

## Visual Orientation of a Ladybeetle, *Coccinella septempunctata* L., (Coleoptera: Coccinellidae), toward Its Prey

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Prey searching movement of a ladybeetle, *Coccinella septempunctata* L., was analyzed using a videorecorder to evaluate the insect's visual orientation toward its prey. The ladybeetle orientated toward the aphid prey at a distance of 7 mm under light conditions; it also orientated toward a dummy prey at a 8 mm distance. However, under dark conditions, the ladybeetle did not orientate toward the prey at even a 2 mm distance and, upon coming in contact with it, turned around, rushed toward the aphid and "captured" it. These results suggest that the ladybeetle visually perceives the prey only at close proximity.

### INTRODUCTION

Many investigations on the behavior of predatory coccinellids conclude that they evidently do not perceive their prey until physical contact occurs and that this contact seems to play a role in eliciting an attack (FLESCNER, 1950; ROBINSON, 1952; PUTMAN, 1955; BANKS, 1957; DIXON, 1959; KADDOU, 1960; KEHAT, 1968; STORCH, 1976).

NAKAMUTA (1983) reported that a ladybeetle, *Coccinella septempunctata* L., did not orientate toward an aphid prey from a distance. This was also true of a coccidophagous ladybeetle, *Pharoscyrnus numidicus* (KEHAT, 1968). However, the involvement of visual orientation toward a prey in close proximity remained to be proved since movement of the ladybeetle was so fast that the observer could not determine the orientation movement in detail.

In the present paper, the movement of a ladybeetle, *C. septempunctata*, in the presence of aphid prey or dummy prey was analyzed using a videorecorder under light and dark conditions.

### MATERIALS AND METHODS

The ladybeetle, *C. septempunctata*, and its prey, the green peach aphid, *Myzus persicae* SULZER, were reared using the method described by NAKAMUTA (1983).

At the center of a filter paper (15 cm in diameter), an apterous *M. persicae* adult or a dummy prey was fixed with adhesive (G-17, Konishi Co. Ltd., Osaka, Japan). The dummy in the form of a rugby ball (major axis: 2.6-2.8 mm and minor axis: 1.3-1.5 mm) was made of a Parafilm® sheet (American Can Co., Connecticut, U.S.A.). This size was just a little bigger than that of an adult *M. persicae*. After the adhesive dried, an adult ladybeetle was released onto the filter paper and the paper was covered with a petri

dish (9 cm in diameter). Prior to each experiment the ladybeetle was deprived of food for 24 hr after satiation.

Movement of the ladybeetle was recorded on a SONY SL-F1 videorecorder through a SONY HVC-F1 video camera under illumination with diffuse light from a 100 W white bulb. A ruler was simultaneously recorded on a videorecorder at the side of the petri dish for later analysis. If the ladybeetle did not capture an aphid within 5 min, the recording was terminated and another ladybeetle was substituted. If the ladybeetle captured an aphid, the recording was continued until it had consumed the aphid. When the insect orientated toward a dummy, the recording was continued until it had left the dummy.

The same procedure using an aphid prey was conducted in a dark room. Ladybeetle movement was recorded on the same videorecorder used in the former experiment through a SONY AVC-1300S infrared sensitive video camera under illumination with a SONY HVL-1300 IRA infrared light. Experiments were conducted at  $25 \pm 3^\circ\text{C}$  from 10:00 to 17:00 during which time the ladybeetle was active under rearing light regime.

