYACRYLAMIDE GEL TRANSPORT AND STORAGE

- Transport and store the gel mixture at a temperature as near to 5° C as is practical.
- The gel should be used as quickly as possible, and within 36 hours of mixing. (do not store un-used mix in dispensers).
- The sauce or inoculation bottles require a narrow tip to fit into the inoculation hole.

Figure 11: 500 ml sauce bottle & dyed gel

INOCULATION PROCESS

Timing

Optimum inoculation time is considered to be during the period May to June. The limitations are that prior to April many of the dying trees aren't obvious, while by August the moisture content of dying trees is likely to be too low to ensure success (sapwood moisture content of >50% is considered preferable).

Tree Selection

Trees for inoculation should be infested with sirex and be current year's deaths. Symptoms are:

- wilted foliage, yellow to copper brown in colour
- resin beading
- tea-coloured brown cambial staining
- evidence of sirex larvae or galleries

If a tree has sirex exit holes, it has died in a previous year and should not be inoculated. For trap trees, assume all trees are infested with sirex regardless of symptoms and inoculate accordingly.

It is important to monitor background nematode levels in the forest. This can be done by setting aside some trees or billets prior to inoculation so that nematode levels of emerging sirex can be determined during the next flight season.

It is also possible to estimate background nematode levels by woodchip sampling prior to inoculation. Chips of wood are placed in containers of water overnight and nematodes which emerge into the water can be observed under a hand lens or microscope.

Note: If background nematode levels are less than 10% then inoculation of extra naturally struck trees is recommended.

- Refer to Sirex Worksheet 4 "Evaluation of Sirex Biological Control Agents" for recommendations.

Inoculation

The trees for inoculation should be felled and trimmed of branches on the top side to facilitate inoculation. Once felled, the cut ends of the trees can be slightly raised off the ground and end-coated with timber sealant to reduce moisture loss.

Materials

- Rebound inoculation hammer with punches
- Nematode mixture
- Nematode dispenser (Figure 12).

Figure 12: Inoculation "kit" (rebound hammer, gel & dispensers, making paint).

METHODS

1. Inoculation holes approximately 10 mm deep into the wood are made using the rebound hammer (Figure 13).

Nematode handling and inoculation

Work Sheet 3

Punch hole spacing:

- **log diameter <15 cm** - 1 row of holes 30 cm apart along the top of the log down to about 5 cm diameter.
- **log diameter >15 cm** - 2 rows of staggered holes 30 cm apart along the log at the 10 to 2 o'clock position.

There is no need to inoculate into the deep fissured bark at the butt of the tree, as sirex is less likely to inhabit this area.

Figure 13: Rebound hammer & extracted punch hole cores.

- *The cutting surface of the punch should be kept sharp and even at all times using a chainsaw file. When punching the log, the tracheids (wood cells) must be cut clean so that nematodes can readily move into the wood from the gel. If the punch goes dull, it needs to be replaced.*
- *Rebound rubbers should be replaced regularly so that the rebound is maintained.*

2. The tip of the gel dispenser (e.g. sauce bottle) is inserted into the base of the inoculation hole and withdrawn as inoculum is squeezed into it (Figure 14).

3. Once filled, the gel is compacted by pressing with a finger or thumb.

- *This compaction is very important as it ensures intimate contact between the gel and the inside of the hole, allowing the nematodes to directly move out of the gel into the wood.*
- *Inoculation during heavy constant rain and days >30° C should be avoided because:*
  - *Rain may wash gel out of holes.*
  - *High temperatures may dry out the gel in the inoculation holes which will result in the death of the nematodes before they enter the wood.*
- *Lubrication of the inside of the punch with WD40 or equivalent (overnight), maintains cutting performance of the punch.*

Tree inoculation is usually carried out by teams of 2 or 3 people with one person punching the holes while the other(s) follow behind inoculating.

Figure 14: Nematode bearing gel is forced into the punch hole from a sauce bottle & pressed with one's thumb to ensure the gel contacts the punch hole wall.

Work Sheet 4

Evaluation of sirex biocontrol agents

OBJECTIVE

To determine establishment, distribution and relative abundance of biocontrol agents in specific geographic localities.

