The development of static trapping systems to monitor for wood-boring insects in forestry plantations

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Summary

The effectiveness of combinations of panel and funnel static traps with lures in surveillance to detect wood-boring insects in softwood (*Pinus*) and hardwood (*Eucalyptus*) plantations was examined. Static trapping systems proved to be an effective tool for monitoring specific pest species such as the wood wasp *Sirex noctilio*, detecting their presence when more traditional surveillance methods did not. Traps can detect a broad range of wood-boring species, enabling detection of low (pre-outbreak) populations of pest species. The panel and funnel traps were found to be at least as effective as Malaise trapping, light trapping and insect rearing in determining the wood-boring insects present in a plantation. A strategy for the operational deployment of static traps for detecting developing outbreaks has still to be finalised — full deployment in all susceptible plantations is unlikely to be cost-effective, but sub-sampling susceptible plantations is feasible. The development of surveillance systems using static traps to detect exotic wood-borers is discussed.

Keywords: surveillance; monitoring; trapping; attractants; pheromone traps; wood borers; plantations; *Sirex noctilio*

Introduction

Static traps are devices that enable insects to be captured over time without daily servicing or maintenance. These traps can be placed in the field and collected or serviced after an interval that may be months. Traditional examples are pitfall traps, Malaise traps[1], sticky traps, pan traps and light traps.

Portable, lightweight traps have been devised in recent times to capture specific species when used in conjunction with pheromone sex lures, or to capture members of a range of insect families using kairomone[2] lures. The traps are made of lightweight plastic or coated cardboard, are waterproof, durable and inexpensive, and can be easily dismantled into flat packages for transport and storage. Information on their numerous designs, colours and sizes is readily available via a web search. In the following studies traps of two designs were used: the Lindgren funnel trap and the Intercept panel trap.

Traditional methods for detecting boring insects in plantations have relied on damage symptoms on the host tree once attack has occurred. Such approaches have a relatively small likelihood of detecting the early stages of attack when damage is restricted to a relatively small number of usually suppressed or sub-dominant trees (Wardlaw and Bashford 2007). By the time obvious visual symptoms of damage are evident in the more easily observed co-dominant and dominant trees the outbreak may be well established and considerable crop loss may have already occurred.

Importantly, delayed detection also delays control activities such as the introduction of biological control agents or silvicultural intervention (e.g. thinning), both of which typically require some time to take effect.

Static traps, incorporating pheromone or kairomone lures that attract particular taxa or groups of insects, have the capacity to detect the presence of target species when these are present in low numbers, typical of developing outbreaks or new incursions (Miller 2006). Static traps have become widely used in plant biosecurity, being installed at high-risk sites to detect new incursions (Hobson *et al.* 2001; Wylie *et al.* 2008). The capacity of static trapping to detect target pest species at low numbers may also have application in forest protection for managing established pests that periodically outbreak, for detecting the spread of established pests into new areas and for detecting new introductions.

In the past five years we have been evaluating the potential of static traps to improve the management of wood-boring insect pests in plantations. This paper reports the performance of static traps deployed in *Pinus* and *Eucalyptus* plantations to detect and monitor key insect pests.

Development of static trapping for *Sirex noctilio* monitoring in young *Pinus radiata* plantations in Tasmania

The sirex woodwasp, *Sirex noctilio* Fabricius (Hymenoptera: Siricidae), has been one of the most damaging exotic insect

[1] Malaise traps are tent-like traps made of fine mesh material and used primarily for the collection of flies (Diptera) and wasps (Hymenoptera). They are generally set out for long periods of time and checked at least weekly.

[2] A kairomone is a chemical substance produced and released by a living organism that benefits the receiver and disadvantages the donor.

pest species to enter Australia and has caused the death of millions of plantation trees over the past five decades (Haugen 1990). The traditional monitoring technique developed in the late 1960s involved establishing trap tree plots, and aerial and roadside surveys for affected trees (National Sirex Co-ordination Committee 2002). These are still the main methods of monitoring, but in Tasmania an adaptation of that system incorporating Intercept® panel static traps and volatile attractants has been evaluated.

During lure testing at the port of Bell Bay in 2003 we found that traps containing α-pinene lures caught a number of female *S. noctilio*. We then examined several studies, conducted in the mid-1970s, in which *P. radiata* volatile oils had been tested as attractants for *S. noctilio* females. Testing, in flight mill and antennograph[3] experiments, of the volatile oils emitted by stressed *P. radiata* trees for response by *S. noctilio* females provided evidence of strong attraction to certain volatiles (Simpson 1976; Simpson and McQuilkin 1976).