The tapes were played back on a SONY SL-F1 videorecorder onto a television monitor (SONY KX-16HF2) at a slower speed (1/3) than that of recording. When the ladybeetle passed near the prey, the beeline distance between the trajectory of the center of the insect's head and the aphid (prey-predator distance: PPD) was measured with a pair of dividers on the television monitor using the ruler graduations on the television monitor as standard (Fig. 1 A). Values which were more than 20 mm were omitted from the data. When the ladybeetle captured a prey, the point of turning toward it could be identified and the beeline distance between the turning point and the aphid was measured by the same method mentioned above (Fig. 1 B). The ways in which the ladybeetle turned toward the prey varied. Turns were sometimes made sharply at an acute angle and other times gradually. When the ladybeetle turned sharply, the turning point could easily be identified. However, when the turn was gradual, the turning point could only be identified with difficulty using the slow and still playback modes of the videorecorder. The turning point was defined as the point from which the ladybeetle went directly toward the prey.

The number of ladybeetles used for the experiment with aphid prey under light

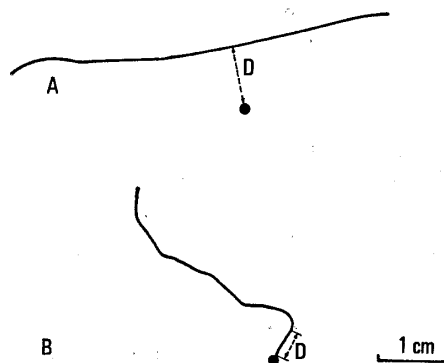


Fig. 1. An example of the searching path of the ladybeetle in an unsuccessful (A) and a successful (B) capture of aphid or orientation toward dummy prey. Solid circle and "D" signify an aphid or dummy prey and the prey-predator distance (PPD), respectively.

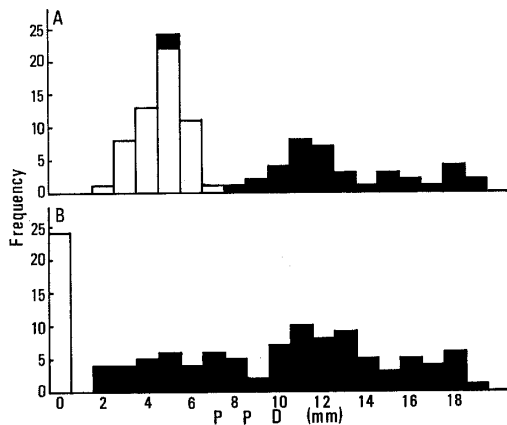


Fig. 2. Frequency distributions of the PPDs in successful (white column) and unsuccessful (solid column) captures of aphid prey under light (A) and dark conditions (B).

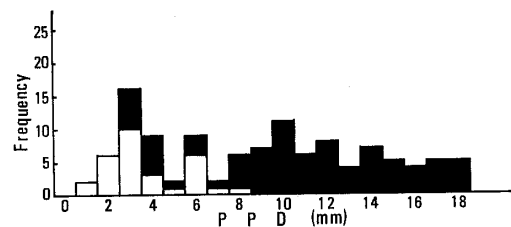


Fig. 3. Frequency distribution of the PPDs in successful (white column) and unsuccessful (solid column) orientations toward dummy prey under light conditions.

and dark conditions and with dummy prey under light conditions was 55, 24 and 30, respectively.

## RESULTS

Figure 2 A shows frequency distributions of PPD in successful and unsuccessful captures of aphid prey under light conditions. When the PPD was more than 8 mm, the ladybeetle passed near the aphid prey without response. When the PPD was less than 7 mm, all the ladybeetles except two orientated toward the aphids and captured them at the center of the filter paper. The PPDs in successful captures were considered as the perceptive distance of the prey.

However, the ladybeetle did not orientate toward the aphid even at a distance of 2 mm under dark conditions (Fig. 2 B). PPD values in successful aphid captures differed significantly between dark ( $0 \pm 0$  mm<sup>1</sup>) and light conditions ( $4.7 \pm 1.1$  mm,  $p < 0.001$ , MANN-WHITNEY'S *U*-test). Under dark conditions the ladybeetle captured the aphid only when it came in contact with it. After contacting the aphid with its appendages (e.g., foreleg, mesoleg, etc.) while passing near it, the ladybeetle turned around and rushed toward it to "capture" it. This behavior of turning around and rushing toward the aphid was not observed under light conditions, and suggests that the ladybeetle perceives the aphid prey visually only at close proximity.