KEY FACTORS

1. Evaluate effectiveness of specific release operations for establishment.
2. Evaluation should relate to specific localities to determine dispersal and estimate distribution.
3. Use results to determine future release programs.

MONITORING METHODS

Nematodes

The main method of assessing nematode levels is to dissect sirex emerging from caged logs. Select sirex-infested trees and cage billets in October/November, with emergence usually occurring from December to April.

For rapid assessment of nematode presence in a locality as trees are dying, woodchips from dying trees can be tested for nematode presence. This is accomplished by placing chips of wood into a petri dish of water and leaving overnight. Any nematodes present will emerge into the water and can be observed using a hand lens or microscope.

Parasitoids

Ibalia are parasitoids which have a similar emergence period to that of sirex (summer/autumn), therefore data for *Ibalia* can be assessed using the same emergence cages and logs described below (Figure 15).

Figure 15: Newly emerged *Ibalia leucospoides* parasitoid.

Other parasitoids emerge in spring i.e. *Schlettereius*, *Megarhyssa* (Figure 16), six months after sirex has emerged and are also assessed using emergence cages. However, it is preferable for sample logs to be collected in the September after the summer sirex emergence period.

Figure 16: Newly emerged *Megarhyssa nortoni* parasitoid.

Emergence Cages

In early October just prior to sirex and parasitoid emergence commencing, place short logs (up to 0.8 m length) from sirex infested trees into open ended netted cages, 200 litre drums, bins or boxes (Figure 17). Emerging sirex will be attracted to the light at the open end, where they are subsequently captured for male/female counts and dissection to ascertain presence of nematodes.

If using 200 litre drums, the interior of drums should be non-toxic to ensure good insect survival. Insects can be collected via a detachable bottle at the open end of the cage or through a collapsible hand hole in mesh covering the drum end.

Figure 17: Netted emergence drums secured in scaffolding.

Drums can be stored horizontally or vertically, but in both cases regular (daily) inspections of the drum are necessary to collect emerged insects. Horizontal drums are more space efficient, however if stacked without racking, they may distort. Cages and drums must be kept in the shade and under cover (emergence

Evaluation of sirex biocontrol agents

Work Sheet 4

facility), which should be dry and well ventilated.

SAMPLING

Nematodes

Nematode sampling is used to determine the background level of nematodes in a sirex population and/or to determine the effectiveness of sirex inoculation of trap trees within trap tree plots or naturally struck trees. In the latter case, a comparison between background and inoculation levels is necessary. A comparison of nematode levels found in inoculated trees is made with non-inoculated trees, and therefore the efficiency of the sirex control operation can be assessed by comparison between the two groups.

- The areas sampled must be of sufficient number to allow management decisions on insect control to be made with confidence.

An example of a sampling regime is where 25 non-inoculated trap or naturally struck trees are sampled in each chosen locality (1x billet per tree, 5 trees/ compartment and 5 compartments/locality). Sample billets should be taken from stem sections containing sirex larvae and/or galleries.

- In low level sirex infestations, samples should be taken from the portion of the tree which contains larval galleries.

These billets are cut and caged in October/November just prior to sirex emergence. They can be end- coated to reduce moisture loss. A similar process is used to assess samples taken from inoculated trees.

Parasitoids

Billets collected for sampling nematodes are also used to sample *Ibalia* as they will emerge at the same time as the s irex wasps being assessed for nematode infection.

To sample for parasitoids other than *Ibalia*, sample billets should be cut in September from trees killed the previous year (i.e. they have exit holes). Where detection of parasitoids is the objective, sampled billets should be selected for maximum number of exit holes and where a representative population level is needed. Logs should be cut from the mid- stratum point of the entire tree.

Suitable trees should be marked in the year they die to ensure correct age samples are taken in the following September.

RECORDING

Cages should be inspected regularly, with all emerging insects recorded by species, sex and number and the date the emergents were collected.

Both male and female sirex are assessed for nematodes by cutting the abdomen off and inspecting the squashed abdomen contents in water under a microscope. Where numbers of emerging sirex exceed 100 in any cage, only a sub-sample (e.g. 10%) of further emergent are required to be examined for nematodes. Where resources are sufficient, it is suggested all sirex emergents be dissected to increase the accuracy of results obtained.

