

Effect of Trap Orientation and Interval Distance on Captures of *Isoceras sibirica* Alpheraky (Lepidoptera: Cossidae)

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Received: December 9, 2014 Accepted: January 27, 2015 Online Published: March 15, 2015

doi:10.5539/jas.v7n4p161

URL: <http://dx.doi.org/10.5539/jas.v7n4p161>

Abstract

Studies were conducted in an asparagus field in taigu (37°18'N, 112°29'E, 824 m above sea level), Shanxi province, China, May to June, 2009 to 2011, to evaluate the influence of interval distance and orientation on catches of the carpenterworm, *Isoceras sibirica* Alpheraky (Lepidoptera: Cossidae) in pheromone-baited traps. The results showed that catches of male *I. sibirica* moths in upwind were higher than in other traps for any intertrap distances. When intertrap distances were shorter than 30 m, interference between traps occurred. These results reveal the effective trap orientation and interval distance for *I. sibirica* and thus provide guidelines for improving the effectiveness of traps in monitoring and controlling *I. sibirica* in fields.

Keywords: carpenterworm, monitoring and controlling, sex pheromone, trap orientations, trap interval distances

1. Introduction

The carpenterworm, *Isoceras sibirica* Alpheraky (Lepidoptera: Cossidae), is one of the major pest of *Asparagus officinalis* Linn. in China, causing significant yield losses (Duan et al., 2008). To date, no effective measures for controlling *I. sibirica* are available; this is due to the root-boring habit of the larvae. The use of synthetic sex pheromones to interfere with reproduction offers an environmental friendly measure to control the pest. Sex pheromones are species-specific and highly selective. They are valuable tools for use in integrated pest management as they are non-toxic and do not represent a health risk to humans and animals. Indeed, the use of pheromones has been reported for a number of insect species, for such purposes as monitoring emergence patterns (Patricia et al., 2008), monitoring pest populations for management decisions (Kehat et al., 1992), assessing the levels of insecticide resistance in pest populations (Haynes et al., 1986, 1987), luring and trapping adult males to suppress pest populations (Zhang et al., 2002), and for mating disruption (Higbee et al., 2008; Il'ichev et al., 2006; Stelinski et al., 2007).

The effectiveness of pheromone-baited traps in capturing insects may be influenced by many factors, including distance of traps (Schlyter, 1992; Byers, 1999; Laboke et al., 2000), environment (Jansson et al., 1989; Laboke et al., 2000; Sappington & Spurgeon, 2000), trap type and trap height (Murad, 2001; Sarzynski, 2004). One of these factors is the density of traps, intertrap distances may affect the number of males captured because of interference between traps. When traps are placed close to each other, their radius of attraction may overlap. Furthermore, the interaction of traps is not constant with distance, but varies with lure concentration and wind conditions. By reducing the pheromone release, the active space of a trap decreases because the average concentration of pheromone downwind from the traps decreases (Bradshaw et al., 1989; Judd & Borden, 1989). In *I. sibirica*, active components present within the extract from the female sex pheromone gland are (Z)-9-tetradecenyl acetate (Z9-14:Ac), (Z)-7-tetradecenyl acetate (Z7-14:Ac), and (Z)-9-hexadecadecenyl acetate (Z9-16:Ac) (Zhang et al., 2011). However, factors relative with traps of *I. sibirica* in field remains unknown, so examination of trap orientation and interval distance will be required for successful implementation of pheromone-based trapping for this insect. Our goals were to determine the effects of trap location and interval distance on efficiency of capture of *I. sibirica* in pheromone-baited traps in Asparagus growing areas. Based on our results, we recommend steps for implementing an effective pheromone-baited trapping program against *I. sibirica* in field.

