

Comparative prey consumption and searching efficiency of *Coccinella septempunctata* Linnaeus and *Coccinella transversalis* Fabricius on different aphid species

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ABSTRACT: The comparative prey consumption and searching efficiency of fourth instar grubs of *Coccinella septempunctata* Linnaeus and *Coccinella transversalis* Fabricius against three aphid species, viz. *Rhopalosiphum maidis* (Fitch), *Myzus persicae* (Sulzer) and *Macrosiphum rosae* (Linnaeus) were evaluated to assess the efficiency of these predators in aphid biocontrol. The larvae of *C. septempunctata* consumed maximum number (245.60 ± 1.92) of *M. persicae* at prey density of 800 and minimum (18.80 ± 0.88) of *R. maidis* at prey density of 25 in 24 hours. Fourth instar of *C. transversalis* consumed maximum number (224.80 ± 1.93) of *M. persicae* at the prey density of 800 and minimum number (17.40 ± 0.58) of *M. rosae* at the prey density of 25 in 24 hours. Area of discovery of *C. septempunctata* and *C. transversalis* was maximum at the lowest predator (1) and prey-densities (25) of *M. persicae*. The same was minimum in the case of *C. septempunctata* and *C. transversalis* at highest predator (8) and prey-densities (800) of *R. maidis* and *M. rosae*, respectively. Prey consumption by both coccinellids increased but their searching efficiency decreased with increase of either prey or predator density. The predatory potential and searching efficiency of *C. septempunctata* was relatively higher than that of *C. transversalis*.

KEY WORDS: Aphids, *Coccinella septempunctata*, *Coccinella transversalis*, functional response, numerical response, searching efficiency

Aphids are economically important insects causing severe damage to a number of crop plants. *Rhopalosiphum maidis* (Fitch) infests maize plants and reduces yield (Foott, 1975). The potato crop is attacked by five aphid species of which *Myzus persicae* (Sulzer) is the most injurious (Verma, 1986). *Macrosiphum rosae* (Linnaeus) infests rose plants (Agarwala, 1983). Therefore, their management is necessary. Certain pesticides, though effective against these aphids cause environmental problems. This has necessitated the search for ecofriendly substitutes (Omkar and Srivastava, 2000). Predaceous coccinellids, *Coccinella septempunctata* Linnaeus and

Coccinella transversalis Fabricius are locally available in crop fields (Omkar and Bind, 1993). Functional and predatory numerical responses are important parameters in the selection of a successful biocontrol agent (Waage, 1990). Functional response is a good measure of an efficient predator (Hassell, 1992) and should form the basis for assessing the comparative efficiency of ladybird beetles (Houck and Strauss, 1985). The present investigation was designed in this light to evaluate the comparative efficacy of fourth instars of *C. septempunctata* and *C. transversalis* against *M. persicae*, *R. maidis* and *M. rosae* to understand their potential in the biocontrol of these aphid pests.

MATERIALS AND METHODS

Two sets of experiments were designed to investigate functional and numerical responses of twelve-hour starved fourth instar grubs of *C. septempunctata* and *C. transversalis* in relation to three aphid species, viz., *R. maidis*, *M. rosae* and *M. persicae*. The first set of experiments was designed to evaluate the effect of various prey densities on prey consumption and searching efficiency of the predators on different aphid species. The second set of experiments was designed to assess the effect of various predator densities on prey consumption and searching efficiency of the predators on different aphid species.

For the first set of experiments, fourth instar grubs of *C. septempunctata* and *C. transversalis* were kept individually in glass jars (diam 11.0cm; height 8.5cm) and starved for twelve-hours in order to standardize the level of hunger and prevent subsequent cannibalism. Six different densities, viz., 25, 50, 100, 200, 400 and 800 of third instar nymphs of the three species of aphids, were kept on twigs of their host plants in separate glass jars. The open ends of the jars were covered with muslin cloth and secured with rubber bands. Third instars of aphids were used to minimize the possibility of increase in aphid numbers through reproduction. One twelve-hour starved larva of each coccinellid species was introduced in each jar for twenty-four hours. After completion of the experiment, the predators were withdrawn from the jars and unconsumed aphids counted to find out the number of prey consumed.

