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VISUAL AND VOLATILE PREFERENCES OF THE GENERALIST HERBIVORE, LYGUS HESPERUS (HETEROPTERA: MIRIDAE)

Cesar Ramiro Rodriguez-Saona
PE Marucci Blueberry and Cranberry Center
Chatsworth, NJ
Jackie L. Blackmer and John A. Byers
USDA-ARS-WCRL
Phoenix, AZ

Abstract

In the laboratory, visual and volatile plant cues facilitated host-location by *Lygus hesperus*. Headspace volatile profiles of a preferred host (alfalfa) included green leaf volatiles (GLVs), terpenes and flower-specific compounds. Volatile profiles were influenced by plant phenology, time of day and *Lygus* feeding. Visual cues, in the form of a green light-emitting diode, enhanced upwind response to plant volatile cues, oftentimes synergistically. Several synthetic compounds, when tested in combination with the visual cue in a Y-tube olfactometer, led to upwind responses that sometimes exceeded 80%, indicating their potential as behavioral modifiers. Here we present results from field trials that focused on determining an effective trap for maximizing *Lygus* capture while minimizing beneficial insect capture. The response of *Lygus* bugs, several other herbivore species and key beneficial insects to hue (white, clear, black, yellow, orange, blue, purple, green or red) and value (black, white and two neutral grays) was examined (RCB design; N=4) using traps coated with Pestick™. Hue (dominant wavelength) and possibly chroma (saturation), but not value (luminosity) influenced *Lygus* trap catch. Traps that collected the greatest number of *Lygus* (blue, black, clear and green; light yellow included due to previous studies that indicated a preference) were subsequently presented with single or binary combinations of two terpenes. Although further studies are needed, one monoterpene appeared attractive to *Lygus* spp. under field conditions.

Introduction

L. hesperus Knight is a serious pest in several cropping systems and one of our primary pests in cotton in Arizona. Conventional pesticides are effective but repeated use often leads to resistance problems. Environmentally sound options have focused on identifying a sex pheromone (Aldrich et al. 1988, Chinta et al. 1994, Gueldner & Parrott 1978, Ho & Millar 2002, McLaughlin 1998); however, responses to likely components in the field have been disappointing (Gueldner & Parrott 1978, Hedin et al. 1985, Ho & Millar 2002, McLaughlin 1998). We have taken another approach that involves identifying pertinent plant cues (i.e., visual and volatile cues) that might be used for monitoring and/or mass trapping *Lygus*. Previously, we showed that *L. hesperus* responded to alfalfa volatiles that were comprised of green leaf volatiles (GLVs), terpenes and flower-specific compounds (Blackmer et al. 2004). More recently, Blackmer & Cañas (2005) found that visual plant cues also played an important role in host location, and when combined with volatile cues, upwind orientation in a Y-tube olfactometer was enhanced in an additive or synergistic manner. Here we examined *Lygus* bug responses to visual and volatile cues in the field. Additionally, responses of other key herbivores and predators were monitored 1) to expand trap catch to include other potential pests and 2) to limit the trapping of beneficial insects.

Materials & Methods

Olfactometer Bioassays

L. hesperus was collected from alfalfa fields located at The University of Arizona-Maricopa Agricultural Center, Maricopa, AZ and reared on green beans, carrots, pink bollworm eggs (*Pectinophora gossypiella* [Saunders]) and 10% sucrose solution. Green beans and carrots also served as oviposition substrates and were changed every other day.

Bioassays were conducted in a Y-tube olfactometer as described in Blackmer et al. (2004) and Blackmer & Cañas (2005). A green light-emitting diode (LED) was used to simulate a visual plant cue. Before each trial, 7- to 10-d-old *L. hesperus* were placed in individual holding/release tubes. At the beginning of the bioassay, the cork was removed from the holding tube and the insect was placed at the downwind end of the Y-tube. Each insect was given 5 min to respond to the odor source, and a choice for the left or right arm of the olfactometer was noted when the insect was 1 cm past the Y junction. Tests with nine of the previously identified monoterpenes and GLVs were conducted (Blackmer et al. 2004; Blackmer et al., unpubl. data) by loading synthetic compounds onto filter paper which were placed inside 1-liter holding chambers. Single and some binary combinations of compounds were tested.