In 2004–2005 we placed static traps containing α-pinene in three northern Tasmanian *P. radiata* plantations: Retreat Block, where *S. noctilio* had been recorded, and at Castra and Virginstowe Blocks where *S. noctilio* had not been recorded. *S. noctilio* was captured in the three Retreat compartments and also at Virginstowe, but not at Castra.

Using this information we field-tested a series of α- and β-pinene combinations in 2005–2006. Lures containing different ratios of α-pinene: β-pinene (70 : 30, 60 : 40, 40 : 60 and 30 : 70) were tested against lures containing either α- or β-pinene alone in the Retreat Block. Beta-pinene by itself did not catch any *S. noctilio*, whereas α-pinene by itself caught ten females. The attractiveness of mixed α- and β-pinene lures increased with increasing proportions of α-pinene relative to β-pinene (Fig. 1). The combination of 70% α-pinene and 30% β-pinene was selected as being the most attractive to *S. noctilio* females. APTIV Inc. in Portland, Oregon, made up this combination of pinene volatiles in permeable plastic pouch lures. These pouch lures allow the volatiles to be released at a set rate over a period of a month. Both the USDA Forest Service and Canadian Forestry use a similar lure combination, produced by private companies under contract, for *S. noctilio*.

Two types of static traps were tested in 2006–2007 with pouch lures containing mixed pinene volatiles. The Intercept™ panel trap (Czokajlo *et al.* 2001) (Fig. 2) has been used in Canada for wood-borer surveys during which numbers of native *Sirex* species were captured (McIntosh *et al.* 2001). The Lindgren multi-funnel trap (Fig. 2) has been used extensively in North America (Hayes *et al.* 1996; Miller and Borden 2000) and Europe (Dubbel and Vaupel 1996) for detecting and monitoring bark beetles. Five pairs of traps were placed in the Retreat Block. The panel traps captured around 40% more *S. noctilio* females than the Lindgren traps (19 females, $n = 3.8 \pm 1.09$ and 12 females, $n = 2.4 \pm 1.52$ for the panel traps and Lindgren traps respectively). Trap design may influence the capture of fast-flying *S. noctilio* females: with the panel trap, the insects encounter a larger surface area and a single-entry funnel into the collecting cup.

[3] An antennograph records the electrical responses of an insect antenna to chemical compounds.

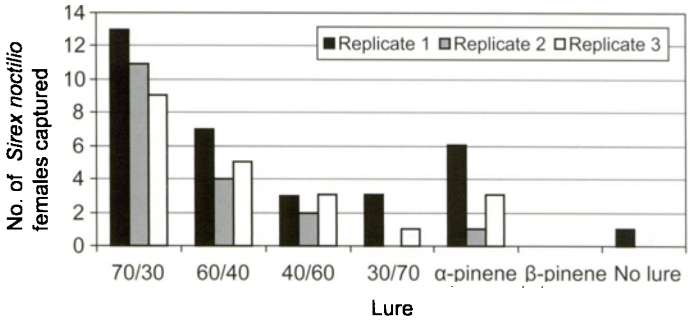

Figure 1. Attraction of *Sirex noctilio* females to α- / β-pinene combination lures in Intercept® panel traps at Retreat, northern Tasmania

Figure 2. Static trap designs used in plantation monitoring. Top: Lindgren multi-funnel trap. Bottom: Intercept® panel trap.

During the 2006–2007 *S. noctilio* flight season we placed three panel traps in each of five 7–9-y-old plantations distributed across the north of the state. These plantations had no previous record of *S. noctilio* attack. At four of the five sites *S. noctilio* females were captured, and in three of those sites suppressed trees attacked by *S. noctilio* were later located.

Development of static trapping for stem-borers in *Pinus radiata* plantations

Lindgren funnel traps have been used for the past two decades in North America to monitor populations of endemic bark beetles (Reeve 1997; Safranyik *et al.* 2004). The successful identification of pheromones for pest species of commercial importance has resulted in an industry synthesising and selling a vast range of pheromones and attractants for many pest species.

In Tasmania we have used Lindgren funnel traps baited with *Ips* pheromone to monitor for *Ips grandicollis* (Eichhoff), an exotic bark beetle species widely established in mainland softwood plantations but not yet in Tasmania. We also found that Lindgren traps baited with α-pinene caught high numbers of *Hylastes ater* (Paykull) and *Hylurgus ligniperda* (Fabricius), two exotic bark beetles established in Tasmania for decades. When ethanol ultra-high release (UHR) lures were added to the α-pinene lures in the traps, the catch increased and many other native species of wood-borers that attack *P. radiata* were caught (Table 1).

Trials of a number of α-pinene–ethanol combinations were made in several pine plantations, and the best combination for generalist capture selected. The combination of α-pinene and 96% ethanol, both as UHR formulations, proved attractive to a wide range of large pine wood-borer beetle species in the United States (Miller 2006).