For the second experiment, fourth instar grubs of the predator were kept in glass jars (diam 11.0cm; height 8.5cm) following starvation for twelve-hours. Two hundred third instar nymphs of different prey were placed on host plants in glass jars. One, two, four and eight larvae of *C. septempunctata* and *C. transversalis* were introduced in different glass jars. The experiment was carried out for three hours. After three hours, the predators were taken out from the jars and unconsumed aphids were

counted to compute the number of prey consumed by the predators.

The experiments were replicated ten times and the data obtained were analyzed by linear regression using Statistix 4.1 (1994) software. The area of discovery was calculated following Nicholson and Bailey (1935).

$a = 1/P \log_e N/S$ (where, a = area of discovery)

N = prey density exposed for predation

P = predator density released for predation

S = number of prey surviving predation

RESULTS AND DISCUSSION

The data revealed that prey (i.e., *M. persicae*, *M. rosae* and *R. maidis*) consumption by fourth instar grubs of *C. septempunctata* increased with increase in prey density (25 to 800) (Table 1). The data (Table 2) revealed that prey namely, *M. persicae*, *M. rosae* and *R. maidis* consumption by *C. septempunctata* increased with increase in predator density from 1 to 8. The regression equations of *C. septempunctata* for *M. persicae*, *M. rosae* and *R. maidis* were: $Y=0.855+3.2792 \log X$, $r=0.99$; $Y=0.9026+2.9844 \log X$, $r=0.98$, and $Y=0.111+0.7061 \log X$, $r=0.96$; $P<0.001$, respectively.

Prey (*M. persicae*, *R. maidis* and *M. rosae*) consumption by larvae of *C. transversalis* increased when prey density increased from 25 to 800 (Table 3) and when predator density increased from 1 to 8 (Table 4). The regression equations of *C. transversalis* for *M. persicae*, *R. maidis* and *M. rosae* were $Y=0.8611+3.1553 \log X$, $r=0.98$; $Y=0.8448+3.0776 \log X$, $r=0.96$ and $Y=0.7894+3.0623 \log X$, $r=0.98$; $P<0.001$, respectively.

The mean number of prey consumed by each predator species is proportional to the prey density. Prey consumption of both the species increased with increase in prey and predator densities. The increase in prey consumption by the predators with increase in prey densities may be due to many

factors, viz., greater interaction of prey and predators, decreased handling time, limited area of searching and the level of starvation (Omkar and Srivastava, 2002). However, when predator density doubled, prey consumption by the predator did not double, but remained less than double. Decreased consumption may be ascribed to the limited time

of predation and the restricted area of searching. When time of predation was limited, the predators had to face hindrance from increased number of prey and predators thus resulting in decreased prey consumption. Satiation can also be a major factor in limiting the predation at increased prey density.

Table 1. Prey consumed by *C. septempunctata* at different densities of different prey species

| Prey density | Prey consumption / Predator / 24 h | | |
|--------------|------------------------------------|-----------------|------------------|
| | <i>M. persicae</i> | <i>M. rosae</i> | <i>R. maidis</i> |
| 25 | 23.20±0.69 | 22.00±0.50 | 18.80±0.88 |
| 50 | 36.40±0.77 | 37.20±0.99 | 32.40±0.83 |
| 100 | 72.00±1.25 | 62.60±1.89 | 49.20±0.69 |
| 200 | 109.00±2.22 | 105.60±2.27 | 82.20±1.41 |
| 400 | 161.40±1.72 | 139.60±2.82 | 100.20±3.07 |
| 800 | 245.60±1.92 | 183.60±2.82 | 132.820±2.08 |

Table 2. Prey consumed by different densities of *C. septempunctata* at constant prey densities of different prey species

| Predator density | Prey consumption (3 h) | | |
|------------------|------------------------|-----------------|------------------|
| | <i>M. persicae</i> | <i>M. rosae</i> | <i>R. maidis</i> |
| 1 | 61.60±2.12 | 42.60±1.54 | 22.60±1.02 |
| 2 | 90.00±1.84 | 68.40±0.92 | 41.60±1.07 |
| 4 | 132.00±2.46 | 90.80±1.26 | 80.80±1.09 |
| 8 | 173.80±2.90 | 147.80±1.76 | 114.20±1.63 |

Table 3. Prey consumed by *C. transversalis* at different densities of different prey species