Visual Preferences Relative to Hue and Value

Field trials of visual and volatile preferences were conducted in 2004 and 2005 in alfalfa fields located in Maricopa, AZ. In 2004, *Lygus* preference to hue (white, clear, black, lt. yellow, orange, blue, purple, green or red) was examined using a RCB design (N=4). In 2005, the same colors plus darker yellow were tested. Additionally, in 2005, we conducted separate trials to examine insect response to trap value or intensity using black, white and two neutral grays (RCB design, N=4). Traps were 30 x 60 cm and were positioned around a 2-m tall post to form an 18-cm diam. cylinder. Traps were hand rolled with a heavy coating of Pestick. In 2004, traps were left in the field for 24 h and then returned to the laboratory where *Lygus* were counted, identified and sex determined. Other key herbivores and predators were counted and identified to species when possible. In 2005, traps were left up for 1, 7 or 14 days, depending on the experiment. In 2005, in trials lasting longer than 24 h, *Colias* spp. were counted and removed from the traps on a daily basis. At the end of the trapping period, other species were counted and identified; *Lygus* were identified, counted and sexed determined.

Response to Visual+Volatile Cue Combinations

In 2005, synthetic compound release rates were determined by weighing loaded devices under constant temperatures in the laboratory over 1- to 7-day periods. In the field, release devices were reloaded at 24-h intervals with 160 µl of the synthetic compound(s).

Two trap designs were tested in 2005; lime green delta traps with or without baits, and later, cylindrical colored traps that had collected the greatest number of *Lygus* in our previous ‘hue’ trials (blue, black, clear and green; light yellow added due to a previous study indicating preference [Landis & Fox 1972, Blackmer et al. unpubl. data]). Cylindrical traps were modified by positioning our release device in the center of the trap. Baited traps contained either single monoterpenes (Mt1 or Mt2) or their combination (presented separately in loaded centrifuge tubes).

Results

Olfactometer Bioassays

In laboratory bioassays, *L. hesperus* showed a strong upwind response to plant synthetic compounds. Females showed a preference to 4 out of 5 monoterpenes and 1 out of 4 GLVs tested. Males were responsive to 2 out of 5 monoterpenes, both of which had been attractive to females, but showed no significant attraction to GLVs.

Response of *Lygus* to Hue.

L. hesperus and L. lineolaris adults displayed a broad response to visual cues (Fig. 1). Cumulative catch in 2005 was greatest on blue, black, green and clear. Trap catch efficiency of yellow decreased after Day 4 as whiteflies and three-cornered hoppers increased on traps. Trap catch on purple increased as alfalfa flowers developed (~Day 7).

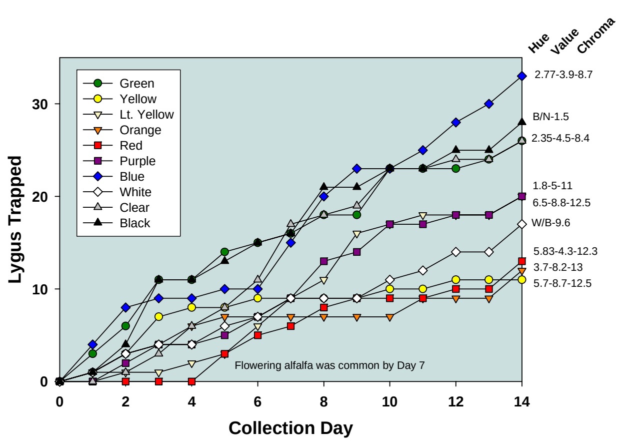

FIG. 1. Representative cumulative trap catch of *L. hesperus* and *L. lineolaris* on Pestick-coated traps in alfalfa, 2005. Hue, value and chroma values determined by comparison with the Munsell Color Sphere.

