

## Another look at prey detection by coccinellids

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**ABSTRACT.** 1. Adult and fourth instar larvae of *Coccinella septempunctata* (L.) were tested to see whether or not they could detect prey prior to physical contact.

2. Adult predators found aphid prey and a silver foil dummy significantly faster than an X-mark on the floor of the arena covering the same area.

3. Fourth instar larvae found crushed prey more quickly than the X-mark but were not able to detect whole frozen prey.

4. The distances at which the predators could detect prey were calculated. This distance was found to be about 1.0 cm for the adults and 0.7 cm for the fourth instar larvae.

### Introduction

It is often claimed that ladybirds are unable to detect their prey prior to actual physical contact. This conclusion has been reached by many workers studying different coccinellid species (e.g. Fleschner, 1950; Banks, 1954, 1957; Kehat, 1968; Storch, 1976).

Fleschner allowed his coccinellid predator *Stethorus picipes* (Casey) to search in a variety of environments with and without prey (citrus red mites, *Paratetranychus citri* (McGregor)). He timed how long a predator took to reach the place where prey were to be found, if present, and grouped his results according to how quickly the predators reached the test area. He found no significant difference in the number of predators reaching the test area in under 30 min, 30–60 min, or not at all in the experiment between tests when prey were present or absent.

Banks (1954) observed first instar ladybird larvae searching for aphids in bean plots. He concluded, 'larvae appear to search in a random manner and are unable to perceive the prey until a physical contact has been made,

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as was concluded by Fleschner (1950)'. He also observed (Banks, 1957) that first instar *Propylea quatuordecimpunctata* (Reitt.) missed clumps of *Aphis fabae* (Scop.) on bean plants on passing very close to them. Kehat's (1968) observations on *Pharoscyrnus numidicus* (Pic.) were similar.

Storch (1976) tested prey detection in fourth instar *Coccinella transversoguttata* (Falderman) by interfering with the sense organs. In one series of experiments he blinded the larvae by painting over the stemmata with black paint. The number of times a larva went close to its aphid prey without capturing it was not significantly different whether or not the larva had been blinded. In a further series of experiments, Storch coated the setae on the tibiae of the first and second pair of legs with clear nail polish. Untreated larvae frequently made initial physical contact with prey with the head and mouthparts whereas treated larvae only made the first contact with their legs. He concluded that setae may be sensitive to odour, temperature or vibration and may assist in directing the predator onto the prey with the mouthparts. He stated, however, that the effect was not important.

Allen *et al.* (1970) reported that adult *Anatis ocellata* (L.) did detect larvae of the jack-pine budworm *Choristoneura pinus* (Freeman) prior to contact. The coccinellids stopped 0.5–0.75 in. (1.3–1.9 cm) from the larvae and then moved forward to snatch the prey with their mandibles. Casual observations on the adult and fourth instar larva of *Coccinella septempunctata* (L.) feeding on the pea aphid, *Acyrtosiphon pisum* (Harris) seemed to support this latter view that touch is not the only means of prey detection in the coccinellids. Experiments similar in design to Fleschner's but with precise time readings were carried out to test these observations quantitatively.

#### Experiments with adult *Coccinella septempunctata*

Prey detection in adult *Coccinella septempunctata* was tested in an arena which consisted of a filter paper floor, enclosed by an inverted dish 10 cm in internal diameter. A strip of Fluon<sup>®</sup> was painted around the side of the dish so that the predators were confined to the floor and a narrow band on the side of the dish. Two crosses were marked on the filter paper. One marked the point where the predator was to be introduced to the arena, the other marked the test area. The test X was drawn so that it marked a circle of 0.4 cm diameter. This is the same size as the aphid prey used in the experiment. The object of the experiment was to compare the mean time taken by the predator to cross the test mark with that taken to find an aphid prey or silver foil dummy prey placed on the test X. The spherical dummy was made the same diameter as the X and the aphids.

When aphid prey was used, it was carefully arranged so that it covered the X exactly. Aphids were immobilized by squeezing the head with forceps.

The coccinellids used in this experiment were reared on *A. pisum* and maintained at 20°C. Pea aphids were selected from a culture on broad bean plants, maintained at approximately 25°C in a plant culture room lit by 'Powerlux' mercury vapour lamps. All experiments were carried out in a constant temperature room at 20°C. In each test the predator

TABLE 1. Time taken by adult *C. septempunctata* to capture prey or cross the X, mean and standard error

	Time (min)	(SE)	n
Dummy	3.05	(0.55)	20
Aphid	3.52	(0.68)	20
X	8.13	(0.76)	20

was introduced into the arena at the starting X, using a paintbrush, and faced towards the edge of the arena, away from the test X. It was allowed to search until it crossed the test X or found real or dummy prey placed on the X. The average time spent searching in each case is given in Table 1. There were twenty replicates of each test.

The mean searching times required to find real and dummy prey were compared with that taken to cross the X without prey and found to be significantly lower ( $t = 4.54$ ,  $P < 0.001$  for aphid prey,  $t = 5.44$ ,  $P < 0.001$  for dummy prey). The times taken to find real and dummy prey were not significantly different ( $t = 0.53$ ). These results suggest that adult *C. septempunctata* can detect prey by sight.

#### Experiments with fourth instar larvae

The experiment was repeated using fourth instar *C. septempunctata* larvae as predators and a wider range of 'prey'. The arena was made slightly smaller by using a petri dish 9 cm in diameter and the larvae were completely excluded from the sides of the dish by Fluon<sup>®</sup>. Five prey types were tested against the control X. They were: (a) large prey, immobilized by freezing; (b) small prey, immobilized by freezing; (c) large prey, crushed onto the filter paper floor; (d) small prey, crushed onto the filter paper floor; (e) silver foil dummy.