2. Materials and Methods

2.1 Experimental Setup

The study was conducted in an asparagus field in taigu (37°18'N, 112°29'E, 824 m above sea level), Shanxi province, China, May to June, 2009 to 2011, during the main peak periods of *I. sibirica* adult moth emergence and flight in this region. Traps were hung on wooden supports, 0.5 to 1 m in height, and set at 30 m intervals for the trap orientation and intertrap distance tests. Traps were deployed in arrays of nine traps in a 3 × 3 grid pattern with 10, 20, 30, 40, or 50 m between traps (Figure 1). Each treatment was replicated four times. The minimum distance between neighboring plots was 50 m. This experiment used 180 traps. The prevailing winds were from the south-east (local meteorological data for the past ten years). Trap catches were checked every morning and captured moths were recorded and removed daily.

2.2 Statistical Analysis

An assumption of normality was tested for all data sets with the Shapiro-Wilk test. If the null hypothesis that data were normally distributed was rejected, count data were transformed with a square-root transformation to stabilize variances (Snedecor & Cochran, 1967). If the transformed data were normally distributed (Shapiro-Wilk test), analysis of variance (ANOVA) was used and means with significant differences were separated using Tukey's studentized range test. Otherwise, the data were analyzed with a Kruskal-Wallis parametric ANOVA of mean ranks.

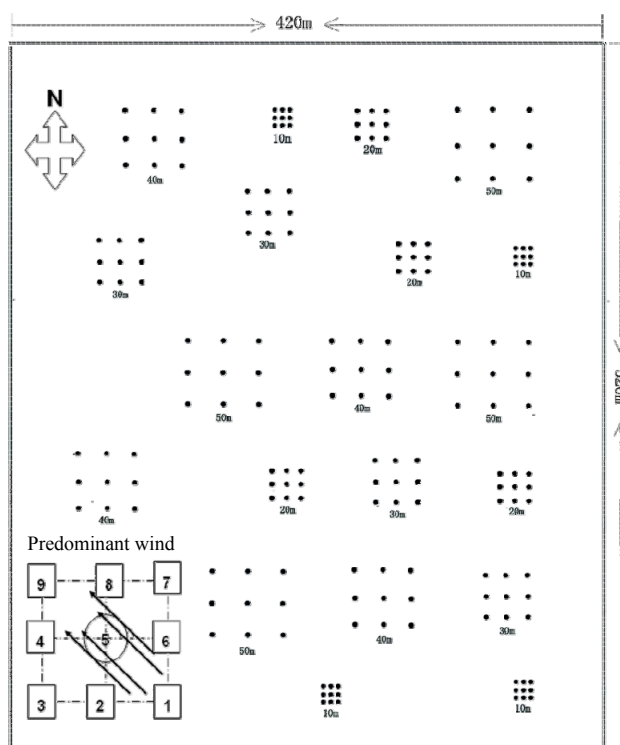


Figure 1. Schematic representation of locations of the *I. sibirica* pheromone-baited traps, showing arrays of 10, 20, 30, 40 and 50 m distance between traps, and the position relative to the cardinal directions and prevailing wind. Arabic numerals in panels expressed the serial numbers of trap position. •: *I. sibirica* Sex Pheromone-Baited Trap

The male capture per square metre as a function of grid distances was estimated using the non-linear regression function $y = axb$, where y is the density of male *I. sibirica* captured per square metre, x is the grid distance, and a and b are constants obtained as fitted parameters. The number of males captured per square meter for each inter-trap distance was estimated by the ratio of the total number of males captured in nine traps to the total area within the trap array for each inter-trap distance (Bacca et al., 2006). All analyses were done with SPSS for Windows Version 16.0 software.

3. Results

3.1 Effect of Trap Orientation

We recorded significantly higher male moth captures on pheromone-baited traps located the upwind edge of grids than the downwind edge, but differences were not significant for any intertrap distance (10 m: $H = 1.5$, $df = 8$, $P = 0.9 > 0.05$; 20 m: $H = 5.4$, $df = 8$, $P = 0.7 > 0.05$; 30 m: $H = 5.8$, $df = 8$, $P = 0.7 > 0.05$; 40 m: $H = 4.3$, $df = 8$, $P = 0.8 > 0.05$; 50 m: $H = 2.4$, $df = 8$, $P = 0.9 > 0.05$) (Figure 2).

