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Improvement of Pheromone Trapping in Low Density Populations of *Choristoneura pinus pinus* (Lepidoptera: Tortricidae)

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Abstract

Pheromone baited bucket traps (e.g., Multipher) are popular as a monitoring tool for the jack pine budworm, *Choristoneura pinus pinus* Freeman (Lepidoptera: Tortricidae), in Canada. However, there is no evidence to support their use when budworm populations are low. We therefore evaluated the capture rate of bucket traps at two placement heights (2 vs 6 m) in two jack pine forests in 2011, having low (≤5 fifth instars per m foliated branch length) budworm populations. Compared to wing traps (e.g., Pherocon 1C), the trap design used initially to evaluate efficacy of the *C. pinus* pheromone, bucket traps caught fewer *C. pinus* and capture rates of both trap designs did not differ significantly between the two heights tested. Loss of bucket traps at 2 m, due to black bears, suggested that higher placement of traps was warranted to maintain the integrity of the array. However, wing traps are recommended due to their ability to consistently catch more moths when *C. pinus* populations are low.

The jack pine budworm, *Choristoneura pinus pinus* Freeman (Lepidoptera: Tortricidae) (hereafter *C. pinus*), is the most damaging insect pest of jack pine, *Pinus banksiana* Lamb, in the north eastern USA and eastern Canada (Kulman et al. 1963, Clancy et al. 1980, Gross 1992). During a *C. pinus* outbreak in Ontario, 5.1 million m³ of jack pine wood volume was lost due to mortality of trees from severe, repeated *C. pinus* defoliation. During this same timeframe growth loss of surviving trees was estimated at 2.1 million m³ (Gross and Meating 1994). Outbreaks of *C. pinus* can develop suddenly and cause heavy defoliation for 1-3 yrs, with large outbreaks occurring every 20 yrs (Clancy et al. 1980, Scarr et al. 2012). Therefore, reliable prediction of the onset (early detection) of damaging *C. pinus* populations is necessary so that foliage protection treatments (e.g., aerial sprays) are timely and appropriate. In Canada, traps baited with synthetic *C. pinus* pheromone (see Silk et al. 1985) are deployed for this purpose (For. Pest Tech. Comm. 2010).

White wing traps (e.g., Pherocon 1C) were used in initial research evaluating efficacy of the synthetic pheromone (Butterworth et al. 1989, Silk and Kettela 2004). However, bucket traps (e.g., Multipher) soon became popular for monitoring *C. pinus* populations in part because they are non-saturating and reusable (Sanders 1986a, 1986b) and they are also used in eastern Canada to monitor populations of spruce budworm, *C. fumiferana* Clemens (Ramaswamy et al. 1982, Sanders 1986b, 1988). However, no empirical data exists for the efficacy of either trap design when *C. pinus* density is low. If wing traps catch more moths and variation in trap captures are more consistent than bucket
traps for monitoring low \textit{C. pinus} populations, then their use would be preferred. Indeed, wing traps are recommended for monitoring low density populations of other important pests of conifers (Angerilli and McLean 1984, Grimble 1988, Daterman et al. 2004).

There are no published accounts addressing the optimum height at which traps used for \textit{C. pinus} monitoring should be deployed in host stands. Placing traps higher off the ground may minimize disturbance by large animals, but may expose traps to high winds, heavy rainfall, or both. However, traps placed immediately adjacent to host foliage may catch more moths than traps placed distal to host foliage (Hanula et al. 1984, David and Horsburg 1989, Knight and Light 2005). Jack pine typically grows in dense stands with very few understory trees as this species is shade intolerant (Harlow et al. 1979). Therefore, as jack pine stands age, lower crown foliage is found increasingly higher in the canopy. For example, in mature stands of jack pine, lower crown foliage could be as high as 16 m above ground. Therefore, traps placed 2 m high would be a considerable distance (e.g., 14 m) from the typical habitat (foliage) of \textit{C. pinus}.

We carried out two experiments in two locations in Ontario, Canada that had low populations of \textit{C. pinus} to compare capture rates in bucket and wing traps and to determine if placement height of traps influenced capture rates. In addition, we also evaluated the loss of traps for each of the two trap types and placement heights.