When a dummy was used as prey instead of an aphid under light conditions, the ladybeetle also orientated toward the dummy (Fig. 3). The PPD values ( $3.7 \pm 1.8$  mm) in successful orientations toward the dummy differed significantly from those in successful captures of the aphid prey under light ( $4.7 \pm 1.1$  mm,  $p < 0.01$ , MANN-WHITNEY'S *U*-test) and dark conditions ( $0 \pm 0$  mm,  $p < 0.001$ , MANN-WHITNEY'S *U*-test).

Before capturing an aphid prey, the ladybeetle passed near it  $0.7 \pm 1.1$  times without contact under light conditions. The values obtained under dark conditions ( $4.0 \pm 3.7$

<sup>1</sup> Mean  $\pm$  S.D. The same shall apply hereinafter.

times) were significantly higher ( $p < 0.001$ , MANN-WHITNEY'S  $U$ -test). The ladybeetle passed near the dummy prey  $3.0 \pm 2.0$  times before orientating toward it. This also differed significantly from the value before capturing an aphid under light conditions ( $p < 0.01$ , MANN-WHITNEY'S  $U$ -test).

#### DISCUSSION

The ability of adult *C. septempunctata* to orientate toward a prey with visual stimuli was confirmed by the direct measurement of perceptive distance. These results support the results of ALLEN et al. (1970) and STUBBS (1980). STUBBS (1980) allowed adult *C. septempunctata* to search for a prey in an arena, measured the time taken for capture and compared it with that taken to cross the test X mark. The ladybeetle found the aphid prey and a silver foil dummy significantly faster than it crossed the X mark. From these results the calculated perceptive distance of *C. septempunctata* was 1.04 cm. *Anatis ocellata*, which feeds on larvae of the Jack-pine budworm, *Choristoneura pinus*, can perceive prey at a 1.27–1.91 cm distance with a visual sense (ALLEN et al., 1970). In the present study the perceptive distance of adult *C. septempunctata* was less than 7 mm (2–7 mm) which is shorter than that calculated by STUBBS (1980). The reason for these differences between their results and those of the present study is not clear.

STUBBS (1980) suggested that the variation in hunger levels of the ladybeetles may be responsible for the variation in perceptive distances as shown in a mantid (HOLLING, 1966). The hunger levels of the ladybeetle were strictly controlled in the present study, and yet variation in perceptive distances emerged. Therefore, the direction of the head or of the movement during the prey search may be considered a reason for this variation rather than variation in hunger levels.

*C. septempunctata* also orientated toward a dummy prey at less than 8 mm. On average, however, the ladybeetle orientated toward the aphid prey from a greater distance than it did toward the dummy prey. And the insect passed near the dummy prey more frequently than near the aphid prey. These suggest that the ladybeetle initially perceives the prey or discriminates a prey-like object from non-prey-like object visually by its size or contour. *C. septempunctata* would, therefore, visually orientate toward an aphid-like object. Its short perceptive distance and the observer's difficulty of recognizing a turning point in the searching movement toward the prey are the reasons why the involvement of visual sense in the detection is little noticed in spite of many investigations on coccinellid behavior (cf. HODEK, 1973).

Although COLBURN and ASQUITH (1970) reported that *Stethorus punctum* feeding on mites detected prey by its scent, this does not appear to be the case in *C. septempunctata* because, under dark conditions, the ladybeetle does not recognize the prey until physical contact has been made (Fig. 2 B). *C. septempunctata* is considered able to detect its prey with a contact stimulus because it can catch it under dark conditions when physical contact is made. Therefore, it can be concluded that adult *C. septempunctata* only uses vision for short range ( $\leq 7$  mm) detection of the first prey item and that physical contact is an aspect of short range orientation.

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