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Visual Response of *Coccinella septempunctata* (L.), *Hippodamia parenthesis* (Say), (Coleoptera: Coccinellidae), and *Chrysoperla carnea* (Stephens), (Neuroptera: Chrysopidae) to Colors

K. M. MAREDIA,* S. H. GAGE,* D. A. LANDIS*† AND T. M. WIRTH*

*Department of Entomology and †Pesticide Research Center, Michigan State University, East Lansing, Michigan 48824

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The response of the seven-spotted lady beetle, *Coccinella septempunctata* (L.) (Coleoptera: Coccinellidae), the parenthesis lady beetle, *Hippodamia parenthesis* (Say), (Coleoptera: Coccinellidae), and the green lacewing, *Chrysoperla carnea* (Stephens), (Neuroptera: Chrysopidae) to seven colors was evaluated in the field using sticky panels. *C. septempunctata* exhibited a strong positive response to yellow. *C. carnea* showed a preference for yellow, green, and red. *H. parenthesis* did not exhibit strong visual orientation to any color. Programs aimed at monitoring these predators should consider their visual responses to colors in designing monitoring systems.

KEY WORDS: Visual response; monitoring; *Coccinella septempunctata; Hippodamia parenthesis; Chrysoperla carnea.*

INTRODUCTION

Responses of many insects to colors have been used, or suggested for use, in designing efficient sampling strategies to monitor populations (Lewis, 1959; Southwood *et al.*, 1961; Prokopy, 1968; Adlerz, 1976; Cross *et al.*, 1976; Capinera and Walmsley, 1978; Berlinger, 1980; Harris and Miller, 1983; Kawai and Kitamura, 1988). Many pest management programs routinely use colored sticky traps to monitor or remove insects (Prokopy and Owens, 1983). However, very little research has been done on the response of beneficial insects to colors. The use of beneficial insects is becoming increasingly popular in agriculture as issues such as sustainability and environmental safety become more critical. Knowledge of visual responses by beneficial insects to colors will be essential in designing strategies to monitor their activity. Such knowledge will aid in making sound pest management decisions.

The seven-spotted lady beetle, *Coccinella septempunctata* (L.), the parenthesis lady beetle, *Hippodamia parenthesis* (Say), and the green lacewing, *Chrysoperla carnea* (Stephens), are important predatory insects. *C. septempunctata* is an introduced species which has recently become established in Michigan (USDA, 1989). Observations made during 1988–1990 suggest that *C. septempunctata* is now one of the most abundant lady beetles in some areas of Michigan. *H. parenthesis* and *C. carnea* are important native predators. All three species prey on many aphid species and on a variety of other insects which are herbivores on crops and nonagricultural plants.

Information is lacking on the visual responses of *C. septempunctata* and *H. parenthesis* to colors. We evaluated visual responses of these two species to colors as part of a large-scale investigation which examines the effects of local landscape structure on the distribution, abundance, and movements of insects. During the *C. septempunctata* visual response study, *C. carnea* was abundant, so its response to colors also was recorded.

MATERIALS AND METHODS

The following colors were used for making double-sided, rectangular, cardboard sticky traps (22.5 × 14.0 cm) to be covered with Tanglefoot sticky material: red, orange, black, white, blue, yellow, and green. The reflectance characteristics of each color at 400–700 nm was described (Table 1 and Fig. 1). The trap standard (Fig. 2) was an aluminum pipe 150 cm long, 1.5 cm diameter, inserted 30 cm deep into the soil into a 30 cm-long, 2.25 cm diameter, aluminum pipe, leaving a 120 cm section above the ground level. On top of the 120 cm section, a wooden dowel (120 cm long, 1 cm diameter) was fitted using a plastic PVC tube (6 cm long, 1.5 cm diameter) forming a 'T'. On one arm of each T trap standard, a sticky trap of the respective color was tied into a groove in the dowel with a wire tie and hung from the dowel.