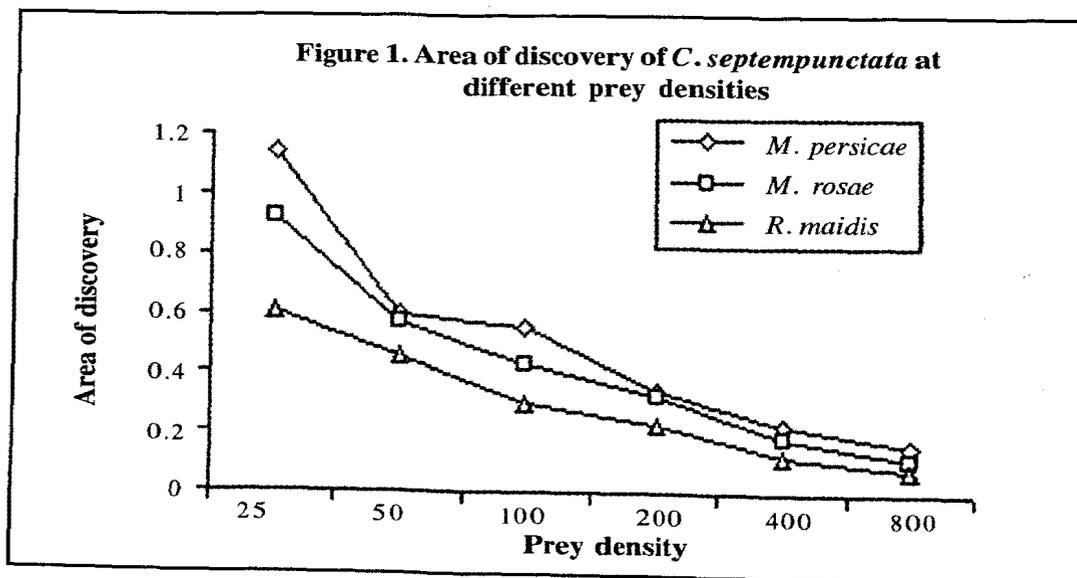
| Prey density | Prey consumption / Predator / 24 h | | |
|--------------|------------------------------------|------------------|-----------------|
| | <i>M. persicae</i> | <i>R. maidis</i> | <i>M. rosae</i> |
| 25 | 22.40±0.48 | 21.00±0.93 | 17.40±0.58 |
| 50 | 34.40±0.62 | 32.00±1.06 | 28.60±0.97 |
| 100 | 62.40±1.07 | 62.20±1.76 | 54.60±1.68 |
| 200 | 99.80±1.32 | 93.40±2.40 | 88.80±2.04 |
| 400 | 146.40±2.37 | 125.40±2.41 | 110.80±2.08 |
| 800 | 224.80±1.93 | 193.60±2.85 | 153.80±2.59 |

