Attraction of female Japanese horntail *Urocerus japonicus* (Hymenoptera: Siricidae) to α-pinene

**Shigeho SATO**1,* and **Kaoru MAETO**2

1 Shikoku Research Center, Forestry and Forest Products Research Institute; Kochi 780–8077, Japan
2 Faculty of Agriculture, Kobe University; Kobe 657–8501, Japan

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**Abstract**

The attraction of *Urocerus japonicus* to volatile chemicals, which discolors the wood of conifers, was examined in the field. Attracting effects of α-pinene and ethanol that were suggested to be effective as attractants were compared to *U. japonicus* with Hodoron®, which has been used as an attractant for woodwasps. Adults of *U. japonicus* were captured in chemically treated adhesive traps, which were set up in a hinoki Cypress *Chamaecyparis obtusa* plantation. More female adults of *U. japonicus* were captured in traps with α-pinene or Hodoron® than in those without chemicals. There was no significant difference between the number of captured females in traps with α-pinene and those with Hodoron®. There were also no significant differences in the number of captured males among treatments. Traps with ethanol did not attract either sex of *U. japonicus*. It was indicated that both α-pinene and Hodoron® have attracting effects on female *U. japonicus*.

**Key words:** Attractant; ethanol; kairomone; *Urocerus japonicus*; α-pinene

**INTRODUCTION**

The Japanese horntail *Urocerus japonicus* causes wood discoloration damage in conifers like hinoki cypress *Chamaecyparis obtusa* and Japanese cedar *Cryptomeria japonica* (Okuda, 1989; Sano, 1992; Miyata, 1999) by infecting the wood with the symbiotic fungus *Amylostereum laevigatum* when it lays its eggs (Tabata and Abe, 1997).

‘Hodoron®’ had been registered as an attractant for woodwasps including *U. japonicus* (Kanasugi et al., 1995). Adhesive traps with Hodoron® were used for monitoring *U. japonicus* (Yamazaki et al., 1994; Sato et al., 2000). Hodoron®, which is a mixture of eugenol, benzoic acid and essential oil of coniferous wood, was originally developed for attracting the Japanese pine sawyer *Monochamus alternatus* (Morimoto and Iwasaki, 1976). However, the production of Hodoron® has recently been stopped because of a decrease in commercial demand. Thus, it has become necessary to look for an alternative attractant for monitoring *U. japonicus*.

Sano (1989, 1991) found that α-pinene, ethanol and Hodoron® may be useful for attracting woodwasps. Togashi (1988) mentioned some examples of woodwasps that had been captured in traps with benzyl acetate. However, the effectiveness of the chemicals as attractants could not be evaluated with the experiments by Sano (1989, 1991) because the numbers of traps in his experiments were inadequate. Also, the study by Togashi (1988) did not evaluate the attracting effect on woodwasps in exact field trials.

α-Pinene and ethanol may attract woodwasps because they are both volatile components of coniferous wood on which female woodwasps lay eggs. On the other hand, benzyl acetate is considered not very attractive to woodwasps because it has the odor of flowers. Thus, we examined the use of α-pinene and/or ethanol for attracting *U. japonicus* in comparison with Hodoron® in the field.

**MATERIALS AND METHODS**

We examined the effects of Hodoron®, α-pinene and ethanol on attracting adult *U. japonicus*. Traps
with Hodoron®, α-pinene, ethanol and α-pinene–ethanol, and those without chemicals were compared for the number of captured female and male adults. A ‘Hodoron® evaporating pipe’ (manufactured by Hodogaya Chemical Co., Ltd.), which is a plastic pipe used with an attractant inside and attached adhesive sheets outside, was used as the trap (Fig. 1). Five adhesive sheets of ‘Kamikirihoihoi’ (manufactured by Earth Chemical Co., Ltd.) were attached to each trap. The area of adhesive sheets for each trap was 1,261 cm². The structure of the traps was described by Yamazaki and Mineo (1991) and by Kanasugi et al. (1995).