Visual Response of C. septempunctata and C. carnea

The study was conducted at the Michigan State University Kellogg Biological Station (KBS), Hickory

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TABLE 1

Description of Different Colors Used to Prepare Sticky Traps

Color	Description
Red	Benjamin Moore Impervo Alkyd high gloss enamel, custom mix color
Orange	Benjamin Moore Ironclad quick dry industrial enamel, safety Orange-07165
Black	Sherwin Williams KemLustral enamel Black-F65-131
White	Benjamin Moore Impervo Alkyd high gloss enamel, White 13301
Blue	Benjamin Moore Ironclad quick dry industrial enamel, custom mix color
Yellow	Benjamin Moore Impervo Alkyd high gloss enamel, custom mix color
Green	Benjamin Moore Impervo Alkyd high gloss enamel, custom mix color

Corners, Michigan, in 1989 and 1990. In 1989, five traps of each color were set up in early August in three alfalfa, *Medicago sativa* L., fields to study the visual response of *C. septempunctata.* However, due to a strong windstorm most of the traps were destroyed and no data were collected. The study was repeated 2 weeks later, but a limited number of traps were available, and only two traps of each color were set up in one alfalfa field to determine preliminary preferences. The alfalfa was ca. 45 cm tall at the time of the study. Traps were set up in two transects with the traps 25 m apart. Each transect consisted of one trap for each of the seven colors, randomly distributed within the transect. Traps were monitored weekly over a 2-week period and the number of adult *C. septempunctata* and *C. carnea* caught was recorded.

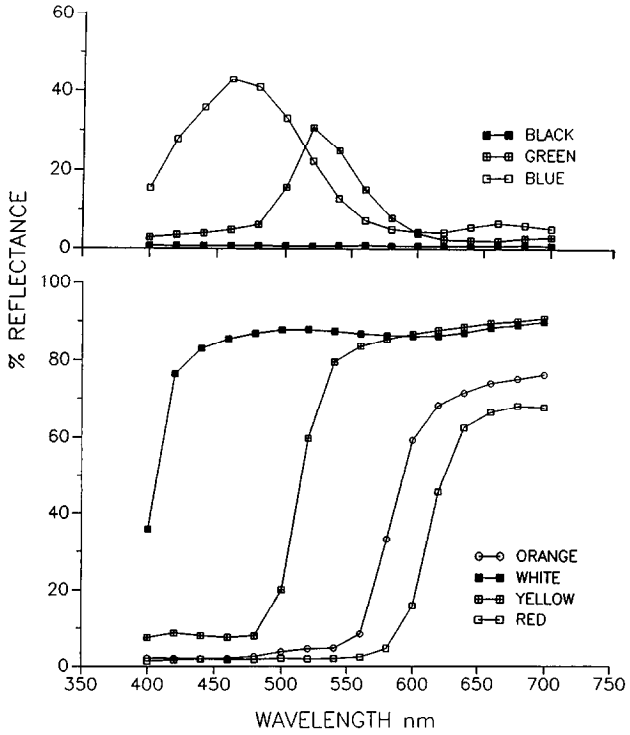

FIG. 1. Reflectance characteristics of color traps.

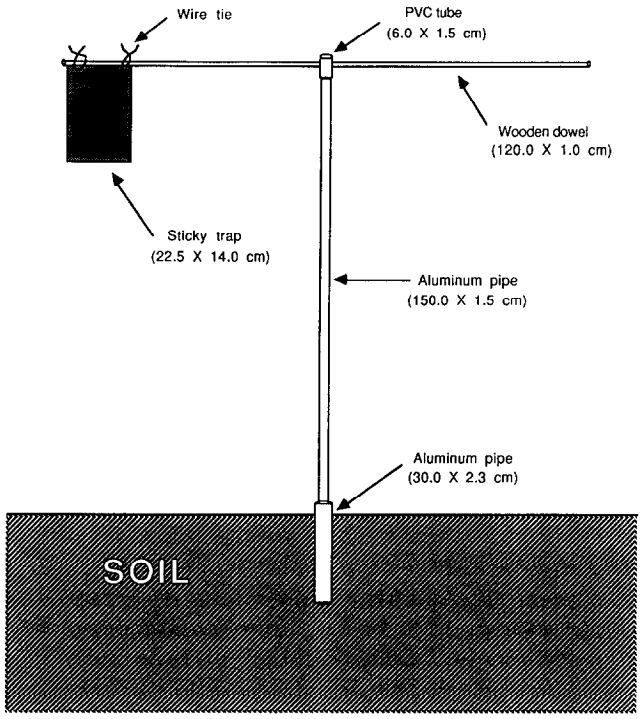

FIG. 2. Trap standard and sticky board dimensions.

