Invasive species survey techniques

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Overview of survey techniques of invasive species

Semiochemicals-based mass trapping of RTB

Novel sampling technique of PWN and sex pheromone of its vector, *Monochamus alternatus*

Traps for beetles in USA

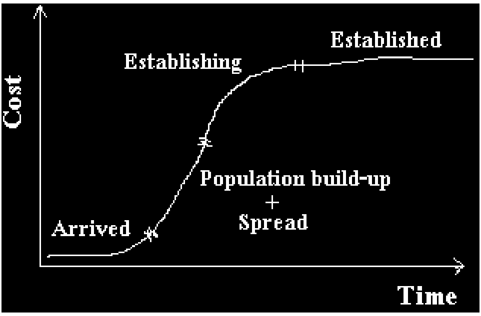
***Hyphantria cunea* with sex pheromone**

Overview

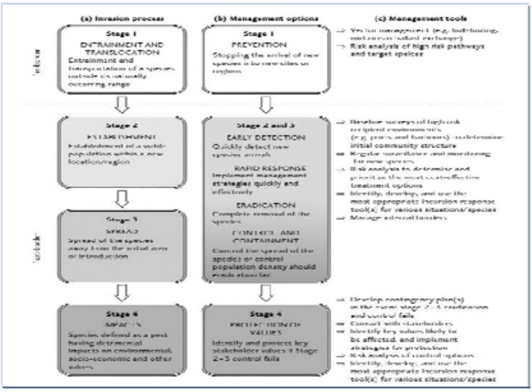
The international and accidental transport and introduction of species to new regions is currently perceived to be one of the primary threats to biological diversity (Hatcher et al. 1989; Suchanek 1994).

An understanding of invasive patterns is critical if we are to develop strategies to manage bio-invasions and to effectively target the limited resources that are currently available for the management of non-indigenous species.

Cost and Invasion Process

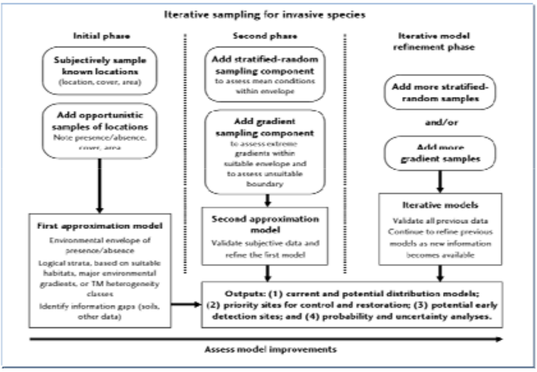


The stages contributing to a successful biological invasion and the management tools



Invasive species management, edited by MN Clout and PA Williams

Sampling approach for documenting, mapping and predicting
the abundance, distribution, and the spread of invasive species



Invasive species management, edited by MN Clout and PA Williams

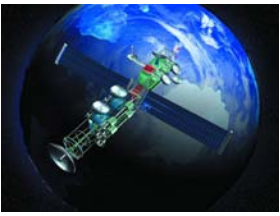
1 Aviation and remote sensing monitoring

1) Plane monitoring

2) Electronic channel plotting and air monitoring

Timely, Accurately, and Conveniently

3) Remote sensing monitoring



2 Attractants monitoring

The current international most widely applied

The most practical application value

Especially for the local area, the most effective pest monitoring technology

1) Attractants from insects

- Semiochemicals
  - Intraspecific action — pheromone
    - aggregation
    - alarm
  - Interspecific action — allelochemical
    - allomone
    - kairomone
    - synomone
    - antimone

2) Attractants from plants

Terpenoid compounds

Green leaves compounds

Nitrogen-containing compounds

Others

Red turpentine beetle, an invasive forestry bark beetle In China

Introduced from NA to China

Dendroctonus valens LeConte
Red turpentine beetle (RTB)

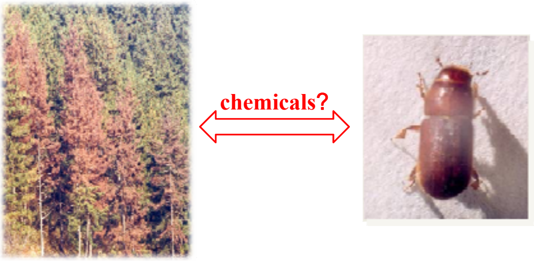
Symptom

In 1999, the first major epidemic of *D. valens* began in Shanxi province in northern China, spreading to three adjacent provinces.