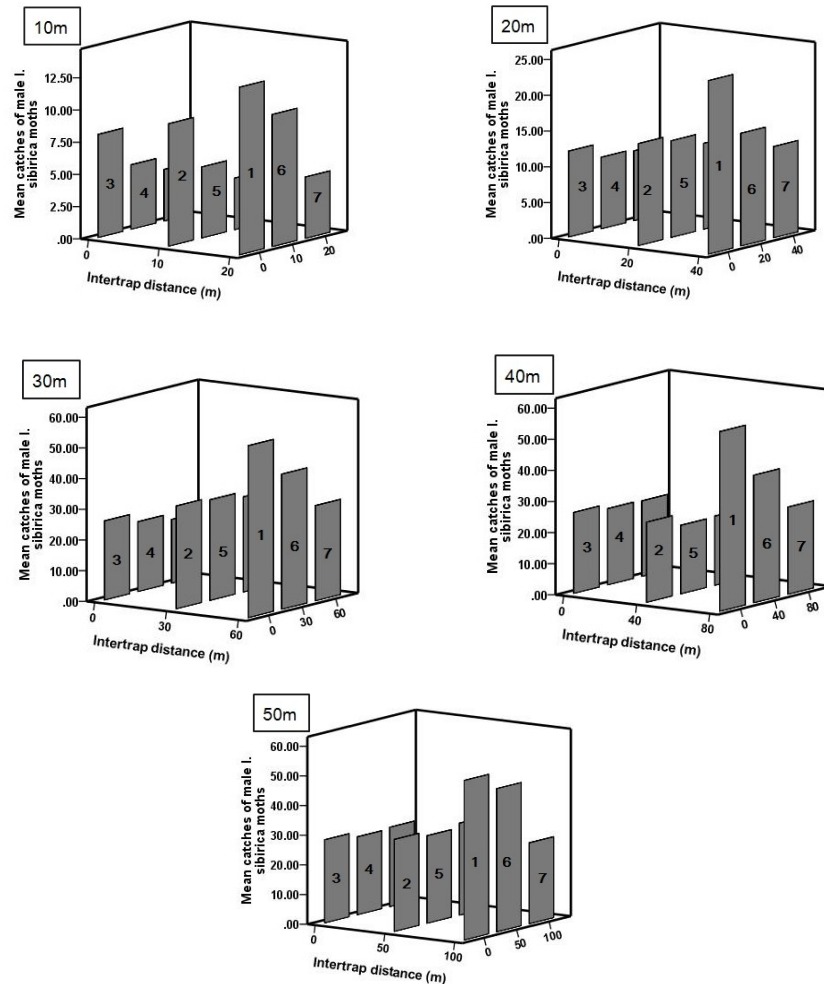


Figure 2. Effect of trap position within grids with different intertrap distances (shown in the upper left of each graph) on mean number of male *I. sibirica* moths captured per trap during the entire flight season. Trap position had no significant effect on mean catch (10 m: $H = 1.5$, $df = 8$, $P = 0.9 > 0.05$; 20 m: $H = 5.4$, $df = 8$, $P = 0.7 > 0.05$; 30 m: $H = 5.8$, $df = 8$, $P = 0.7 > 0.05$; 40 m: $H = 4.3$, $df = 8$, $P = 0.8 > 0.05$; 50 m: $H = 2.4$, $df = 8$, $P = 0.9 > 0.05$). The prevailing winds were from the south-east

3.2 Effect of Distances between Traps

The largest numbers of *I. sibirica* were captured in the traps placed 30m apart ($H = 116.6$, $df = 4$, $P = 0 < 0.05$) (Figure 3), but no significant difference in captures among traps placed more than 30 m apart ($H = 1.6$, $df = 2$, $P = 0.44 > 0.05$) (Figure 3). The capture density (males captured per square meter) depended on the distance among traps: the greater the distance, the smaller the capture density (Figure 4). At intertrap distance of 30 m or greater, capture density stabilized and traps did not compete with each other (Figure 4).

