Forest Research Institute

Alien Invasive Species and International Trade

Edited by
Hugh Evans and Tomasz Oszako

Warsaw 2007

Reviewers:
Steve Woodward (University of Aberdeen, School of Biological Sciences, Scotland, UK)
François Lefort (University of Applied Science in Lullier, Switzerland)

ISBN 978-83-87647-64-3

Description of photographs on the covers:
Alder decline in Poland – T. Oszako, Forest Research Institute, Poland
ALB Brighton – Forest Research, UK;
Anoplophora exit hole (example of wood packaging pathway) – R. Burgess, Forestry Commission, UK
Cameraria adult Brussels – P. Roose, Belgium;
Cameraria damage medium view – Forest Research, UK;
other photographs description inside articles – see Belbahri *et al*.

Language Editor: *James Richards*
Layout: *Grażyna Szujecka*

Print: Sowa–Print on Demand www.sowadruk.pl, phone: +48 022 431 81 40

Instytut Badawczy Leśnictwa
05-090 Raszyn, ul. Braci Leśnej 3, phone [+48 22] 715 06 16
e-mail: Wydawnictwa_IBL@ibles.waw.pl

DETECTION OF WOOD-BORING SPECIES IN SEMIOCHEMICAL-BAITED TRAPS

Jonathan Sweeney[1], Peter de Groot[2], Leland Humble[3], Linda MacDonald[2], Jessica Price[1], Tomasz Mokrzycki[4], Jerzy M. Gutowski[5]

[1]Canadian Forest Service, Natural Resouce Canada, Fredericton NB
[2]Canadian Forest Service, Natural Resouce Canada, Sault Ste. Marie ON
[3]Canadian Forest Service, Natural Resouce Canada, Victoria BC
[4]Department of Forest Protection and Ecology, Faculty of Forestry, Warsaw Agricultural University, Poland
[5]Forest Research Institute, Department of Natural Forests, 17-230 Bialowieza, Poland

We need effective, practical survey and detection tools for early detection of invasive species, to assist in delimiting the area of recently established pest populations once they are detected, and for monitoring the progress of eradication and containment programs. Sex and aggregation pheromones are great for species-specific detection at low densities, and the obvious lure choice for monitoring an established invasive or determining pest-free status. However, insect communication and host-finding behaviours are poorly understood for many species of wood-boring beetles and there is a limit to the number of species-specific lures/traps that can be used in operational surveys.

Host volatiles may be less effective than pheromones at detecting low-density populations of a particular species, but can attract (detect) a large number of different species. For example, α-pinene is attractive to many species of coniferous bark- and wood-borers, including the cerambycids (*Asemum striatum* (L.)*, Arhopolus rusticus nubilus* (LeConte)*, Monochamus titillator* (F.)*,* and *Xylotrechus integer* (Hald.); the scolytines (*Hylastes ater* (Payk.)*, Ips grandicollis* (Eichhoff)*, Tomicus minor* (Hartig)*,* and *T. piniperda* (L.); the buprestid (*Buprestis lineata* F.), and the predators *Enoclerus nigripes rufiventris* (Spinola), *E. nigrifrons gerhardi* Wolcott*,* and *Thanasimus formicarius* (L.) (Cleridae) (Pertunnen 1957, Byers *et al.* 1985, Schroeder 1988; Chénier & Philogčne 1989; Miller 2006; Allison *et al.* 2004). Ethanol, often produced in stressed or diseased trees, is attractive to several scolytines, e.g., *Trypodendron lineatum* (Oliv.)*, T. domesticum* (L.)*, Gnathotrichus sulcatus* (LeConte), *Xyleborus saxeseni* (Ratz.), *X. affinis* Eichhoff*, Hylurgops palliatus* (Gyll.)*,* and curculionids, e.g., *Hylobius abietis* (L.) (Moeck 1970; Schroeder 1988; Salom & McLean 1990; Byers 1992; Lindelöw *et al.* 1993). Some species are more attracted to a blend of monoterpenes than to either α-pinene or ethanol alone, e.g., *Xylotrechus undulatus* (Say)*, Tetropium fuscum* (F.)*,* and *Monochamus urussovii* (Fischer) (Cerambycidae) (Sweeney *et al.* 2004, 2006) and *Hylastes ater, Ips grandicollis* (Eichhoff), and