Stereo microscopes are necessary to detect the nematodes (with lighting from a dark-field base if available). If nematodes are numerous, they will be visible at 10X magnification, but a higher magnification may be necessary to detect nematodes at low levels.

The results obtained should be summarised by locality and not pooled by region as management decisions are made at the locality level.

Figure 18: When the female abdomen is cut open her eggs will be evident. Nematodes if present can be seen in the translucent body fluids or from squashed eggs.

EVALUATION OF RESULTS

Nematode levels

As the prime biocontrol agent, nematode levels are vital information for making decisions on future programs and predicting sirex levels.

Nematode levels from cage samples reflect the nematode status of trees killed the previous year. Therefore, when deciding on future inoculation an

Evaluation of sirex biocontrol agents

allowance must be made for the increase in nematodes in the trees that are killed in the current year. A guide has been developed to assist future inoculations (Table 4-1).

Sirex Levels

If a locality sample relates to 25 trees or some other reasonable sample size, the average number of emerging sirex gives some indication of the sirex level in that locality. This information should be assessed in conjunction with tree mortality data and nematode levels to predict future sirex levels.

Parasitoid Levels

Parasitoid presence or absence indicates whether a particular species is established. This and the knowledge of previous releases is used to indicate the dispersal rate of the parasitoid. Data can therefore be used to map distribution and select sites for further releases (Figure 19).

Table 4-1: Supplementary inoculation recommendations.

Background nematode level from emergence monitoring	Recommended inoculation as % of sirex struck trees
0%	20%
1-5%	10%
5-10%	5%
>10%	0%

Figure 19: Emerged *Ibalia* collected for release.

Breeding nematode-free sirex wasps

Work Sheet 5

OBJECTIVE
The objective of this program is to establish a nematode-free sirex population, which will enable the maintenance of breeding populations of various sirex parasitoids.

KEY FACTORS

1. Maintenance of a nematode-free sirex population in an insectary culture if not easily obtainable from the field.
2. Maintaining a wide gene pool within the population.

EVALUATION
As the prime biocontrol agent against sirex wasp, *Deladenus* nematodes have been widely and intensively used throughout sirex infected plantations. This together with the nematode's self-perpetuating method of spread within the tree, has drastically decreased the availability of a nematode-free sirex population.

SELECTION OF STOCK
To minimise the chance of a nematode-infected sirex population, select a field site where no known inoculation has taken place or only at very low intensity. Field site material to be collected can be either previously prepared trap trees or naturally struck trees. This operation should be carried out between April and August to ensure correct selection of suitable trees and to obtain the optimum moisture content of the trees. Trees for selection should be those infected by sirex the previous summer and exhibit the following characteristic signs.

1. Coppery brown wilted foliage, the dieback having commenced from the lower canopy.
2. The presence of the sirex fungal staining beneath the bark on the cambium of the tree.
3. Small resin beads on the outer bark of the tree, often associated with sirex oviposition holes.
4. The presence of emergence holes would indicate that the tree had been killed in the previous year, and therefore would not contain sirex. *These should not be sampled.*

As a further check to determine whether nematodes are present, or at what levels, the "woodchip" test can be applied to some trees. With an axe remove a portion of the outer bark of the tree to expose the cambium layer (approx. 10 cm x 20 cm). The area should have fungal staining. Remove a chip approximately 10 cm x 5 cm x 5 cm deep from several trees and place them into a shallow plastic bag of water for a few hours. If nematodes are present, they will be visible at 10X magnification in a sample of the water. Sampling should be confined within the areas of staining and billets should have their ends sealed to retain their moisture.

EMERGENCE CAGES
Sample billets can be cut to 0.8 m lengths for storage in an insectary emergence room where they will be stacked. Allow space between billets for light and air circulation and exposed surface area for insect emergence.

Alternatively, billets can be cut to 0.8 m lengths for storage in 200 litre drums. The drums should allow air circulation with 5 to 8 billets/drum, and for the easy collection of emerging insects.

REARING CAGES
To ensure the emerging sirex are nematode-free the females should be tested prior to release into rearing rooms. Emerging females are collected and placed into small (approx. 60 x 120 mm) holding cages placed on green billets and allowed to oviposit.