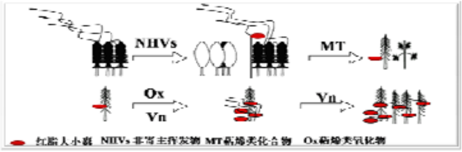
Killed more than 7 million pines in China

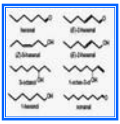
Chemical control of RTB

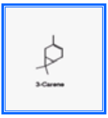
Chemical communications between RTB and host pines

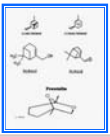


Mechanisms of Chemical communications









Annals of Forest Science 2007 64: 267-273 **Journal of Chemical Ecology 2007** 33: 147-156 **PLoS ONE 2007** 12:1-9, e1302.doi:10.1371
Environmental Entomology 2009 38: 471-477 。。。。。。

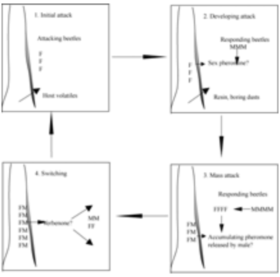
Table 2 Mean number of beetles responding per day to monoterpene baited multiple funnel traps, Shanxi Province, China, 2002

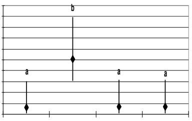
Code	Monoterpenes	Device	Ratio	Rate	Catches/per day
STD	(+)-α-pinene:(-)-β-pinene:(+)-3-carene	Sun	1:1:1	180	23.51±33.02a
2XB	(+)-α-pinene:(-)-β-pinene:(+)-3-carene	Sun	1:2:1	180	23.21±44.60a
4XB	(+)-α-pinene:(-)-β-pinene:(+)-3-carene	Sun	1:4:1	180	24.92±28.60a
3XC	(+)-α-pinene:(-)-β-pinene:(+)-3-carene	Sun	1:1:3	180	43.67±47.24c
BPN	(-)-β-pinene	Sun	NA	180	4.17±6.27b
APN	(+)-α-pinene	Sun	NA	180	3.07±6.78b
3CR	(+)-3-carene	Sun	NA	180	71.77±106.40d
LIM	(+)-α-pinene:(-)-β-pinene:(+)-3-carene:(+)-limonene	Sun	1:1:1:0.5	180	13.25±23.96a
CTR	None	None	NA	0	0.31±0.69b
P110	(+)-α-pinene:(-)-β-pinene:(+)-3-carene	Phero Tech	1:1:1	110	7.78±13.00a
S150	(+)-α-pinene:(-)-β-pinene:(+)-3-carene	Sun	1:1:1	150	35.84±52.93b
S180	(+)-α-pinene:(-)-β-pinene:(+)-3-carene	Sun	1:1:1	180	23.51±33.02b
S210	(+)-α-pinene:(-)-β-pinene:(+)-3-carene	Sun	1:1:1	210	28.64±38.12b

Means in the same column followed by a different letter are significantly different at α=0.05, using the Bonferroni approach.

Environ. Entomol. 2004, 33(3):206-212
Environ. Entomol .2006, 35(3):655-660

Verbenone as RTB attacking population regulator





Frontalin as an aggregation pheromone and a female-produced sex pheromone

Canadian Entomologist 2003, 135: 721-732.
Environmental Entomology 2006, 35 (4): 1037-1048.
Journal of Chemical Ecology 2011, Revised

