E-MYRCENOL: A NEW PHEROMONE FOR THE PINE ENGRAVER, ZPS PZNZ (SAY) (COLEOPTERA: SCOLYTIDAE)

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Abstract

E-Myrcenol reduced catches of the pine engraver, *Ips pini* (Say), to ipsdienol-baited, multiple-funnel traps in a dose-dependent fashion. The sex ratio was unaffected by *E*-myrcenol treatments. Lures containing *E*-myrcenol in ethanol solution failed to protect freshly cut logs of lodgepole pine from attack by *I. pini*. Rather, *I. pini* preferentially attacked logs treated with devices releasing *E*-myrcenol and ethanol, over nontreated, control logs. Our results demonstrate that *E*-myrcenol is a new pheromone for *I. pini*, and emphasize the importance of understanding basic pheromone biology before utilisation of a semiochemical in forest pest management.


Résumé


Introduction

The pine engraver, *Ips pini* (Say) (Coleoptera: Scolytidae), aggregates rapidly and in large numbers to suitable host pines (Anderson 1948). Both sexes are attracted to males producing the pheromone *ipsdienol* (2-methyl-6-methylene-2,7-octadien-4-ol) (Vité et al. 1972; Stewart 1975). No other pheromone component has been reported.

Ipsdienol is an oxidation product of the monoterpene myrcene (Hughes 1974; Renwick et al. 1976; Hendry et al. 1980). Several other oxidation products of myrcene are associated with the pheromone biology of *I. pini* (Fig. 1). Ipsenol (2-methyl-6-methylene-7-octen-4-ol) is produced by other species of *Ips*, such as *I. paraconfusus* Lanier, and repels *I. pini* (Birch and Wood 1975; Birch and Light 1977; Birch et al. 1977). Linalool (3,7-dimethyl-1,6-octadien-3-ol) has been identified in frass of male *I. pini* (Young et al. 1973; Stewart 1975) and elicits response from antennal receptors of *I. pini* (Angst and Lanier 1979; Mustaparta et al. 1979). Linalool may (Birch and Wood 1975) or may not (Birch et al. 1977) inhibit the response of other *Zps* spp., such as *I. paraconfusus*, to sources of their own pheromones. *E*-Myrcenol (2-methyl-6-methylene-2,7-octadien-3-ol) has been found in volatiles of *I. pini* (Gries et al. 1988), *I. schmutzenhoferi* Holzschuh, and *I. sexdentatus* (Francke et al. 1988). *E*-Myrcenol is also produced by other species such as *Dendroctonus ponderosae* Hopkins (Conn 1981; Hunt et al. 1986; Pierce et al. 1987). *E*-Myrcenol was attractive to *D. ponderosae* in laboratory assays (Conn 1981), but not in the field (Conn et al. 1983).

*E*-Myrcenol is structurally similar to compounds active for *I. pini*, such as ipsdienol, ipsenol, and linalool (Fig. 1), and is produced in comparable quantities (Gries et al. 1988). Therefore, we hypothesized that *E*-myrcenol is a pheromone for *I. pini*. If true, then it
should affect the behaviour of *I. pini* to sources of the known pheromone ipsdienol, and/or to host material. We tested the effect of E-myrcenol with ipsdienol-baited, multiple-funnel traps and with freshly felled logs of lodgepole pine, *Pinus contorta var. latifolia* Engelmann.

**Materials and Methods**

**Chemicals and Release Devices.** E-Myrcenol (>99% E; chemical purity, 83%) was obtained from H.D. Pierce, Jr. (Dept. of Chemistry, Simon Fraser University, Burnaby, B.C. V5A 1S6). Racemic ipsdienol (chemical purity, 98%) was obtained from Phero Tech Inc. (1140 Clark Dr., Vancouver, B.C. V5L 3K3). E-Myrcenol and ipsdienol were released from separate devices. Each device consisted of a length of C-flex@ tubing (ID = 1.6 mm; OD = 2.4 mm) (Concept Inc., 12707 U.S. 19 South, Clearwater, FL 33546-7295), filled with an ethanol solution of either myrcenol or ipsdienol (80 mg/mL), or plain ethanol (99%) for controls, and heat-pressure sealed at both ends. Different release rates, obtained by varying the length of C-flex@ tubing, were estimated at a constant 24°C.

**Trapping Experiments.** On 3 July 1987, 80 eight-unit multiple-funnel traps (Lindgren 1983) (Phero Tech Inc., 1140 Clark Dr., Vancouver, B.C. V5L 3K3) were set in a mature forest of lodgepole pine near Princeton, B.C., in 10 replicates of eight traps each. Replicates were spaced at least 100 m apart, and traps were spaced 10-15 m apart in a 2 X 4 grid. Each trap was baited and suspended from a metal pole such that the top funnel of each trap was 1.3-1.5 m above ground.

Two ranges of E-myrcenol release rates were tested in two experiments. In both experiments, E-myrcenol was tested at three different release rates, singly and in combination with racemic ipsdienol. Ipsdienol and an ethanol control were the remaining two treatments. The release rate for ipsdienol was approximately 0.6 mg per day. Release rates for E-myrcenol were approximately 0.06, 0.18, and 0.60 mg per day in the low-range experiment, and 0.6, 3.0, and 6.0 mg per day in the high-range experiment. The low range of release rates was tested from 16 July to 9 August 1987, and the high range was tested from 3 to 16 July 1987.