Response of Other Herbivores and Predators to Hue

Other common herbivores showed more definitive color preferences: *Colias* spp. showed a strong preference for light yellow and clear; *Conotelus mexicanus* was trapped in high numbers on white, *Spissistilus festinus* and *Bemisia tabaci* were trapped primarily on the light yellow and yellow, respectively, and *Frankliniella occidentalis* was trapped in highest numbers on white and blue (Fig. 2). Predators were less likely to show a preference for any one color, although *C. carnea* showed a moderate response to orange and black (Fig. 3).

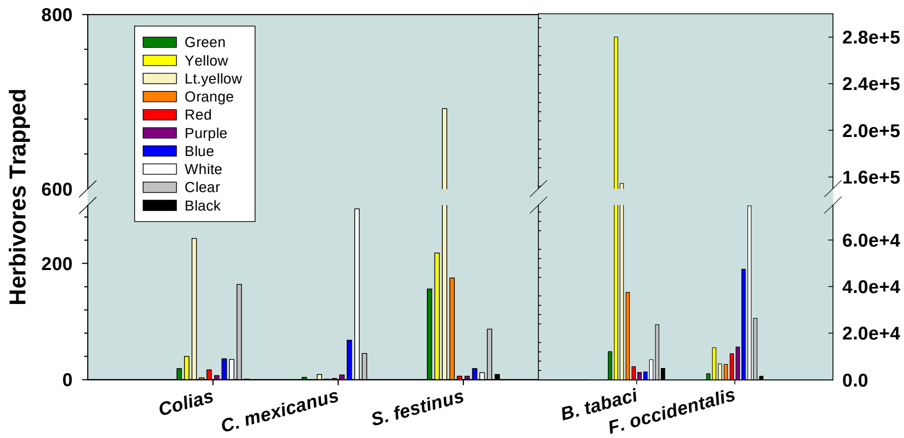

FIG. 2. Cumulative trap catch in alfalfa of *Colias* spp., *C. mexicanus*, *S. festinus*, *B. tabaci* and *F. occidentalis* on Pestick-coated traps of various hue, value and chroma as determined by the Munsell Color Sphere, 2005.

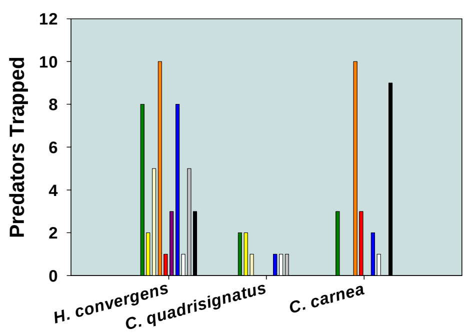

FIG. 3. Cumulative trap catch in alfalfa of *Hippodamia convergens*, *Collops quadrisignatus* and *Chrysoperla carnea* on Pestick-coated traps of various hue, value and chroma as determined by the Munsell Color Sphere, 2005.

Response to Value

Lygus bugs showed no preference relative to trap value (Fig. 4). *Colias* spp., *C. mexicanus* and *F. occidentalis* preferred high value (white) traps, whereas the two homopterans, *S. festinus* and *B. tabaci*, showed no preference. No obvious preference was observed with predators; however, trap catch was low.