In 1990, the study was repeated at KBS in two alfalfa fields using a larger sample size. Traps were set up in five transects (25 m apart). Each transect consisted of one trap of each of the seven colors, randomly distributed. At the time the traps were set up, the alfalfa was ca. 40 cm tall. Traps were monitored weekly over a 2-week period and the number of adult *C. septempunctata* and *C. carnea* caught was recorded.

Visual Response of H. parenthesis

During 1990, five traps of each color were set up at KBS in an early successional field, dominated by grasses, including *Agropyron repens, Andropogon virginicus, Bromous inermis,* and *Phleum pratense.* The colored traps were set up using the same design as that used in the *C. septempunctata* study. Traps were monitored weekly over a 2-week period and the number of *H. parenthesis* adults caught was recorded.

Data for each species were converted to percentage of total number of insects caught for each week. Percentage data were transformed to $\sqrt{x + 0.5}$ for analysis of variance. Wherever appropriate, data for each species was analyzed for each year separately. Data also were combined over 2 years and analyzed. Tests with significant F values were subjected to LSD mean separation at the 5% level (STATISTIX, 1989).

TABLE 2

Mean Number of Adult *C. septempunctata* and *H. parenthesis* Caught on Colored Sticky Traps

Trap color	No. *C. septempunctata* caught								No. *H. parenthesis* caught, 1990	
	1989		1990 Site 1		1990 Site 2		Overall			
	N	Mean ± SEM	*N*	Mean ± SEM	*N*	Mean ± SEM	*N*	Mean ± SEM	*N*	Mean ± SEM
Red	3	0.33 ± 0.33	10	1.10 ± 0.28	10	0.70 ± 0.34	23	0.82 ± 0.19	10	1.20 ± 0.29
Orange	3	0.67 ± 0.67	10	1.40 ± 0.40	10	0.80 ± 0.33	23	1.04 ± 0.24	10	0.70 ± 0.21
Black	4	0.50 ± 0.29	10	1.60 ± 0.34	10	0.80 ± 0.29	24	1.08 ± 0.21	10	0.70 ± 0.30
White	4	0.50 ± 0.29	10	2.30 ± 0.54	10	1.90 ± 0.46	24	1.83 ± 0.32	10	1.00 ± 0.33
Blue	4	1.50 ± 0.96	10	2.40 ± 0.67	10	1.60 ± 0.52	24	1.92 ± 0.38	10	1.10 ± 0.41
Yellow	4	2.75 ± 0.75	10	6.10 ± 1.56	10	2.70 ± 0.75	24	4.13 ± 0.79	10	1.00 ± 0.29
Green	3	0.33 ± 0.33	10	3.90 ± 1.04	10	2.00 ± 0.52	23	2.61 ± 0.56	10	1.20 ± 0.53

Note. Traps were monitored weekly and changed every 2 weeks. *N*, sample size.

RESULTS AND DISCUSSION

Visual Response of C. septempunctata and C. carnea

Yellow traps consistently caught more adult *C. septempunctata* during both years (Table 2). The number of *C. septempunctata* caught on an individual trap ranged from 0 to 4 in 1989 and from 0 to 16 in 1990. The analysis of variance of the individual studies with a small sample size indicated that even though yellow consistently caught more *C. septempunctata* than other colors, in some cases it was not significantly different from some of the other colors. However, the combined analysis over 2 years indicated a significant positive response by *C. septempunctata* to yellow (Table 4).

Yellow traps consistently caught more adult *C. carnea* during both years than did the other colors (Table 3). The number of *C. carnea* caught on individual traps ranged from 0 to 1 in 1989 and from 0 to 9 in 1990. The analysis of variance for 1989 data indicated no significantly different responses by *C. carnea* to colors. In 1990, *C. carnea* exhibited a significant preference for some colors. Overall analysis indicated that even though yellow caught the highest percentage of *C. carnea,* the number caught on yellow traps was not significantly different from the number caught on green and red (Table 4). Capinera and Walmsley (1978) also trapped more *C. carnea* on yellow traps than on traps of other colors, though not significantly more.

Visual Response of H. parenthesis

Adult *H. parenthesis* did not exhibit statistically significant response to any of the colors (Table 4). The number of *H. parenthesis* caught on individual traps ranged from 0 to 5. Capinera and Walmsley (1978) reported no significantly different responses of the congeneric convergent lady beetle, *Hippodamia convergens,* to colors.