**Experiment with Logs.** On 7 August 1988, 20 lodgepole pines (mean diameter at breast height? SE = 20.0 ± 0.47 cm) were felled near Gang Ranch, B.C., and sawed into logs, 10 m in length. Each log was marked into 10 equal segments of 1 m each. The logs were grouped into four replicates of five treatments each. Replicate plots were spaced 1-2 km apart, and the logs were 25-50 m apart within replicates. The treatments, set in a randomised block design, were as follows: (1) nontreated control; (2) one E-myrcenol release device at the centre of the log; (3) three devices, spaced 5 m apart; (4) five devices spaced 2.5 m apart; and (5) nine devices spaced 1.25 m apart. Each device was placed on the uppermost surface of each log and protected from damage with wire mesh. The release rate of E-myrcenol from each device was approximately 0.6 mg per day (determined by
LOW-RANGE EXPERIMENT

\[ \ln(y+1) = 5.25 - 2.14x \]

\[ r^2 = 0.586 \]

HIGH-RANGE EXPERIMENT

\[ \ln(y+1) = 4.61 - 0.365x \]

\[ r^2 = 0.713 \]

**Results**

**Trapping Experiments.** E-Myrcenol inhibited the response of *I. pini* to traps baited with racemic ipsdienol (Fig. 2). Inhibition was weakly significant in the low-range experiment [ANOVA, \( F(3,25), P = 0.082 \)] and strongly significant in the high-range experiment [ANOVA, \( F(3,30), P = 0.004 \)]. The presence of ipsdienol significantly increased trap catches in both tests [ANOVA, \( F(1,25), P < 0.001 \), and \( F(1,30), P < 0.001 \) for the low- and high-range experiments, respectively], compared with the catches in traps baited with E-myrcenol alone.

In both experiments, the numbers of *I. pini* responding to traps baited with ipsdienol decreased exponentially as the release rate of E-myrcenol increased (Fig. 2). The slope was steeper in the low-range experiment than in the high-range experiment (t-test, df= 16, \( P < 0.01 \)). Heteroscedasticity in the data sets precluded fitting the data directly to exponential equations.

E-Myrcenol had no significant effect on the sex ratio of *I. pini* responding to traps baited with ipsdienol (Kruskal-Wallis test, \( P = 0.762 \), df = 17, and \( P = 0.888 \), df = 17, for
Table 1. Effect of E-myrcenol on the attraction of *Ips pini* to lo-m-long logs of lodgepole pine near Gang Ranch, B.C., 7-31 August 1988 (*n* = 4)

<table>
<thead>
<tr>
<th>Number of devices releasing E-myrcenol</th>
<th>Mean* (± SE) number of attacks per log</th>
<th>Mean* (± SE) number of 1-m segments attacked per log</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>6.3 ± 6.25a</td>
<td>0.3 ± 0.25a</td>
</tr>
<tr>
<td>1</td>
<td>5.5 ± 5.17ab</td>
<td>1.0 ± 0.71ab</td>
</tr>
<tr>
<td>2</td>
<td>1.3 ± 0.63ab</td>
<td>1.0 ± 0.41abc</td>
</tr>
<tr>
<td>3</td>
<td>1.3 ± 0.63ab</td>
<td>1.0 ± 0.41abc</td>
</tr>
<tr>
<td>5</td>
<td>15.3 ± 4.89bc</td>
<td>3.0 ± 0.91bc</td>
</tr>
<tr>
<td>9</td>
<td>82.3 ± 46.64c</td>
<td>5.5 ± 2.10c</td>
</tr>
</tbody>
</table>

*Means within a column followed by different letters are significantly different at *p* = 0.05 [Duncan’s multiple range test on data transformed by \( \ln(Y + 0.1) \)].

Discussion

Our results support the hypothesis that E-myrcenol is a pheromone for *Ips pini*; it is produced by *Ips pini* and influences their behaviour toward hosts and sources of ipsdienol. The decreased trap catches due to the presence of E-myrcenol in ipsdienol-baited traps (Fig. 2) suggest that E-myrcenol is an anti-aggregation pheromone. It may facilitate spacing of galleries on host material and switching to new hosts when a current host is saturated.

However, when we attempted to protect lodgepole pine logs from *Ips pini*, we found that lures containing E-myrcenol and ethanol induced attack. Ethanol alone is not attractive to *Ips pini* (unpublished results). However it is possible that ethanol interacted with host odours to induce an attraction that was not countered by the presence of E-myrcenol. Alternatively, E-myrcenol might have interacted with either host odours, or both ethanol and host odours, in attracting *Ips pini*. It is possible that E-myrcenol could function as a multifunctional pheromone, attracting beetles to a log undergoing attack but acting as an epideictic pheromone (Prokopy 1981) when beetles are in close proximity to established galleries.

E-Myrcenol may also act as a kairomone, as it is produced by other species, such as *Dendroctonus ponderosae* (Conn 1981; Hunt et al. 1986; Pierce et al. 1987). In some instances, brood of *Ips pini* can outcompete brood of *D. ponderosae* (Rankin 1988), and *Ips pini* could benefit by attacking hosts soon after attack by *D. ponderosae*. E-Myrcenol may help to locate such hosts. Multifunctionalities of semiochemicals are known for other scolytid species. For example, at most release rates frontalin inhibits the response of *D. ponderosae* to semiochemical-baited traps (Borden et al. 1987) but induces attacks on standing trees (Chatelain and Schenk 1984; Borden et al. 1987; unpublished data). More detailed work is obviously required to understand fully the functional value of semiochemicals such as E-myrcenol.

The importance of understanding basic pheromone biology cannot be overemphasized. Our experience with E-myrcenol shows that repellency with a pheromone-baited trap should not be used as a sole criterion to select anti-aggregation pheromones for operational...
protection of logs or trees. Premature utilisation of such semiochemicals may cause high losses and impede development of a valuable technology.

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References


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