A Hodoron® trap was set with a 500 ml bottle of Hodoron® (manufactured by Izutsuya Chemical Co., Ltd.). The bottles of Hodoron® in the traps were not replaced during the experiment, because the attracting effect of a 500 ml bottle of Hodoron® continues for 4 mo (Kanasugi et al., 1995). An α-pinene trap was set with absorbent cotton soaked with 12 ml of (−)-α-pinene (purity, 98%) in a polypropylene bottle without its cap. An ethanol trap was set with absorbent cotton soaked with 25 ml of 99.5% ethanol in a polypropylene bottle with six holes of 1 mm² for volatilizing. A combination α-pinene–ethanol trap was set with a polypropylene bottle of (−)-α-pinene and a bottle of ethanol which were the same as those used in the α-pinene traps and ethanol traps, respectively.

We had confirmed that α-pinene and ethanol remained in the cotton for at least 2 wk in a preliminary experiment. In the α-pinene traps, ethanol traps and α-pinene–ethanol traps, the chemically treated cotton was replaced every 2 wk. A control trap was set without chemicals.

The research site was set in a 30-y-old stand of hinoki cypress in Nankoku City, Kochi Prefecture. The altitude of the stand was 470–500 m above sea level (a.s.l.), and the average height of the trees was about 20 m. The area of the stand was 15 ha. About 3,000 trees per hectare had been planted in the stand. From April to June 2000, about 20% of the trees were thinned. Many adults of U. japonicus were expected to emerge in the stand in the summer of 2001, because thinned trees that were usable for U. japonicus had been left.

Thirty points of six lines and five files were set for traps in the stand. Each point was at least 10 m from adjacent points. Each line lay almost along the contour line. Traps were treated in five different ways; that is, Hodoron® traps, α-pinene traps, ethanol traps, α-pinene–ethanol traps and control traps, were set on the five points of each line (Fig. 2). A total of six traps treated in each way were set in the stand.

The adhesive sheets were replaced every 2 wk and the adults of U. japonicus trapped on the with-
drawn adhesive sheets were counted. The experiments were repeated three times. The points of the traps treated in different ways were alternated for each trial. Traps were set on 17 July and withdrawn on 2 August 2001 in the early period of the emergence season, set on 2 August and withdrawn on 16 August 2001 in the middle period, and set on 16 August and withdrawn on 31 August 2001 in the late period. The experiments were conducted at the peak of emergence of *U. japonicus* adults, that is July to August in Kochi Prefecture (Miyata, 1997).

The numbers of *U. japonicus* captured in traps treated in five different ways were compared using a two-factor ANOVA to evaluate attractant chemicals and three periods of emergence for both sexes after adding 0.5 and making logarithmic transformations in order to improve the normality of the distribution.

Furthermore, the data were subjected to multiple comparisons of Scheffé for each of the three periods of emergence. The data were analyzed using Statistica (StatSoft Inc.) and StatView (SAS Institute Inc.).

**RESULTS**

The numbers of male adults of *U. japonicus* captured per trap in the early period of emergence season were 1.33±1.51 (average±SD) in the Hodoron®-trap, 5.67±7.12 in the α-pinene trap, 0.67±0.82 in the ethanol trap, 2.83±3.71 in the α-pinene–ethanol trap and 1.83±3.13 in the control trap (Fig. 3). The numbers in the middle period were 0.17±0.41 in the Hodoron®-trap, 0.50±0.55 in the α-pinene trap, 0.83±2.04 in the ethanol trap, 0.33±0.52 in the α-pinene–ethanol trap and 0.33±0.52 in the control trap (Fig. 3). The numbers in the late period were 2.00±3.95 in the Hodoron®-trap, 0.83±0.75 in the α-pinene trap, 0.83±1.33 in the ethanol trap, 0.83±1.17 in the α-pinene–ethanol trap and 0.00±0.00 in the control trap (Fig. 3). Overall, the average number of males captured per trap was 2.47±4.07 in the early period, 0.43±0.97 in the middle period and 0.90±1.94 in the late period. According to the results of ANOVA, the number of captured males differed significantly among the three periods of the emergence season, though not among the attractant chemicals (Table 1).