Interspecific Invasion of RTB and *Hylastes parallelus*

3-carene

terpinolene

RTB

Hylastes parallelus

myrtenol,trans-verbenol, cis-verbenol,myrtenal

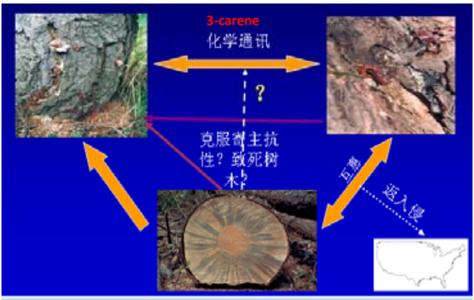
RTB

Cross attraction between RTB and an native bark beetle *Hylastes parallelus*

Interspecific Invasion in 2007

PLoS One *2007 2(12):* e1302

Chemical communication between bark beetles, fungi, and hosts



Mutualistic Invasion of RTB and its associated fungus

L. terebrantis 40%
L. procerum 30% (Klepzig *et al*. 1995)

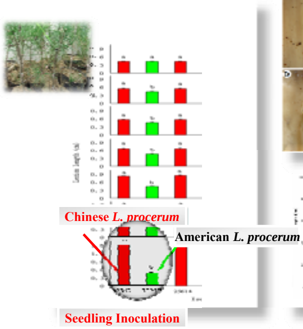
L. procerum	70%
L. truncatum	< 1%
L. pini-densiflorae	< 1%
O. ips	< 5%
O. flocossum	<15%
O. minus	< 1%
O. piceae	< 1%
O. rectangulosporium	< 1%
O. abietinum	< 1%
H. pinicola	< 1%

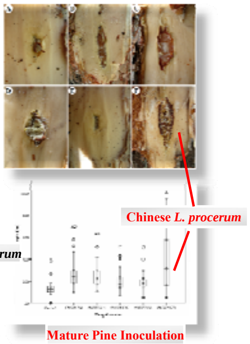
Leptographium procerum is common asscoaite of RTB in China

Fungal Diversity 38:133-145

Mutualistic Invasion of RTB and its associated fungus

RTB benefits from *L. procerum* 1



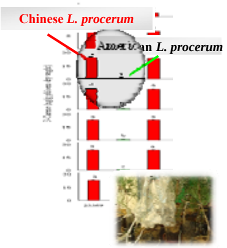


Chinese *L. procerum* has the higher pathogenicity on the host than American strain.

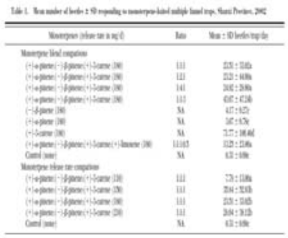
Mutualistic Invasion of RTB and its associated fungus

RTB benefits from *L. procerum* 2

3-Carene extraction

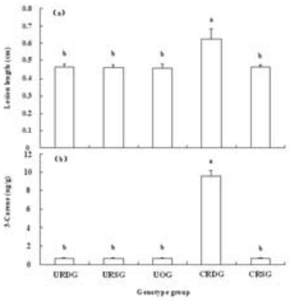


RTB field trapping by 3-carene



Chinese *L. procerum* result in greater numbers of *D. valens* on infected host trees than do the other fungi.

Chinese Novel genotypes were more pathogenic and could induce more 3-carene (attractant of RTB) than the other genotypes



Pathogenicity tests

Chemical extraction

Mutualistic Invasion of RTB/fungus Complex

A possible mutualistic relationship that could enhance invasion by and/or spread of a beetle/fungal complex.

New Phytologist 2010 187: 859-866

Novel Genotypes Facilitate Invasion of RTB/fungus Complex and reinvasion

For future studies, it would be interesting to explore whether RTB, together with its newly acquired fungal genotypes, could cause equivalent damage to American pine hosts if it were to reinvade North America.

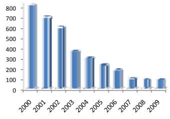
Ecology 2011 92: 2013-2019

Mass Trapping(＞1.5 million ha)

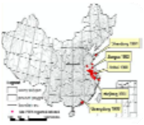
RTB is under control!

The red turpentine beetle: an innocuous native and an invasive tree killer in China with potential reinvasion

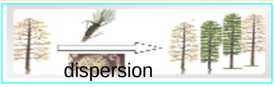
ARE, 2013, Volume 58.

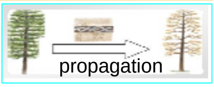


Pine Wood Nematode (PWN)



Pinewood nematode Life Cycle





Dispersal Route

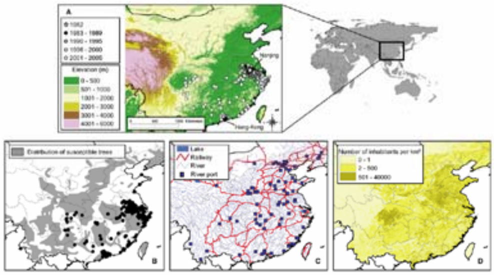


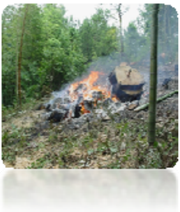
Figure 1. Invasion data and potential driving factors. The pinewood nematode invasion in China between 1982 and 2005 (Panel A). The first pinewood nematode observation in China (in Nanjing) is represented by a white star. Spatial distribution of 10 susceptible tree species (Panel B). Black dots represent locations already infested. Potential anthropogenic pathways (Panel C), and spatial distribution of human-population density in 2000 (Panel D).
doi:10.1371/journal.pone.0004646.g001