Tomicus minor (Scolytinae) (Schroeder 1988; Chénier & Philogčne 1989). Furthermore, attraction of many species is synergized by a combination of ethanol plus α-pinene or ethanol plus a blend of monoterpenes, e.g., *Monochamus scutellatus scutellatus* (Say), *M. notatus* (Drury), *Xylotrechus longitarsis* Casey, *Tetropium fuscum, T. castaneum* (L.), *T. cinnamopterum* Kirby, *Spondylis buprestoides* (Cerambycidae) (Allison *et al.* 2001; Morewood *et al.* 2002; Sweeney *et al.* 2004), *Hylobius pales* (Herbst), *H. abietis, H. pinastri* (Gyll.) (Curculionidae), *Dryocoetes autographus* (Ratz.), *T. piniperda* (but too much ethanol repels), *Hylastes cunicularius* Erichson, *H. opacus* Erichson, *H. brunneus* Erichson (Scolytidae), and the clerid, *Thanasimus dubius* (F.) (Tilles *et al.* 1986; Vité *et al.* 1986; Schroeder 1988; Chénier & Philogčne 1989; Lindelöw *et al.* 1993; Miller 2006). Finally, some cerambycids are attracted to bark beetle pheromones (e.g., ipsenol, ipsdienol, MCH, and frontalin) or pheromones plus monoterpenes plus ethanol, e.g., *Monochamus clamator* (LeConte), *M. s. scutellatus, M. titillator* (F.), *M. obtusus* Casey, and *M. notatus* (Drury) (Billings & Cameron 1984; Allison *et al.* 2001, 2003; de Groot & Nott 2004).

Lindgren funnel traps baited with either: 1) α-pinene + ethanol (for woodborers of conifers); 2) ethanol (for woodborers of deciduous hosts); or 3) the 3-component *Ips* lure consisting of *cis*-verbenol, 2-methyl-3 buten-2-ol, and racemic ipsdienol (targeting *Ips typographus* (L.), *I. sexdentatus* (Börner), *Hylurgus ligniperda* (F.), and *Orthotomicus erosus* (Woll.) have been used by the Canadian Food Inspection Agency (CFIA) and the USDA Forest Service and Animal and Plant Health Inspection Service (APHIS) for several years. These traps have provided the first records of established populations of several species introduced to North America, including *Hylurgops palliatus* (2001, α-pinene+ethanol), *Arhopalus pinetorum* (Woll.) (2001, α-pinene+ethanol), *Xyleborus similus* Ferrari (2002, ethanol), *X. glabratus* Eichhoff (2002, ethanol), *Scolytus schevyrewi* Semenov. (2003, α-pinene+ethanol), *Sirex noctilio* F. (2005, *Ips* lure), as part of the USDA FS and APHIS rapid detection pilot program or APHIS-Cooperative Agricultural Pest Surveys (CAPS) (Duerr 2005; Hoebeke & Acciavatti 2006; Rabaglia 2005). However, traps baited with these standard lures did not detect every forest insect species recently introduced to North America; notable exceptions include the Asian longhorned beetle, *Anoplophora glabripennis* (Motschulsky) (ALB), brown spruce longhorn beetle, *T. fuscum,* and the emerald ash borer, *Agrilus planipennis* Fairmaire (EAB). Both the ALB and EAB were first detected in New York and Michigan, respectively, on or near infested host trees (Haack *et al.* 1996; McCullogh & Katovich 2004). The earliest recorded collection of *T. fuscum* in Canada actually was in volatile-baited traps (in 1990 in Point Pleasant Park, Halifax, Nova Scotia on stickem-coated stovepipe traps baited with turpentine (Robertson 1990) but the specimens were misidentified as the nearctic *T. cinnamopterum* and *T. fuscum* was not actually detected in Halifax until 1999, when it was reared from bolts cut from infested spruce trees (Smith & Hurley 2000).

The most effective lure to date for *T. fuscum* is a blend of monoterpenes (spruce blend) plus ethanol released at ultra high rates (UHR) (Sweeney *et al.* 2006) and it attracts mainly *Tetropium* spp., at least among the cerambycids species trapped in Halifax, Canada and Białowieża, Poland. Of 41 species of cerambycids trapped in

Halifax and Poland in 2002 and 2003, 74% to 89% of specimens were *Tetropium* spp. caught in spruce blend plus ethanol-baited traps; *Tetropium* accounted for only 0% to 11% of cerambycid specimens captured in unbaited traps (Sweeney *et al.* 2004, 2006).

