# SEX PHEROMONE OF *CONOPHTHORUS PONDEROSAE* (COLEOPTERA: SCOLYTIDAE) IN A COASTAL STAND OF WESTERN WHITE PINE (PINACEAE)

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An isolated stand of western white pine, *Pinus monticola* Dougl. ex D. Don, on Texada Island (49°40′N, 124°10′W), British Columbia, is extremely valuable as a seed-production area for progeny resistant to white pine blister rust, *Cronartium ribicola* J.C. Fisch. (Cronartiaceae). During the past 5 years, cone beetles, *Conophthorus ponderosae* Hopkins (= *C. monticolae*), have severely limited crops of western white pine seed from the stand. Standard management options for cone beetles in seed orchards are not possible on Texada Island. A control program in wild stands such as the one on Texada Island requires alternate tactics such as a semiochemical-based trapping program. Females of the related species, *Conophthorus coniperda* (Schwarz) and *Conophthorus resinosae* Hopkins, produce (+)-pityol, (2*R*,5*S*)-2-(1-hydroxyl-1-methylethyl)-5-methyl-tetrahydrofuran, a sex pheromone that attracts males of both species (Birgersson *et al.* 1995; Pierce *et al.* 1995). The host compound α-pinene significantly increases attraction of male *C. coniperda* to pityol-baited traps in stands of eastern white pine, *Pinus strobus* L. (de Groot *et al.* 1998).

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**TABLE 1. Catches of *Conophthorus ponderosae* in baited Japanese beetle traps on Texada Island, British Columbia, during the period 28 March to 28 July 1997.**

| | No. of beetles | | Sex ratio | |
|---|---|---|---|---|
| Treatment | *n* | Mean ± SE | *n* | % male ± SE |
| Control | 8 | 0.1±0.1*a* | – | – |
| Pityol | 8 | 6.4±2.4*b* | 7 | 100±0.1*a* |
| Pityol + α-pinene | 7 | 39.1±15.7*c* | 7 | 96±1.9*a* |

NOTE: Means followed by the same letter within a column are not significantly different (LSD multiple comparison test, P > 0.05).

Our objectives were to identify the sex pheromone of *C. ponderosae* and to develop an effective lure to attract male cone beetles. Western white pine cones infested with *C. ponderosae* were collected from the Texada Island seed-production area (12 ha) in February and March 1997. Eleven second-year western white pine cones with attached small branches (about 4 cm in length) from the Saanich Seed Orchards (48°35′N, 123°23′W) (Saanichton, British Columbia) were placed with 99 female *C. ponderosae* in a glass Petri plate (15 × 145 mm) within a 5-L glass aeration chamber. Similarly, 89 male cone beetles were placed with 15 small twigs (about 5 cm in length) on a Petri plate in a separate glass chamber. Volatiles were collected in glass analytical traps (6 mm o.d.) packed with a 30-mm length of Porapak Q. Humidified, charcoal-filtered air was drawn through the chambers and Poropak Q traps at a rate of 1 L/min for 3 days. Volatiles were recovered by eluting each trap with 1 mL of double-distilled pentane.

Unless otherwise stated, instrumental methods were the same as in Pierce *et al.* (1995). Enatiomeric compositions were determined by gas chromatography (GC) with a Cyclodex B column (30 m × 0.25 mm i.d.) (J&W Scientific, Folsom, California) subsequent to isolation by micropreparative GC. Female *C. ponderosae* produced (+)-pityol (100% optical purity), whereas male cone beetles produced (–)-conophthorin, (5*S*,7*S*)-methyl-1,6-dioxaspiro[4.5]decane (96% optical purity). These optical purities are consistent with those for *C. coniperda* (Birgersson *et al.* 1995) and *C. resinosae* (Pierce *et al.* 1995). Conophthorin interrupts the attraction of male *C. coniperda* and male *C. resinosae* to pityol (Birgersson *et al.* 1995; Pierce *et al.* 1995).

Japanese beetle traps baited with (±)-pityol and placed in the crown of seed trees, adjacent to cones, are effective in trapping cone beetles (de Groot and DeBarr 1999). On 28–31 March 1997, 24 yellow Japanese beetle traps (Trécé, Salinas, California) were baited and placed within the upper third of crowns of 24 western white pines in the Texada Island seed-production area. The mean ± SE height and diameter (at breast height) of trees were 21.5 ± 0.3 m and 31.3 ± 1.1 cm, respectively.

The traps were grouped into eight replicates with three treatments per replicate: (1) blank control; (2) (±)-pityol; and (3) the combination of (±)-pityol and α-pinene. Lures consisted of (±)-pityol (40 mg) in a polyethylene bubblecap and (–)-α-pinene (15 mL) in a closed polyethylene bottle (Phero Tech Inc., Delta, British Columbia), both with chemical purities >98%. The release rates of pityol and α-pinene from lures were about 0.2 and 150 mg/d, respectively, at 24°C. Beetles were collected in 500-mL plastic Mason jars, filled with about 200 mL of plumber's antifreeze (pink propylene glycol solution) as a killing and preservation agent.

Trap catches were collected at 3- to 4-week intervals, with the glycol solution replaced on each occasion. Traps were taken down on 27–28 July 1997. Voucher

specimens were deposited at the Entomology Museum, Pacific Forestry Centre, Victoria, British Columbia. Sexes of captured beetles ($n \leq 30$ per trap) were determined by dissection and examination of internal genitalia. Trap catch data were transformed by $\ln(x + 1)$ to remove heteroscedasticity and analysed using ANOVA followed by the least significant difference (LSD) multiple comparison test (SYSTAT 7.1; SPSS Inc., Chicago, Illinois).

Traps baited with the combination of (±)-pityol and α-pinene captured approximately five times more beetles than those baited only with (±)-pityol (Table 1). Blank control traps caught less beetles than those baited with (±)-pityol ($F_{1,56} = 12.20$, $P = 0.001$). Males were predominant in all trap catches ($F_{2,12} = 360.79$, $P < 0.001$). These results indicate that the semiochemical ecology of *C. ponderosae* is similar to that of *C. coniperda* with respect to the effect of α-pinene in the attraction of male beetles (de Groot *et al.* 1998). The combination of (±)-pityol and α-pinene is a promising trap lure for a mass-trapping attempt, integrated with a cone-bagging program and removal of infested cones to ensure control efficacy.

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