The numbers of female adults of *U. japonicus* captured per trap in the early period of the emergence season were 6.00±3.95 in the Hodoron®-trap, 7.83±4.36 in the α-pinene trap, 0.17±0.41 in the ethanol trap, 6.33±2.94 in the α-pinene–ethanol trap and 0.67±1.21 in the control trap (Fig. 4). The numbers in the middle period were 4.17±1.83 in the Hodoron®-trap, 2.67±0.52 in the α-pinene trap, 0.17±0.41 in the ethanol trap,
2.17±1.17 in the α-pinene–ethanol trap and 0.17±0.41 in the control trap (Fig. 4). The numbers in the late period were 4.33±2.66 in the Hodoron®-trap, 1.17±0.75 in the α-pinene trap, 0.17±0.41 in the ethanol trap, 1.83±0.98 in the α-pinene–ethanol trap and 0.17±0.41 in the control trap (Fig. 4). Overall, the average number of females captured per trap was 4.20±4.25 in the early period, 1.87±1.83 in the middle period and 1.53±2.00 in the late period. According to the results of ANOVA, the number of captured females significantly differed both among attractant chemicals and among the three periods of the emergence season, though there were no significant interactions between attractant chemicals and periods of emergence (Table 2). There were significant differences between the number of captured females in the Hodoron® trap and those in the ethanol trap ($p<0.001$), between those in the Hodoron® trap and those in the control trap ($p<0.001$), between those in the α-pinene–ethanol trap and those in the ethanol trap ($p<0.05$) and between those in the α-pinene-ethanol trap and those in the control trap ($p<0.05$) with multiple comparisons of Scheffé in

### Table 1. ANOVA of the captured males of *Urocerus japonicus*

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>S.S.</th>
<th>d.f.</th>
<th>M.S.</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals</td>
<td>3.81</td>
<td>4</td>
<td>0.95</td>
<td>1.19</td>
<td>0.321</td>
</tr>
<tr>
<td>Periods of emergence</td>
<td>8.93</td>
<td>2</td>
<td>4.46</td>
<td>5.58</td>
<td>0.005</td>
</tr>
<tr>
<td>Chemicals×Periods of emergence</td>
<td>3.60</td>
<td>8</td>
<td>0.45</td>
<td>0.56</td>
<td>0.805</td>
</tr>
<tr>
<td>Residual</td>
<td>59.95</td>
<td>75</td>
<td>0.80</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Fig. 4](image.png)

**Fig. 4.** Mean numbers of captured females of *Urocerus japonicus* in traps with different chemicals. Error bars are standard deviations.

### Table 2. ANOVA of the captured females of *Urocerus japonicus*

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>S.S.</th>
<th>d.f.</th>
<th>M.S.</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals</td>
<td>66.00</td>
<td>4</td>
<td>16.50</td>
<td>48.36</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Periods of emergence</td>
<td>7.22</td>
<td>2</td>
<td>3.61</td>
<td>10.58</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Chemicals×Periods of emergence</td>
<td>5.19</td>
<td>8</td>
<td>0.65</td>
<td>1.90</td>
<td>0.072</td>
</tr>
<tr>
<td>Residual</td>
<td>25.59</td>
<td>75</td>
<td>0.34</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
DISCUSSION

Female adults of *U. japonicus* were noticeably attracted to α-pinene and Hodoron®. Sano (1989) suggested that α-pinene and Hodoron® might be useful for attracting woodwasps, though the effectiveness of the chemicals as attractants could not be evaluated with his experiments. Our results support the concept that α-pinene and Hodoron® are effective for attracting female *U. japonicus*. Sano (1991) also mentioned that shapes of traps might affect the capturing efficiency for woodwasps according to the results of his experiments using bucket-traps and ‘L-shaped’ adhesive-traps. The adhesive traps that we used were effective for collecting woodwasps, while Sano (1991) had collected many woodwasps with L-shaped adhesive traps.