To determine whether the combination of spruce blend plus ethanol and similar lures might be useful for detecting scolytines, we recorded the scolytine species captured in trapping experiments (for *T. fuscum*) conducted in Halifax in 2003 and Poland in 2005. The forest in Halifax was dominated by white spruce, *Picea glauca* (Moench) Voss., red spruce, *P. rubens* Sarg., and balsam fir, *Abies balsamea* L.. In Białowieża, Poland, the experiment was conducted in an old growth mixed deciduous forest with the most common species being Norway spruce, *Picea abies* L. Karst., English oak, *Quercus robur* L., European hornbeam, *Carpinus betulus* L., Scots Pine, *Pinus sylvestris* L., aspen, *Populus tremula* L., and European silver birch, *Betula pendula* Roth. In Halifax, cross-vane pan traps baited with five different combinations of spruce blend and ethanol at high or low release rates plus an unbaited control captured 19 different scolytine species (Table 1). The combinations of spruce blend (UHR or low release rate) plus ethanol (UHR) were significantly attractive to four species including *Trypodendron lineatum, Dendroctonus rufipennis* (Kirby), and

Table 1. Total numbers of Scolytine species captured in cross vane pan traps baited with five different combinations of spruce blend plus ethanol, at low or ultra high release rates, or an unbaited control trap, in a spruce dominated forest on McNabs Island, Halifax, Nova Scotia, Canada, in 2003

Species	Numbers captured
Cryphalus ruficollis Hopkins	15
Crypturgus pusillus (Gyllenhal)	5
Dendroctonus rufipennis (Kirby)	213
Dryocoetes affaber (Mannerheim)	49
Dryocoetes autographus (Ratz.)	48
Gnathotrichus materiarius (Fitch)	101
Hylastes porculus Erichson	9
Hylurgops pinifex (Fitch)	3
Ips borealis Swaine	5
Ips pini (Say)	4
Orthotomicus caelatus (Eichhoff)	10
Pityophthorus ramiperda Swaine	81
Pityophthorus sp. Eichhoff	1
Polygraphus rufipennis (Kirby)	23
Trypodendron lineatum (Oliv.)	381
Trypodendron retusum (LeConte)	1
Xyleborus dispar (F.)	69
Xyleborus sayi (Hopkins)	24
Xyloterinus politus Say	12

Table 2. Total numbers of Scolytine species captured in intercept traps baited with seven different host volatile lures at ultra high release rates or an unbaited control, in an old growth mixed deciduous forest with Norway spruce, English oak, Scots pine, European hornbeam, aspen and European silver birch near Białowieża, Poland, 2005. The lures were composed of blends of monoterpenes simulating those emitted from red spruce, alone or combined with ethanol

Species	Numbers captured
Crypturgus cinereus (Herbst)	84
Crypturgus hispidulus Thoms.	1
Dryocoetes autographus (Ratz.)	537
Hylastes angustatus (Herbst)	3
Hylastes ater (Payk.)	222
Hylastes cunicularius Erichson	2317
Hylastes opacus Erichson	143
Hylurgus ligniperda (F.)	3
Ips typographus (L.)	192
Ips sexdentatus (Börner)	1
Orthotomicus laricis (F.)	2
Pityogenes chalcographus (L.)	30
Tomicus piniperda (L.)	16
Trypodendron lineatum (Oliv.)	1
Xyleborinus saxeseni (Ratz.)	11
Xyleborus dispar (F.)	51
Xyleborus monographus (F.)	3

Gnathotrichus materiarius (Fitch). In 2005 we varied the ratios of monoterpenes in the spruce blend lures to simulate those emitted from stressed (girdled) vs. unstressed red spruce trees and tested 6 different lures or lure combinations plus an unbaited control in, black IPM intercept traps (Advanced Pheromone Technologies, Marylhurst, OR) in Białowieża. A total of 17 different scolytine species were captured (Table 2), with five species (*Hylastes cunicularius, H. opacus, H. ater, Dryocoetes autographus, Crypturgus cinereus* (Herbst)) significantly attracted to unstressed spruce blend plus ethanol (both UHR lures).