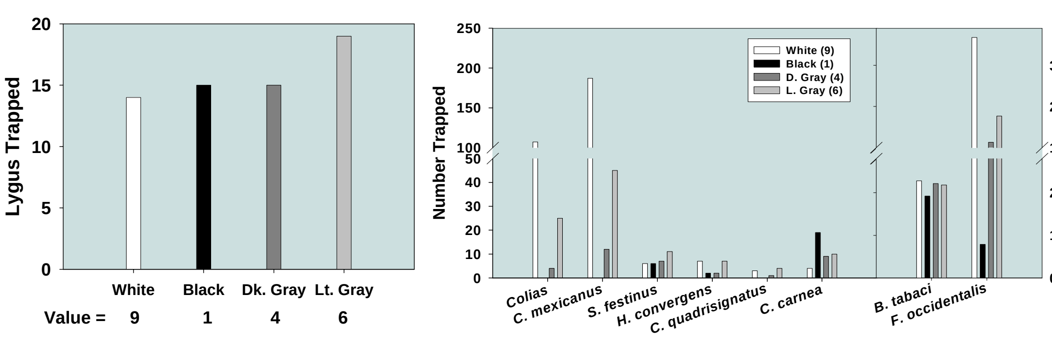

FIG. 4. Cumulative trap catch relative to value (1, 4, 6, 9) for *Lygus* bugs, key herbivores and predators.

Response to Volatile and Visual Cue Combinations

In the laboratory, *L. hesperus* males and females responded strongly (76-82% upwind response) to the two terpenes that were tested in the field. Upwind response, however, was reduced when Mt 1 and Mt 2 were combined.

Under field conditions, preference to one of the monoterpenes (Mt 2) was demonstrated in two out of three trials.

- Trial 1 – 29% were trapped at Mt 1; 57% at Mt 2; 0% at the combination of Mt 1 and 2; 14% at unbaited traps [lime-green Delta traps w/ or w/o baits]
- Trial 2 – 18% were trapped at Mt 1; 45% at Mt 2; 18% at the combination; 18% at the unbaited traps [cylindrical colored traps w/ or w/o baits]
- Trial 3 – 11% were trapped at Mt 1; 33% at Mt 2; 17% at the combination; 38% at the unbaited traps [cylindrical colored traps w/ or w/o baits]

Both sexes of *L. hesperus* and *L. lineolaris* were trapped with Mt 2; however, trap catch was low. Trap placement and orientation has yet to be examined, but placement at or near less preferred (or non-hosts) will be examined in an effort to reduce competition from background plant cues.

Conclusions

Laboratory bioassays showed that both male and female *L. hesperus* responded positively to monoterepenes, and in some cases GLVs, by progressing upwind in a Y-tube olfactometer. Responses exceeded 75% for some compounds, demonstrating their potential as behavioral modifiers.

Lygus bugs displayed a broad response to cylindrical traps varying in hue with the following preference: blue>black>green=clear>purple=lt. yellow>white>red>orange>yellow. Over longer trapping periods, the preference to yellow by other key herbivores (i.e., three-cornered hoppers and whiteflies) caused interference in *Lygus* captures; trap catch of *Lygus* decreased as the number of these two herbivores increased on the traps. When trap catch was limited to a 24-h period, yellow caught a higher proportion of *Lygus*, but was still no better than green and blue in most cases. Other key herbivores showed distinct preferences relative to trap hue. Predators were trapped in low numbers, but generally showed a broad response to hue. Seasonal variations in trap collection may have been due to plant phenology or reproductive status of *Lygus* and needs to be examined further.

Lygus bugs and two homopteran species did not respond to trap value, but three other key herbivores did respond to high trap value (white). Predators were trapped in low numbers, but showed no distinct preference relative to trap value.

Laboratory bioassays and preliminary field trials with Mt1, Mt2 and their combination concurred. Both monoterpenes were attractive to males and females, but their combination reduced upwind response in the Y-tube olfactometer and trap catch in the field. Further synthetic combinations need to be tested in the laboratory and subsequently in the field. Additional trials in the field will examine new synthetic combinations, trap placement and trap design enhancement to increase collections.

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Unnumbered Footnotes

Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the USDA for its use.

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