Robinet, C., Roques, A., Pan, H.Y., Fang, G.F., Ye, J.R., Zhang, Y.Z., and **Sun J.H.*** 2009. *PLoS ONE* 4(2):e4646. doi:10.1371/journal.pone.000464

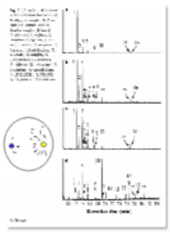
Traditional Control Technique

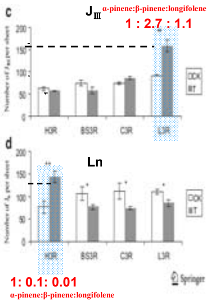
There is no cure for pine wilt disease.

Management of the disease is primarily limited to preventing the introduction and spread of the nematode.



Vector Beetle Regulate the Aggregative Behavior of PWN

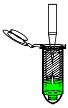


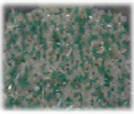


The different life stages of pinewood nematode can be attracted by different ratios of terpenes produced by their host and vector.

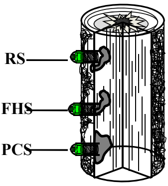
Zhao, L.L., Wei, W., Kang, L. and Sun, J.H*. 2007. *Journal of Chemical Ecology* 33:1207-1216.

We developed a novel sampling technique!





Zhao, L.L., Wei, W., Liu, X.Z. Kang L.and **Sun, J.H.*** 2007. *Canadian Journal of Forest Research* 37:1867-1872.



Nov. - Apr.

FHS: Feeding hole sampling

States of decay	Sampling place
Cessation of oleoresin exudation begins	The infection site
The yellow needles,wilt become visible	2m tall
Reddish color, diseased trees	1-1.5m tall
Fading color, dead or dying tree	1m tall

Be useful for different states of decay **Be useful in different tree species**

May.-Oct.

We can find more than twenty pinewood nematodes in 2 hour by the trap tube.

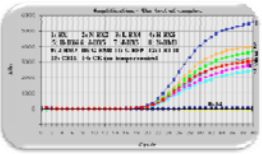
Zhao, L.L., Jiang, P., Humble, L.M. and **Sun, J.H.*** 2009. *Forest Ecology and Management 258: 1932-1937*

Control methods of pinewood nematode in China

- **Popularization of Sampling Technique**

The novel attractant-baited sampling technique may facilitate the rapid detection of plant-parasitic nematodes for import quarantine and field monitoring.

Control methods of pinewood nematode in China



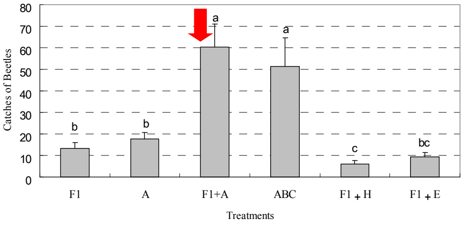
Trapping and kill of *Monochamus* beetle in conjunction use with *B. bassiana*

Effect of male-produced pheromone on the traps of *Monochamus alternatus*

Table 1. Compounds of lures used in the trapping experiments for *M. alternatus*.

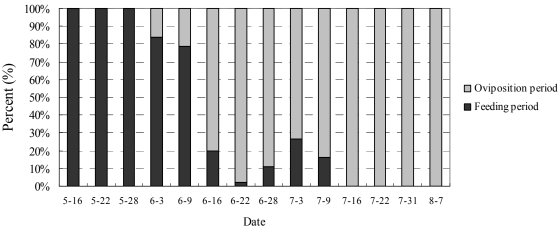
Treatment	Compound
F1	α-pinene + aldehyde
A	2-undecyloxy-1-ethanol
F1+A	α-pinene + aldehyde + 2-undecyloxy-1-ethanol
ABC	2-undecyloxy-1-ethanol + ipsenol + 2-methyl-3-buten-2-ol + α-pinene
F1+ H	α-pinene + aldehyde + 2-hexanol+ 3-hexanol+ 2-hexanone + 3-hexanone
F1+E	α-pinene + aldehyde + Emulsifier

Figure 1. The number of M. alternatus adults caught by the traps in different treatments.