In 2006, we initiated some field trapping trials in Canada (Vancouver, Toronto, and Halifax) to test whether we could improve the suite of lures for the detection of potentially invasive wood/bark-boring beetles. Specifically, our objectives were to test a series of 7 lures (including the three standards) plus an unbaited control to determine which lures were significantly attractive to wood-boring species, to compare lures for total number of species detected, and to determine the minimum number of traps required to detect most of the (significantly attracted) species in an area. Processing of catches has begun and one of the first points to emerge is that certain species, e.g., *Trypodendron lineatum,* are flooding the traps and slowing down the work of species sorting and identification. A repellent that deterred the catch of very common native species without disrupting the attraction of target species would be very useful, if such exists. It would be useful to repeat these experiments in coniferous forests in Europe and China.

In summary, we need a practical and effective suite of lures/traps to assist in early detection of invasive species. Host volatiles are significantly attractive to a range of wood-boring beetles, and can be surprisingly selective, but will never be as sensitive as a pheromone-based lure. Slight changes in terpene ratios can significantly affect attraction of some species. Our experiments will hopefully lead to improvements in invasive wood-borer surveillance and detection.

Acknowledgments*. We thank the Canadian Forest Service, Canadian Food Inspection Agency, Forest Protection Limited, New Brunswick Dept. Natural Resources & Energy, Ontario Ministry of Natural Resources, Nova Scotia Dept. of Natural Resources and Halifax Regional Municipality for supporting this research, and Nichole Braun, Katie Burgess, Gregg Cunningham, Art Doane, Nelson Carter, Bob Guscott, Glenn Harrison, Ed Kettela, Troy Kimoto, Karen O'Leary, Wayne MacKay, Lee Mailman, Chris McQuarrie, Taylor Scarr, Dave Seaboyer, Georgette Smith, Krzysztof Sućko and Tom Walsh for logistical or technical assistance.*

References

Allison J. D., Borden J. H. , McIntosh R. L., de Groot P., Gries. R. 2001. Kairomonal response by four *Monochamus* species (Coleoptera: Cerambycidae) to bark beetle pheromones. J. Chem. Ecol., 27: 633-646.

Allison J. D., Morewood W. D. , Borden J. H. , Hein K. E., Wilson I. M. 2003. Differential bio-activity of *Ips* and *Dendroctonus* (Coleoptera: Scolytidae) pheromone components for *Monochamus clamator* and *M. scutellatus* (Coleoptera: Cerambycidae). Environ. Entomol., 32: 23-30.

Allison J. D., Borden J. H., Seybold S. J. 2004. A review of the chemical ecology of the Cerambycidae (Coleoptera). Chemoecology, 14: 123–150.

Billings R. F., Cameron R. S. 1984. Kairomonal responses of Coleoptera, *Monochamus titillator* (Cerambycidae), *Thanasimus dubius* (Cleridae), and *Temnochila virescens* (Trogossitidae), to behavioural chemicals of southern pine beetles (Coleoptera: Scolytidae). Environ. Entomol., 13: 1542-1548.

Byers J. A., Lanne B. S., Schlyter F., Löfqvist J., Bergström G. 1985. Olfactory recognition of host-tree susceptibility by pine shoot beetles. Naturwissenschaften, 72: 324-326.

Byers J. A. 1992. Attraction of bark beetles, *Tomicus piniperda, Hylurgops palliatus,* and *Trypodendron domesticum* and other insects to short-chain alcohols and monoterpenes. J. Chem. Ecol., 18: 2385-2402.

Chénier J. V. R., Philogčne B. J. R. 1989. Field responses of certain forest Coleoptera to conifer monoterpenes and ethanol. J. Chem. Ecol., 15: 1729–1745.

de Groot, P., and R. Nott. 2004. Response of the whitespotted sawyer beetle, *Monochamus s. scutellatus* and associated woodborers to pheromones of some *Ips* and *Dendroctonus* bark beetles. J. Appl. Entomol. 128: 483-487.

Duerr D. A. 2005. Early detection and rapid response pilot project. pp. 16-17 *in*: Gottshalk, K.W., ed. Proceedings, 16th U.S. Department of Agriculture Interagency research forum on gypsy moth and other invasive species 2005; 2005 January 18-21; Annapolis, MD. Gen. Tech. Rep. NE-337. Newtown Square, PA. USDA Forest Service, Northeastern Research Station. 107 pp.