Within 5 minutes of oviposition, the female is captured, and the ovipositor dipped into a drop of water, which is then examined under a microscope to determine whether nematodes are present. Nematode-free sirex females can then be released into the prepared rearing rooms. The rearing rooms are set up with racks which allow the billets to be held vertically, allowing plenty of light and air circulation, emulating a field environment.

A ratio of approximately 2 female sirex per billet (2:1) should be released in order to avoid overcrowding. Green billets should be collected just prior to the sirex emergence period to optimise billet moisture levels. The billets should be 1.5 m in length, between 15 and 20 cm in diameter and the ends sealed to retain their moisture. Heavily furrowed, coarse thick bark such as that close to butt of a tree should be avoided, to ensure maximum usable surface area for the female sirex to oviposit.

Female sirex released into rearing rooms should be collected and examined more accurately for the presence of nematodes at the completion of their life cycle. This is easily done by cutting off the abdomen and squeezing out its contents onto a petri dish. Add a drop of water and macerate it, then under 40X magnification examine for the presence of nematodes. If nematodes are present sirex egg sacks will be deformed and numerous nematodes will be present. Live nematodes appear curled and should be moving; dead nematodes on the other hand appear straight, tapered and worm-like.

Work Sheet 6

Rearing of sirex wasp parasitoids

OBJECTIVE

The object of this program is to maintain a viable population of sirex wood wasp parasitoids for release and establishment in the field.

KEY FACTORS

1. Monitoring for establishment of parasitoid species.
2. Timing of billet collections suitable for culture.
3. Availability of nematode-free sirex infected logs.
4. Maintaining a wide gene pool within populations.

MONITORING AND COLLECTION METHODS

Billets for rhyssine parasitoid assessment should be collected in August/September from trees killed the previous year (Figure 20). Trees suspected of containing parasitoid larvae and/or pupae are collected from previous field release sites and, where evidence of establishment has been recorded, throughout sirex infected plantations.

Figure 20: Billet for parasitoid collection selected from trees displaying multiple sirex emergence holes.

Selection of suitable trees is based on the presence of the characteristic sirex fungal staining beneath the bark on the cambium of the tree. It is also important that the billets have large numbers of sirex emergence holes and have evidence of parasitoid pupae when cross cuts are made. Billets are 0.8 m in length, ideally between 10-20 cm in diameter (billets can be end wax sealed to help retain moisture).

EMERGENCE AND REARING METHODS

Sample billets are placed in isolation rooms such as in an insectary or placed in well aerated drums and a means by which the emerging insects can be easily collected as they emerge.

Billets which are to be caged in drums are cut to 0.8 m and once again the ends sealed (5 to 8 billets/ drum). In an insectary emergence room, the 1.5 m billets can be stacked (crosshatch), which provides space for air circulation and maximises surface area for insect emergence. Rhyssine parasitoid emergence usually begins late September and may extend into mid-January.

Characteristically, males make up a large proportion of the early emergence before female number increase. These early emergences are collected, allowed to feed on a solution of honey and water (1:5) and then kept at approximately 5° C to slow their metabolism. It is advisable to bring the container of insects out to room temperature every third day and allow them to feed. They can be stored in this manner for up to 10 days without detrimental effects.

Males of both *Rhyssa* and *Megarhyssa* are not ready to mate for several days, so once a suitable number of females have emerged (minimum of 5 adults), stored males can be introduced. It has also been observed that *Megarhyssa* (Figure 21) and to a lesser extent *Rhyssa*, often mate whilst the female is emerging from the log. Therefore, it is very important to have 'old' males in the mating cage at the time of female emergence. Females and males, once allowed to stabilise to room temperature, should be combined within the smaller collecting containers for a few hours to promote mating.

Figure 21: Released reared *Megarhyssa* (note long ovipositor)

Most rhyssines do not oviposit until about a week after emergence yet can mate as soon as they emerge. By keeping adults for a week and providing them with a honey and water solution as a food supplement and either a pollen solution or fresh flowers as a protein source they will then oviposit as soon as they are released in the field.
For the insectary culture (i.e. not for re-release into the

Rearing of sirex wasp parasitoids

Work Sheet 6

field) these adults are transferred into rearing rooms set up with billets infected with nematode-free sirex larvae. (Refer to worksheet establishing and maintaining nematode free sirex cultures).