Prey were chosen by eye and then measured to check their size. Large prey were the same size as those used in the previous experiment (0.4 cm diameter). Small prey were 0.2 cm in diameter. All other prey were made the same size as large aphids. The predators were reared in separate tubes from the day of hatching at 20°C and fed on an

TABLE 2. Time taken by fourth instar larvae to capture prey or cross the X, mean and standard error. Individuals taking less than 10 s to complete the test omitted.

	Time (min)	(SE)	<i>n</i>
Large aphid, crushed	2.90	(0.62)	15
Small aphid, crushed	3.85	(0.86)	14
Large aphid, frozen	6.72	(1.28)	15
X	6.97	(1.52)	14
Small aphid, frozen	10.23	(2.42)	15
Small aphid, frozen, corrected for size	8.70		
Dummy	10.07	(1.36)	15

excess supply of *A. pisum*. They were used in the experiment on the second day after moulting into the fourth instar.

The predators were introduced into the arena on the second X as before. Larvae were less easy to handle than adults and could not always be introduced to the arena facing in a uniform direction. Because of this slight variation in starting position, any larvae which caught their prey during the first 10 s of the experiment were discarded. Fifteen replicates were carried out for each prey type. The average times taken to find prey or cross the X are given in Table 2. In order that the time taken to find small aphid prey can be compared with the other values, this reading is multiplied by a conversion factor of 0.85: the diameter of a small aphid plus two ladybird widths divided by that of a large aphid plus two ladybird widths (see below).

Results for all test prey were compared with that for the X by the *t*-test. Neither whole frozen prey (large or small) nor dummy prey were found significantly faster than the X (*t* = 0.13, -0.16 and -1.51 respectively). Frozen prey were eaten readily when encountered. However, large crushed prey were found more rapidly than would be expected by chance (*t* = 2.47, *P* < 0.02). When very close to this prey, some larvae slowed down, attached the 'anal organ' to the floor and cast about with the front part of the body, often contacting the prey. This behaviour was also observed on occasions with small crushed prey although the decrease in time taken to find this prey type is not quite significant (*t* = 1.72, *P* < 0.10). As the

predators seem to be able to detect crushed prey but not whole frozen prey prior to physical contact, it is possible that scent may be involved in this case rather than sight.

### Distance at which prey are detected

#### (a) Adults

If a prey can be detected before contact, then it can be said to have a 'zone of danger' around it, corresponding to the predator's perceptive distance, in which the prey can be detected and may, therefore, be caught. The probability of the predator's path entering into the prey's zone of danger at any particular time depends on the area of the arena and the overall diameter of the prey and zone of danger. Obviously, the wider the zone of danger, the greater the chance of the prey being caught. The control X has no zone of danger. The difference between the average time taken to find prey on X and the X alone can be used to calculate the diameter of the prey's zone of danger and thus the predator's perceptive distance.

In order to estimate this distance, it was assumed that the mean time taken to find the X ( $T_1$ ), or the prey ( $T_2$ ) was inversely proportional to the diameter of the area in which the predator could touch X ( $D_1$ ) or detect prey ( $D_2$ ).  $D_1$  is the diameter of the X plus the width of the ladybird to each side of the X (any part of the ladybird may touch the X).  $D_2$  is  $D_1$  plus the zone of danger to each side of the prey.

Therefore:

$$T_1 \propto 1/D_1 \quad (1)$$

$$T_2 \propto 1/D_2 \quad (2)$$

and

$$D_2 = (T_1 \times D_1)/T_2 \quad (3)$$

The diameter of X is 0.4 cm and the average width of the predators used was 0.59 cm.  $D_1$  is therefore 1.58 cm.

$$\begin{aligned} D_2 &= (8.13 \times 1.58)/3.52 \text{ cm} \\ &= 3.65 \text{ cm} \end{aligned}$$

The actual distance at which prey can be detected is  $(D_2 - D_1)/2 = 1.04$  cm.

## (b) Larvae

$T_2$  for larvae is taken as the average of the times taken to find large and small crushed prey. The width of a fourth instar larva is 0.45 cm so  $D_1 = 1.30$  cm.

$$D_2 = (6.97 \times 1.30)/3.38 \text{ cm} \\ = 2.68 \text{ cm}$$

The perceptive distance for fourth instar larvae is therefore 0.69 cm.

### Discussion

The ability of adult *Coccinella septempunctata* to detect prey visually, as demonstrated by their reaction to aphid and dummy prey, supports Allen *et al.*'s (1970) results with *Anatis ocellata*. No mention is made of prey detection in the larvae of this species. In the present experiments, larvae do appear to detect prey by their scent as there is no reaction to whole frozen or dummy prey. Aphids are known to produce alarm pheromones (Nault & Bowers, 1974) and it is possible that the coccinellid larvae detect these. The freezing of prey might interfere with the emission of these pheromones and thus make frozen prey impossible to detect at a distance.

Perhaps the main reason that prey detection prior to physical contact in the coccinellids has been so little noticed in the past despite a number of experiments and observations is that the distances involved are, to the observer, very small. To the ladybird, however, the ability to detect prey at a distance of 1.04 cm (adult) or 0.69 cm (fourth instar larva) to each side of the body increases the overall perceptive field very substantially: 4.5 times for the adult. Of course, as the values given are means, not all individuals can be expected to respond to prey at these distances. Indeed, some do not appear to react to prey at all until they touch it. There will be some variation in the

hunger levels of the predators for although food was available to all of them prior to the tests, some will have fed more recently than others. The hunger level may affect the distance at which predators react to their prey, as shown by Holling (1966) for the mantid *Hierodula crassa* (Giglio-Tos).

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