Haack R. A., Cavey J. F., Hoebeke E. R., Law K. R. 1996. *Anoplophora glabripennis*: a new tree-infesting exotic cerambycid invades New York. Newsletter of the Michigan Entomological Society, 41(2-3): 1-3.

Hoebeke E. R., Acciavatti R. E. 2006. *Hylurgops palliatus* (Gyllenhal) (Coleoptera: Curculionidae: Scolytinae), an Eurasian bark beetle new to North America. Proc. Entomol. Soc. Wash., 108: 267-273.

Lindelöw A., Eidmann H. H., Nordenhem H. 1993. Response on the ground of bark beetle and weevil species colonizing conifer stumps and roots to terpenes and ethanol. J. Chem. Ecol., 19: 1393-1403.

McCullough D.G., Katovich S. A. 2004. Pest Alert: Emerald Ash Borer. USDA Forest Service State and Private Forestry Northeastern Area, Newtown Square, PA. NA-PR-02-04.

Moeck H. A. 1970. Ethanol as the primary attractant for the ambrosia beetle *Trypodendron lineatum* (Coleoptera: Scolytidae). Can. Entomol., 102: 985-995.

Miller D. R. 2006. Ethanol and (–)-α-Pinene: Attractant kairomones for some large wood-boring beetles in southeastern USA. J. Chem. Ecol., 32: 779-794.

Morewood W. D., Simmonds K. E., Wilson I. M., Borden J. H., McIntosh R.L. 2002. α-Pinene and ethanol: key host volatiles for *Xylotrechus longitarsis* (Coleoptera: Cerambycidae). J. Entomol. Soc. Brit. Columbia, 99: 117-122.

Perttunen V. 1957. Reactions of two bark beetle species, *Hylurgops palliatus* Gyll. And *Hylastes ater* Payk. (Col. Scolytidae) to the terpene α-pinene. Ann. Entomol. Fenn., 23: 101-110.

Rabaglia R. J. 2005. Exotic scolytids in North America: Who's here and what are the impacts. p. 67 *in:* Gottshalk, K.W., ed. Proceedings, XV U.S. Department of Agriculture interagency research forum on gypsy moth and other invasive species 2004; 2004 January 13-16; Annapolis, MD. Gen. Tech. Rep. NE-332. Newtown Square, PA. USDA Forest Service, Northeastern Research Station. 98 pp.

Roberston S. 1990. Point Pleasant Park Halifax, Nova Scotia bark beetle survey. Halifax Field Naturalists Report to the Technical Advisory Committee of the Point Pleasant Park Commission. 18 pp.

Salom S. M., McLean J. A. 1990. Flight and landing behavior of *Trypodendron lineatum* (Coleoptera: Scolytidae) in response to different semiochemicals. J. Chem. Ecol., 16: 2589-2604.

Schroeder L. M. 1988. Attraction of the bark beetle *Tomicus piniperda* and some other bark- and wood-living beetles to the host volatiles α-pinene and ethanol. Entomol. Exp. Appl., 46: 203-210.

Smith G., Hurley J. E. 2000. First North American record of the Palearctic species *Tetropium fuscum* (Fabricius) (Coleoptera: Cerambycidae). Coleopt. Bull., 54: 540.

Sweeney J., de Groot P., MacDonald L., Smith S., Cocquempot C., Kenis M., Gutowski J.M. 2004. Host volatile attractants for detection of *Tetropium fuscum* (F.), *Tetropium castaneum* (L.), and other longhorned beetles (Coleoptera: Cerambycidae). Environ. Entomol., 33: 844–854.

Sweeney J., Gutowski J. M., Price J., de Groot P. 2006. Effect of semiochemical release rate, killing agent, and trap design on capture of *Tetropium fuscum* (F.), and other longhorn beetles (Coleoptera: Cerambycidae). Environ. Entomol., 35: 645-654.

Tilles D. A., Sjodin K., Nordlander G., Eidmann H.H. 1986. Synergism between ethanol and conifer host volatiles as attractants for the pine weevil, *Hylobius abietis* (Coleoptera: Curculionidae). J. Econ. Entomol., 79: 970-973.

Vité J. P., Volz H. A., Paiva M. R. 1986. Semiochemicals in host selection and colonization of pine trees by the pine shoot beetle *Tomicus piniperda.* Naturwissenschaften, 73: 39-40.