The results of this study indicate that *C. septempunctata* is preferentially attracted to yellow as is *C. carnea* to some extent. *H. parenthesis* did not show a significant preference for any color. Obata (1986) evaluated the visual response of the lady beetle, *Harmonia axyridis Pal-*

TABLE 3

Mean Number of Adult *C. carnea* Caught on Colored Sticky Traps

Trap color	No. *C. carnea* caught							
	1989		1990 Site 1		1990 Site 2		Overall	
	N	Mean ± SEM	*N*	Mean ± SEM	*N*	Mean ± SEM	*N*	Mean ± SEM
Red	3	0.00 ± 0.00	10	0.90 ± 0.41	10	1.40 ± 0.27	23	1.00 ± 0.23
Orange	3	0.00 ± 0.00	10	0.50 ± 0.22	10	1.50 ± 0.60	23	0.87 ± 0.29
Black	4	0.00 ± 0.00	10	1.00 ± 0.26	10	0.20 ± 0.13	24	0.50 ± 0.15
White	4	0.25 ± 0.25	10	0.50 ± 0.17	10	0.40 ± 0.22	24	0.42 ± 0.12
Blue	4	0.25 ± 0.25	10	0.30 ± 0.21	10	0.10 ± 0.10	24	0.21 ± 0.10
Yellow	4	0.50 ± 0.29	10	1.80 ± 0.89	10	2.20 ± 0.88	24	1.75 ± 0.52
Green	3	0.33 ± 0.33	10	1.40 ± 0.45	10	1.30 ± 0.42	23	1.21 ± 0.28

Note. Traps were monitored weekly and changed every 2 weeks, *N*, sample size.

TABLE 4

Percentage of Insects Caught on Colored Sticky Traps

Trap color	$\bar{X}$ % *C. septempunctata* caught[a,b] 1989	1990 Site 1	1990 Site 2	Overall	$\bar{X}$ % *H. parenthesis* caught[a,b], 1990	$\bar{X}$ % *C. carnea* caught[a,b] 1989	1990 Site 1	1990 Site 2	Overall
Red	5.0 b	5.9 c	6.7 c	6.2 d	17.3 a	0.0 a	14.1 abc	19.7 a	17.1 ab
Orange	10.2 b	7.5 c	7.6 c	7.8 d	10.1 a	0.0 a	7.8 bc	21.1 a	14.9 bc
Black	7.6 b	8.5 c	7.6 c	8.1 cd	10.1 a	0.0 a	15.6 abc	2.8 c	8.5 cd
White	7.6 b	12.2 bc	18.1 ab	13.8 bc	14.4 a	18.8 a	7.8 bc	5.6 c	7.1 cd
Blue	22.8 ab	12.8 b	15.2 ab	14.4 bc	15.9 a	18.8 a	4.7 c	1.4 c	3.5 d
Yellow	41.8 a	32.5 a	25.7 a	31.1 a	14.4 a	35.6 a	28.1 a	30.9 a	30.0 a
Green	5.0 b	20.7 ab	19.1 a	19.6 b	17.3 a	24.8 a	21.9 ab	18.3 a	20.8 ab

Note. Traps were monitored weekly and changed every 2 weeks.

[a] Percentages based on (No. of insects recovered on each color trap/total insects recovered on all color traps) × 100.

[b] Means within a column followed by the same letter are not significantly different (LSD $P = 0.05$).

las to colored boards (yellow, green, white, red, and black) in Japan and found that white and yellow were the two most attractive colors. Other researchers have shown yellow to be preferred by some insects (Prokopy, 1968, 1972; Capinera and Walmsley, 1978; Harris and Miller, 1983; Vernon and Gillespie, 1990). Prokopy (1972) reported that apple maggot flies *Rhagoletis pomonella* (Walsh) show the strong preference for yellow and that yellow constitutes a "supernormal" foliage-type stimulus eliciting food seeking and/or host plant seeking behavior.

Since the results of this study show that the yellow preferentially attracted *C. septempunctata,* and since yellow was as good or better than other colors for *C. carnea,* it should be favored in programs designed to monitor these species. *H. parenthesis* was equally attracted to all colors tested; thus, the use of yellow color should also provide appropriate measurements of its activity. Pest monitoring using colored traps has had great success for a number of years. Results presented here indicate that color is also significant for monitoring predator activity. A program aimed at efficiently monitoring these predators therefore should consider these visual responses in its design.

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