Two locations, Britt (45°46.510’ N, 80°33.391’ W) and Algonquin (45°57.638’ N, 78°3.890’ W), were trapped in 2011. Trees at each location were similar in height and dbh, but markedly different in basal area, age and stand index (basal area = 6.2 vs. 20.4 m²/ha; age: 72 vs. 40 yrs; and stand index = 9.5 [low productivity] vs. 17 [high productivity]) (Carmean et al. 2001). Ten plots were established at each location to place pheromone traps, resulting in a total of 20 plots. Plots were at least 1 km apart and were confirmed to have low budworm populations, with ≤5.0 fifth or larger instar larvae per 1 m long branch tip. Traps were installed ~2 wk prior to predicted peak moth flight.

Two wing (Pherocon 1C; Trécé Inc., Adair, OK) and two bucket (Multipher; Les Services BioContrôle, St.Foy, QC, Canada) traps were installed along a 75 m long transect at each plot, with inter-trap spacing of 25 m. Two traps (one wing and one bucket) were hung 6 m high within the lower portion of the live crown of jack pine; and a second pair was hung 2 m high along the transect. Proximity of jack pine foliage varied between the two locations for traps at the 2 m height. At Britt, traps placed at 2 m were immediately adjacent to foliage of jack pine. At Algonquin, traps placed at the 2 m height were ≥4 m away from host foliage. The trap design-placement height combinations used were randomized for each of the four positions of the transect at the beginning of the experiment. The 2 m height is also the height that traps are placed each year for operational monitoring of \textit{C. pinus} in several Canadian provinces (For. Pest Tech. Comm. 2010).

Each trap was baited with a \textit{C. pinus} lure, consisting of 1.0 mg of \textit{C. pinus} pheromone loaded in a grey rubber septum (ISCA Technologies Inc., Riverside, CA). Septa were attached to the underside of the lid of bucket traps using a safety pin or were placed in the adhesive at the center of the lower half of wing traps (sticky surface area ~323 cm²). A recent field study established that trap catches of \textit{C. pinus} using ISCA lures did not differ from that of custom-made lures from our laboratory (Fidgen and Silk, unpubl. data). A strip of Hercon VapourTape II® (10% dichlorvos; Hercon Environmental, Emigsville, PA) was placed in the bottom of bucket traps to ensure rapid death of trapped insects. A large stainless steel hook (Mid-West Wire Products, Sturgeon Bay, WI), 50 cm long × 16 cm wide and 160 g in weight, was attached to the top of each trap placed 6 m high. Hooks facilitated attachment of traps to branches in the live crown of host trees because they provided sufficient weight to keep most traps in place throughout the experiment. Traps were serviced mid-way through the
experiment (3 wk): This involved replacing the sticky bottom of the wing traps and transferring the lure to the new bottom. Bucket traps were serviced by emptying the contents into 40 dram plastic pill bottles. At 6 wk all traps were recovered and the experiment was terminated. Also, if possible the cause (e.g., bear, wind or rain, human, etc.) of all traps found dislodged at the 3 or 6 wk periods was recorded.

Analysis of variance (ANOVA) (R Development Core Team 2010) was used to determine if a significant proportion of the variation in capture rate (number of moths per day) was attributable to the deployment height × trap design interaction. There were apparent differences in stand architecture and of C. pinus population levels between locations (populations at Britt were about 9× higher than Algonquin), so we ran separate models for each location. If significant differences were detected in the ANOVAs, Tukey’s HSD tests were used to separate means at $P \leq 0.05$ or less. Variance ratio tests were used to determine if catch rate of wing traps was less variable than catch rate of bucket traps, separately for the Britt and Algonquin locations ($F$-tests, Zar 1984). Chi-square tests were used to determine if loss of traps was independent of placement height and design of trap (Zar 1984). Results appear as raw means ± standard error.

**Results.** Eight traps, or 10% of the total number of traps, were dislodged during the experiments at the Britt location whereas all traps were in-place at the Algonquin location. Of these 8 traps, seven bucket traps (5 at 2 m and 2 at 6 m) and one wing trap (6 m height) were dislodged. Loss of bucket traps at 2 m was due to black bears, whereas the three traps at 6 m were lost due to high winds. Loss rate of bucket traps was significantly higher than loss rate of wing traps ($\chi^2 = 5.00, P = 0.03$). However, loss rate of traps was not significantly influenced by trap placement height ($\chi^2 = 0.56, P = 0.47$).