The generalist lure combination was tested in three plantations in both Tasmania and Queensland in 2004. The system incorporated three Lindgren multi-funnel traps set up 5 m apart in a triangular configuration. Trapping in Queensland plantations at Ingham, Toolara and Beerburrum provided a total of 23 pinhole borer species (13, 13 and 16 species at Ingham, Toolara and Beerburrum, respectively) with a number of samples still to be processed. Of interest were new records for the little pinhole borer *Cyrtogenius brevior* (Eggers) and the red-haired bark beetle *Hylurgus ligniperda* (De Baar 2005).

Trapping in the Tasmanian plantations of Lisle, Wurra Wurra and Pittwater provided a total of 9 bark beetle species (8, 8 and 9 species at Lisle, Wurra Wurra and Pittwater, respectively). *Hylastes ater* and *Hylurgus ligniperda* were collected in large numbers at all sites. The scolytid *Chryphalus pilosellus* Erichson was collected for the first time in a northern Tasmanian plantation. *Ips grandicollis* was not collected.

Development of static trapping for stem-boring insects in *Eucalyptus* spp. plantations

We are accumulating reports from forest health surveys of tree mortality in mid-rotation plantations on drier sites. This appears to be correlated with drought events. We assume that mid- rotation unthinned eucalypt plantations experience an elevated level of water stress, making them at risk of attack by stem-boring insects. The level of hydration within potential host trees influences the degree of resistance to successful insect attack (Hanks *et al.* 2000). Damage by stem-boring insects can kill or degrade pruned trees so severely that they are suitable only for pulpwood or are discarded. Current operational health surveillance by aerial observation, drive-through surveys and ground surveys is ineffective in detecting attack by stem-boring insects at an early stage when symptoms are cryptic (Wardlaw *et al.* 2007)

Static trapping is one approach to detecting the presence of low (pre-outbreak) populations of stem-borers where a range of

Table 1. Number of individuals of stem-boring insect species captured in Lindgren funnel traps baited with ethanol–α-pinene lures installed in four *Pinus radiata* plantations in northern Tasmania

Species	Pittwater (8 traps)	Lisle (3 traps)	Virginstowe (3 traps)	Retreat (3 traps)
*Sirex noctilio**	16	2	11	3
*Hylurgus ligniperda**	449	2	45	0
*Hylastes ater**	74	12	5	0
Platypus subgranosus	2	18	6	13
*Ernobium mollis**	76	3	4	0
Trypopitys multimaculata	42	1	2	1
*Xyleborinus saxeseni**	0	39	33	17
Xyleborus compressus	3	8	2	0
Xylosandrus truncatus	3	0	0	0
Xylebosca bispinosa	2	0	0	1
Hadrobregmus australiensis	1	0	0	0
Cryphalus pilosellus	17	11	18	1
Hadrobregmus aereolicollis	0	0	0	3
Total insects trapped	685	96	126	39

*Exotic to Australia

species emerge at different times during the summer months. In 2004–2005 we tested a number of host tree volatiles for attractiveness to stem-boring beetle species. Treatments consisted of five different eucalypt volatile lures in Intercept® panel traps, plus empty traps as a control. Traps were installed in a 7-y-old *E. nitens* plantation in northern Tasmania that had experienced two episodes of mortality associated with borer attack following drought events (Wardlaw and Bashford 2007). Two replicates were installed in each of a thinned and adjacent unthinned stands and operated for a six-month period (October 2004 – March 2005). Each replicate consisted of a transect of the six traps, spaced 30 m apart. Within each stand, the lures were placed in the traps in mirror order in each transect. In order to determine the full suite of stem-boring species present within the plantation, we reared species from a sample of logs taken from dead, attacked trees and placed in an insectary. A pair of Malaise traps was placed in both the thinned and unthinned sections of the plantation during October 2004 and March 2005. Two bucket black-light traps, one in each of the thinned and unthinned sections, were also run opportunistically during 2004–2005 when suitable weather coincided with visits to service the static traps. The static traps captured 29 species out of a total of 31 species captured by all methods. Of the six volatiles tested, the ethanol UHR lures captured the greatest number of species and among the highest number of individuals (Table 2).

Discussion

The development of static trap and lure technology provides another tool for routine forest insect surveillance and monitoring in both softwood and hardwood plantations. Routine surveillance involving aerial and roadside inspections is inefficient in detecting cryptic damage typical of the initial stages of developing outbreaks of wood-boring insects (Wardlaw and Bashford 2007). It is not until the later stages of outbreaks, when mortality begins to occur among dominant trees, that detection becomes efficient using routine surveillance.