The rearing rooms are set up with racks which allow the billets to be held vertically thus allowing light penetration and air circulation and emulating a field environment. Billets can be naturally struck from the field. These should be collected prior to the start of the sirex emergence period (November), and have no emergence holes prior to collection.

Alternatively, billets can be from insectary cultures containing viable sirex larvae. Each rearing room should contain a minimum of 50 billets in order to sustain a minimum of 100 pairs of two females per billet. Parasitoids within these rooms should be supplied with the honey and water solution and a pollen solution to increase their longevity.

When the parasitoids "flight" season (September to January) is complete the rearing rooms remain dormant until the following season when the emerging adults can be used to establish or replenish field sites and provide the next generation for the insectary culture.

If the rearing billets used were naturally struck in the field, it is likely that there will be emergence of other *Rhyssa* / *Megarhyssa* or later *Ibalia* and sirex larvae not parasitized by the introduced parasitoid. The emerging sirex can be collected and examined for the presence of nematodes, therefore also providing a means of predicting nematode levels in the sirex population.

Similar procedures are used in rearing *Ibalia* (Figure 22).

As *Ibalia*'s life cycle coincides with that of sirex and they parasitize their hosts' eggs rather than larval stages, freshly struck sirex billets are required. *Ibalia* emerge from late December through to March. They seldom feed and rarely take water, but these should always be provided. Care should be taken when collecting early emergents for storage, not to over crowd so as to avoid them damaging each other.

Figure 22: Released reared *Ibalia*

For rearing cultures of the rhyssines and Ibalia parasitoids the main requirements are a nematode free sirex population.

Determination of nematode infectivity

Work Sheet 7

OBJECTIVE

The object of this program is to ensure that nematodes present in operational programs retain their ability to infect sirex larvae.

KEY FACTORS

1. Maintenance of nematode cultures on fungi over many years can result in selection against the key trait of ability to convert to infective form in the presence of sirex larvae.
2. Laboratory testing should be undertaken periodically to ensure nematode performance meets expectations.
3. Background populations of nematodes may also be evaluated for infectivity.

METHODS

Nematodes *Deladenus (Beddingia) siricidicola* must be extracted from sirex or from woodchips using sterile technique onto agar plates on which the sirex fungus (*Amylostereum areolatum*) has been already established (Figure 23).

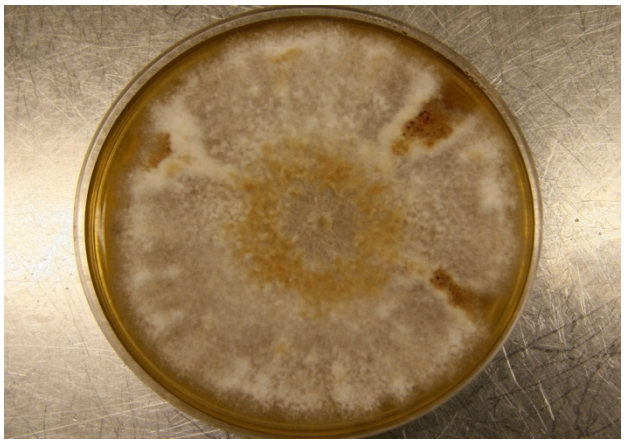
- Plates are maintained at room temperature to promote nematode development.
- Multiple plates are used to build nematode numbers to a satisfactory level and until many eggs have been laid.
- Nematode eggs are washed from plates and plated onto a special agar and placed in a high CO2 environment for x days.
- Nematodes are washed off, subsampled and examined under a microscope to determine the proportion of nematodes which have developed into the infective form.

INTERPRETATION OF RESULTS

The nematode strain currently being produced by the NSCC for field distribution was originally re-collected from Kamona in Tasmania in 1989 and has been stored in liquid nitrogen since. Periodically, new vials are withdrawn from storage and used to replace the laboratory production population.

Infectivity levels for this nematode strain are usually above 90%. By comparison, field collected strains, whose origins are not known often have infectivity levels below 10%. These are sometimes referred to as the defective strain.