Little is known about the process by which *U. japonicus* is attracted to chemicals, but female adults of the *Sirex* woodwasp are known to be attracted to stressed pine trees in response to monoterpenes such as α-pinene and β-pinene (Madden, 1988). Female adults of *U. japonicus* disperse far from the site of their emergence, while male adults of *U. japonicus* stay near by (Sato et al., 2000), probably waiting for females that have emerged from the same log. Thus, it is understandable that female adults of *U. japonicus* are attracted to α-pinene for oviposition but males are not.

It is known that more pinene is released from stressed Japanese red pine *Pinus densiflora* than from healthy pine trees (Ikeda and Oda, 1980). A longicorn beetle *M. alternatus*, which oviposits on stressed pines, is also attracted to pinene and ethanol (Ikeda et al., 1980, 1986). It is thought that female adults of *U. japonicus* are attracted to α-pinene as a kairomone released from stressed trees, which would be suitable for reproduction.

α-Pinene is contained in hinoki cypress, though not in Japanese cedar (Yatagai, 1998), but *U. japonicus* attacks both species (Sano, 1992; Miyata, 1999). Monoterpenes other than α-pinene, contained in Japanese cedar, might also attract the female adults of *U. japonicus*.

Neither sex of *U. japonicus* was attracted to ethanol, although the α-pinene–ethanol traps attracted females, as well as did the α-pinene traps. Sano (1991) suggested that ethanol might attract woodwasps as effectively as α-pinene and Hodoron®. However, the number of traps in his experiment was too small to evaluate the attracting efficiency of chemicals. Ueda et al. (2000) indicated that ethanol attracted some kinds of beetles including Scolytidae, Rhizophagidae, Colydiidae and Anthribidae. Also, ethanol is known to have

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**Table 3. Probability by Scheffé's multiple comparison among chemicals for female adults of *Urocerus japonicus***

<table>
<thead>
<tr>
<th>Period</th>
<th>Hodoron® *</th>
<th>α-Pinene</th>
<th>Ethanol</th>
<th>α-Pinene–ethanol</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early period of emergence season</td>
<td>0.988</td>
<td>0.000</td>
<td>1.000</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.000</td>
<td>0.991</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle period of emergence season</td>
<td>0.836</td>
<td>0.000</td>
<td>0.266</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.000</td>
<td>0.850</td>
<td>0.002</td>
<td>1.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Late period of emergence season</td>
<td>0.205</td>
<td>0.001</td>
<td>0.705</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.214</td>
<td>0.889</td>
<td>0.031</td>
<td>1.000</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>0.031</td>
<td></td>
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</tr>
</tbody>
</table>
synergistic effects with pinenes to attract beetles like *M. alternatus* and *Trogossita japonica* (Ikeda et al., 1986; Ueda et al., 2000). According to our results, ethanol is not considered to have either an attracting effect or a repelling effect on *U. japonicus*.

The number of female *U. japonicus* captured using \( \alpha \)-pinene and Hodoron\(^*\) was smaller in the late period of the emergence season than in the early and middle periods. This is explained in part by low adult female density in the late season due to a short mean longevity of female wasps of *d* (Okuda, 1987) and a small proportion of adults emerging in the late period (Miyata, 1999). However, the difference in attraction efficiency by the chemicals among the three periods of emergence remains to be studied.

\( \alpha \)-Pinene and Hodoron\(^*\) seem to attract only female adults of *U. japonicus*. It is important to know the emerging density of female adults of *U. japonicus* in monitoring, because females cause wood discoloration in trees through oviposition (Okuda, 1989; Fukuda, 1997). As a substitute for Hodoron\(^*\), \( \alpha \)-pinene is usable for monitoring the emergence of *U. japonicus*. It is not necessary to replace the bottles of Hodoron\(^*\) in traps because the attracting effect of a 500 ml bottle of Hodoron\(^*\) continues for 4 mo (Kanasugi et al., 1995). On the other hand, \( \alpha \)-pinene in traps should be renewed every 2 wk during the emergence of *U. japonicus*, which requires more labor to control the damage. Development of new traps that do not need the replacement of the attractant for *U. japonicus* is needed.

**ACKNOWLEDGEMENTS**

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