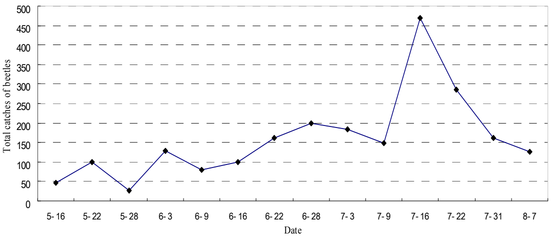
- Traps in treatment F1+A with the addition of 2-undecyloxy-1-ethanol caught 4.5 times beetles more than that of treatment F1.
- Traps in treatment A with 2-undecyloxy-1-ethanol alone is not significantly different with treatment F1 for attracting *M. alternatus* beetles.
- It demonstrates that the addition of the male-produced pheromone of *M. galloprovincialis* significantly improved the attraction of plant source lures to *M. alternatus*.

Figure 2. The different period of *M. alternatus* adults caught.

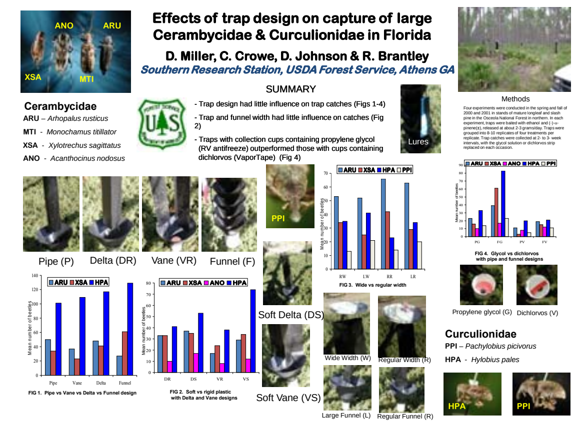


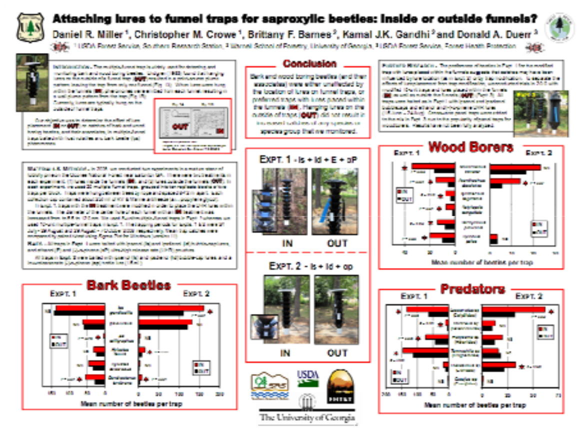
- Before May 28: All adults are in feeding period, immature.
- June 3 ~ July 9: Some adults are in oviposition period.
- After July 9 All adults caught are in oviposition period.

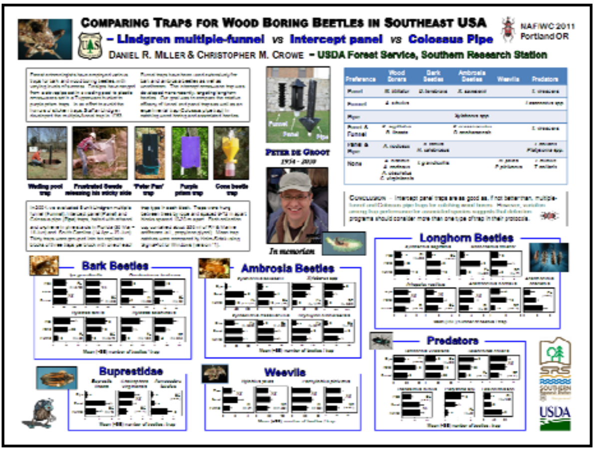
Figure 3. The number of M. alternatus adultes caught in different dates.



- At July 16 the traps caught the most *M. alternatus* beetles in the whole trapping period.







Hyphantria cunea with sex pheromone