Figure 23: *Amylostereum* fungal culture on which the biocontrol nematode *Deladenus* are reared. Note the culture colour matches the under bark 'tea stain' sirex indicator.



Panel trap installation & maintenance

Work Sheet 8

OBJECTIVE

To use panel traps for early detection of sirex, particularly in non-plantation situations where trap trees are not possible or efficient, in order that control measures may be established to minimize the risk of damaging sirex attack.

KEY FACTORS

1. Panel trap lures must be maintained fresh and replaced regularly (monthly)
2. Regular inspections are required to ensure that the catch fluid has not evaporated.
3. Panel traps may catch other potential plantation pests and the catch should be retained and referred to an entomologist for review.

OVERVIEW

Monitoring of sirex wasp abundance and biocontrol agent levels using trap trees is described in a related worksheet. The use of static traps to detect sirex and assess the abundance of the parasitic nematode biocontrol agent *Deladenus* (*Beddingia*) *siricidicola* is a more recent development, having the advantage of being cheap and quick, and not requiring the presence of susceptible plantation trees.

Static traps however do not provide the opportunity for evaluating parasitoid wasp levels, or for supplementing nematode levels.

- Panel traps baited with specific pheromone lures are used to attract and catch female *Sirex noctilio* wasps.
- Sirex collected in panel traps are to be dissected to determine the presence of nematodes.
- Where un-infested sirex are found, installation of trap trees should be considered to enable inoculation with nematodes in the following season.

MATERIALS

1. Panel traps and lures (70% alpha pinene and 30% beta pinene) can be purchased from a specialist insect trapping companies e.g. alphascents.com in the USA (Figures 24 & 25).

Assembly instructions are included with the traps.

2. Preservative catch fluid (propylene glycol), at 500 ml per trap, but this is often available in bulk quantities only. Ethylene glycol (antifreeze) can be substituted for propylene glycol and is available in smaller quantities, but it has a less favourable OHS risk profile.

Figure 25: Sirex pinene lure

INSTALLATION

Selection of trapping sites should consider

- Optimal plantation age of 7-10 years
- Sirex historical records and biocontrol agent activity
- Site location as sirex have a flight range approx. 7 km

1. Traps should be deployed during the peak sirex flight season (January to late March).

Up to 15 sirex have been intercepted in several traps during a single trapping period but in general catch numbers will be substantially fewer.

2. Three traps should be deployed as a group 50 m apart to adequately sample sirex activity in the area. Deploy traps at least 4 km away from trap tree plots.
3. Lures can be stored for up to 12 months in the freezer but will only be effective for 4 weeks once deployed (less if temperatures >30° C).
4. Branches should be pruned from beside the trap especially if cast needles are likely to be collected by it.

Panel trap installation & maintenance

Work Sheet 8

5. The collecting cup is half filled with preservative (diluted with water 1:1) at the time of installation. Rain in the following weeks could be collected in the cup, further diluting the preservative.

6. Inspect traps every 2-4 weeks. More frequent checking and trap maintenance e.g. lure and trap fluid replacement, required during periods of high rainfall and high temperatures. Tip the entire contents of the collecting cup into a bucket through a kitchen strainer. Remove any wasps into a sealed jar and have these assessed for nematodes.

Note presence of other insects and collect samples if unable to identify insects which may be parasitoid wasps.

7. When refilling the trap collecting container, use fresh preservative if rain has diluted the original solution.

After 4 weeks replace the lures and re-locate the traps if required (high temperatures will require more frequent replacement of lures).

KEY SAFETY ISSUES

Avoid contact with lure compounds and antifreeze (if used) by use of appropriate protective clothing. Refer to the relevant Safety Data Sheet.

DISSECTION OF WASPS

Dead wasps recovered from the panel traps should be handled with protective gloves if they have been preserved in antifreeze.

Parasitic nematode infestation can still be detected upon dissection even though the nematodes will have died.

Insect samples collected should be kept in alcohol, propylene glycol or antifreeze to prevent deterioration

FURTHER READING

Bashford R. (2008) The development of static trapping systems to monitor for wood-boring insects in forestry plantations. *Australian Forestry* Volume 71 No 3 pp236-241.