At Algonquin, 0.04 ± 0.02 and 0.34 ± 0.07 male C. pinus moths were caught per day in the bucket and wing traps during the 6 wk period. A significant proportion of the variation in moth catch was explained by trap design (Table 1A), with wing traps outperforming bucket traps (Fig. 1A). The variance ratio tests indicated that moth capture rate in wing traps was considerably more variable than bucket traps ($F = 46.53; df = 20, 16; P < 0.0001$).

At Britt, 2.25 ± 0.45 and 4.37 ± 0.16 male C. pinus moths were caught per day in bucket and wing traps during the 6 wk trapping period. If servicing of wing traps had not been performed at 3 wks, trap saturation would have occurred prior to the end of the experiment at Britt. This would have lead to an underestimate of the potential of wing traps to attract and hold moths, though not necessarily a catastrophe for prediction of subsequent population intensity. For example, Daterman et al. (2004) showed that trap saturation was a good predictor of visible defoliation of the Douglas-fir tussock moth, Orgyia pseudotsugata McDunnough, the following season. A significant proportion of the variation in catch rate of male C. pinus was due to trap design (Table 1B), with wing traps outperforming bucket traps (Fig. 1B). The variance ratio test indicated that moth capture rate in bucket traps was considerably more variable than wing traps ($F = 5.99; df = 14, 18; P = 0.0005$).

The use of wing traps for detection and monitoring of low (prior to onset of visible damage) C. pinus populations is supported by this study; provided that a secure form of attachment, such as a tether line, is used to anchor traps in the live crown of the co-dominant and dominant trees to aid absorption of weather shocks. These findings support previous studies regarding use of non-reusable sticky traps to monitor endemic pest populations (e.g., Angerilli and McLean 1984, Grimble 1988, Daterman et al. 2004). We were surprised that higher placement of traps did not significantly increase moth capture rates due to their proximity to host foliage. Perhaps the pheromone is so attractive that proximity to foliage is not necessary for C. pinus trapping or the difference in trap placement height (4 m) was not sufficient to detect statistical significance.
Table 1. Influence of placement height and design of trap on capture of male *C. pinus* moths at the Algonquin and Britt locations.

<table>
<thead>
<tr>
<th>Variable</th>
<th>DF</th>
<th>Algonquin Sum Squares</th>
<th>Mean Squares</th>
<th>F-value</th>
<th>P &gt; F</th>
<th>Britt Sum Squares</th>
<th>Mean Squares</th>
<th>F-value</th>
<th>P &gt; F</th>
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<td>Trap Height</td>
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<td>0.09</td>
<td>1.81</td>
<td>0.19</td>
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<td>Trap Design</td>
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<td>0.90</td>
<td>18.41</td>
<td>0.0002</td>
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<td></td>
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<td></td>
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<tr>
<td>Trap Height × Design</td>
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<td>0.07</td>
<td>0.07</td>
<td>1.46</td>
<td>0.24</td>
<td></td>
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<tr>
<td>Residuals</td>
<td>32</td>
<td>1.56</td>
<td>0.05</td>
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</tbody>
</table>

Figure 1. Influence of trap type and placement height of traps on mean number ± SE of *C. pinus* males caught per day at (a) Algonquin and (b) Britt. Columns of same shading with different letters differed significantly (*P* ≤ 0.05, Tukey’s HSD).
Perhaps this situation would be different in mature jack pine stands in northern Ontario where the bottom of the live crown begins 16 m above ground, or about 10 m more vertical spacing than the present study. Clearly more work is needed to refine the trapping procedure for *C. pinus*.

Higher variability in capture rate in bucket traps at Britt suggests a less effective trap design compared to wing traps (Dent 2000, Jactel et al. 2006). However, we were surprised that bucket traps were less variable than wing traps at Algonquin. Upon closer examination of the data, 5 of 16 (31%) bucket traps caught zero moths with remaining buckets catching very small numbers of moths (0.05 moths/day), resulting in low variance. Although wing traps caught significantly more (6-8×) moths per day than bucket traps on average, there was a 12× difference in capture rate in wing traps among plots. The high variance in captures in wing traps among plots, therefore, explained the reversal in the variance ratio test results between Britt and Algonquin. Because our experiments were conducted in remnant populations of *C. pinus* that had collapsed, future research should focus on improvement of a trapping protocol that provides suitable accuracy at predicting building *C. pinus* populations prior to the onset of moderate or higher intensity defoliation.

Acknowledgments

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Literature Cited