Static trapping provides an opportunity to detect small populations of wood-boring insects before they cause significant mortality in the dominant trees. An example is the use of static traps to detect the early presence of *S. noctilio* females in unthinned mid-rotation *P. radiata* plantations. Static traps with pinene lures detected *Sirex* females in three 'apparently' healthy plantations, where attack was restricted to a small number of suppressed trees. This level of damage had not been detected during routine forest surveys, which rely heavily on aerial inspection. Being able to detect *S. noctilio* at this early stage enables us to introduce biological control agents, especially nematodes, several years earlier than would otherwise be possible. A strategy for the operational deployment of static traps for detecting developing outbreaks has still to be finalised. Full deployment in all susceptible plantations is unlikely to be cost-effective. However, sub-sampling susceptible plantations within a local area on a rotational basis (e.g. a 3-y cycle) is feasible.

Experience to date has shown that static trapping captures insects from a broad range of taxonomic groups including taxa in the families Cerambycidae, Scolytidae, Bostrichidae, Buprestidae and Anobiidae. Many of these families contain exotic species not yet present in Tasmania. One example is the introduced bark beetle *I. grandicollis*, an exotic species present throughout softwood plantations in mainland Australia but not yet found in Tasmania. This species poses a high risk of establishment because of its widespread presence in mainland states and the climatic compatibility of Tasmania (Neumann and Morey 1984).

Table 2. Number of individuals and species of wood-boring insects captured using a range of lures installed in Intercept® panel traps in thinned and unthinned sections of a *Eucalyptus nitens* plantation at Blackwood Creek, northern Tasmania, and results of supplementary sampling in the same plantation

Replicate and lure	Total no. of species	Thinned		Unthinned	
		Number of species	Number of individuals	Number of species	Number of individuals
Replicate 1					
Ethanol UHR		21	76	14	20
Cineole		14	49	9	12
Phellandrene		16	59	8	13
α-pinene		16	37	11	19
α- / β-pinene		10	31	6	6
Control		8	34	7	10
Replicate 2					
Ethanol UHR		17	47	13	33
α- / β-pinene		10	37	5	7
α-pinene		12	65	7	9
Phellandrene		8	20	9	18
Cineole		9	34	7	16
Control		6	11	2	14
Supplementary sampling					
Malaise traps	18				
Light traps	6				
Reared from logs	7				

Officers of the Australian Quarantine and Inspection Service detect large numbers of forest insects when inspecting containers and cargo on the wharf and at devanning sites. In the USA, the total number of annual interceptions at ports of entry exceeds 30 000–40 000 plant pests (Wheeler and Hoebeke 2000). In Australia, 3500 insects were intercepted in 2002 (Caley *et al.* 2008). World-wide the number of port interceptions of forestry, especially timber, pests is increasing annually. While many of these species would have difficulty establishing if they did pass through the screening process, with increasing cargo trade and passenger numbers entering Australia the probability of exotic insects breaching the barrier and becoming established increases. In New Zealand, long-term interception records include an annual average of 58 insects likely to colonise *P. radiata*. During the same period more than two species established annually on *P. radiata* (Carter 1989).

In the United States and Canada, static trap surveillance for invasive forest pests has expanded beyond port facilities into nearby forest habitats. The result has been increased detection of established incursions, especially of frequently intercepted wood- and bark-borer species. Most of these surveys use non-specific host volatile lures (CAPS 2006). Surveillance programs in and around ports provide evidence of incursions but not about pests that have spread beyond the port environs and established in plantations and forest areas (Humble *et al.* 2003). Extending static trapping to plantations and other forests beyond the port surrounds would provide additional value by detecting those exotic insects that have passed the urban transitional establishment stage and also species that established in past decades but remain undetected. An example is the detection of the bostrichid *Xylotillus lindi* (Blackburn) in urban surveillance static traps at Hobart Airport in 2006. This species, native to New South Wales, has not been previously recorded from Tasmania during quarantine inspections (L. Hill, Department of Primary Industries and Water, Quarantine Diagnostics Section, Devonport, *pers. comm.*, 2008). The species has subsequently been recorded from static trap collections in an *E. nitens* plantation in northern Tasmania.

Innovative trapping systems that can detect the presence of exotic wood-boring insects at an early stage of establishment enhance the prospect of management before significant losses occur. However, more work is required to develop deployment strategies that are both practical, in terms of samples generated and diagnostic capabilities, and cost-effective. Operational trapping programs that target plantation and other forest areas adjacent or near to ports and urban high-risk areas have been proposed as a key biosecurity measure in the National Plantation Timber Industry Biosecurity Plan (Plant Health Australia 2007).

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