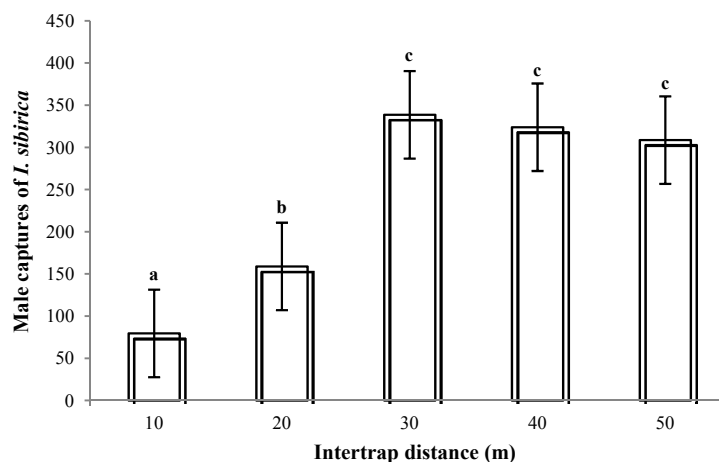


Figure 3. Effect of intertrap distance among traps and mean number (\pm SE) of male *I. sibirica* moths captured in the whole period corresponding to peak moth flight ($H = 116.6$, $df = 4$, $P = 0 < 0.05$; $n = 1800$ traps)

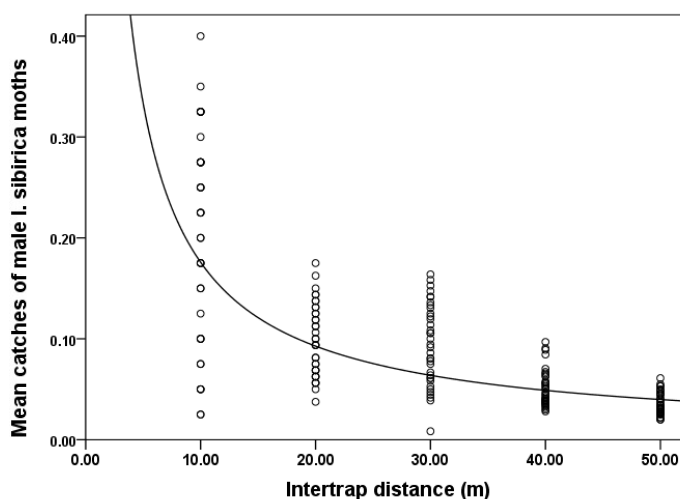


Figure 4. Relationship between capture of male *I. sibirica* moths per square meter and distance among traps ($y = 3.931x^{-0.50}$, $R^2 = 0.930$, $F = 54.2$, $d.f. = 4, 179$, $P < 0.0001$; $n = 1800$)

4. Discussion

For trap spacing, the present results show that capture density stabilized and traps did not compete with each other at intertrap distance of 30 m or greater, suggesting 30 m should be the minimum intertrap distance for monitoring *I. sibirica*. The interference between traps occurred when intertrap distances were shorter than 30 m, the reason is that the short distances among traps can lead to competition among the pheromone plumes of neighboring traps (Wedding et al., 1995; Wall & Perry, 1982; Bacca et al., 2006; Elkinton & Cardé, 1988).

For trap orientation, we found higher catches of male *I. sibirica* moths in upwind than in other traps regardless of intertrap distances but differences were not significant. Pheromone plumes from traps deployed upwind apparently prevented captures in traps deployed downwind (Wall & Perry, 1982; Knight et al., 2007).

Our results indicate that trap orientation and intertrap distance significantly affect mean catch of *I. sibirica* in pheromone-baited traps and should thus be considered when using traps to monitor or control *I. sibirica* in Asparagus growing areas. Trap interval distances should be adjusted depending on the circumstances. An intertrap distance of over 30m would be suitable for monitoring and mass trapping of *I. sibirica*, respectively.

Acknowledgements

This research was supported by the National 12th Five-year Science and Technology Support Plan of China (Grant no.2012BAD19B07) and the Research Foundation of the Introduction of Talents of Shanxi Agricultural University (Grant no.2014ZZ09).

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