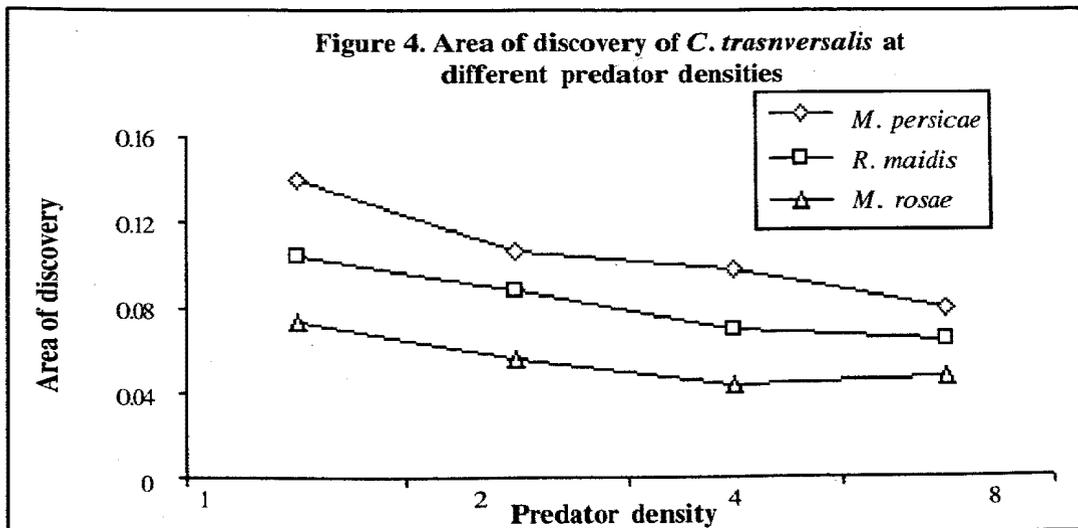
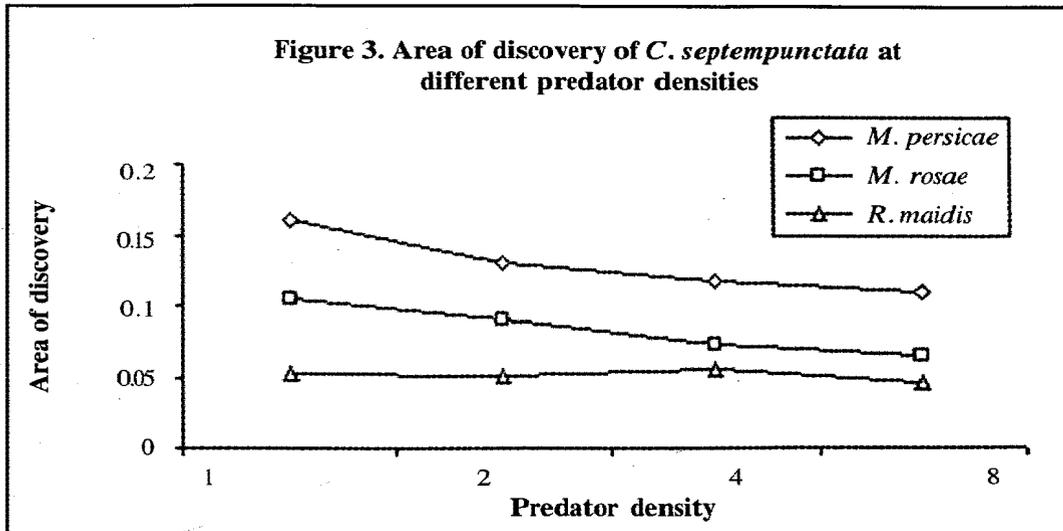
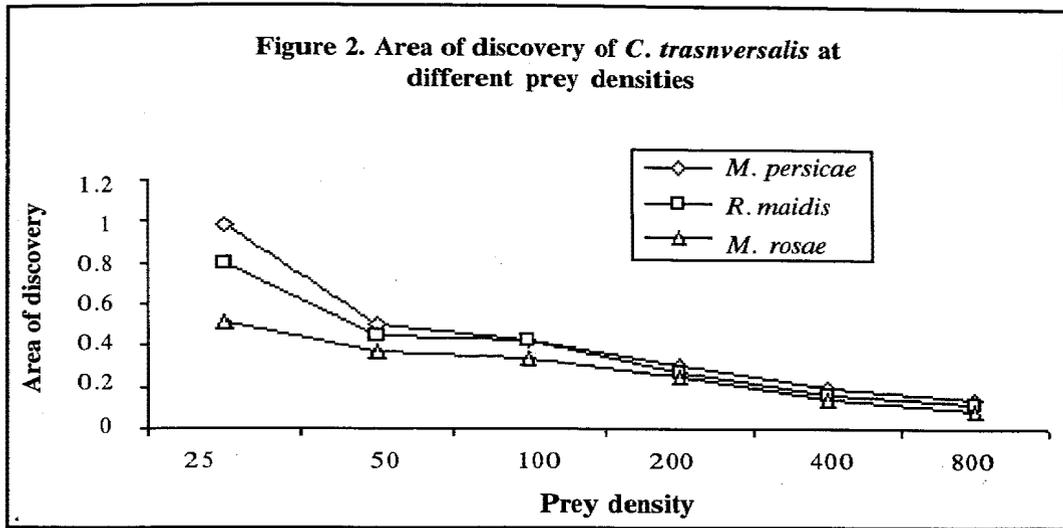
Table 4. Prey consumed by different densities of *C. transversalis* at constant prey densities of different prey species

| Predator density | Prey consumption (3 h) | | |
|------------------|------------------------|------------------|-----------------|
| | <i>M. persicae</i> | <i>R. maidis</i> | <i>M. rosae</i> |
| 1 | 55.20±1.07 | 42.80±1.30 | 31.00±0.64 |
| 2 | 77.40±1.24 | 66.80±1.26 | 45.80±0.97 |
| 4 | 103.20±1.94 | 89.60±1.54 | 65.20±1.79 |
| 8 | 167.00±2.75 | 144.20±2.74 | 115.20±2.89 |

The number of prey consumed by a predator depends upon one of the following reasons: (a) the nutritive value of the prey for a predator plays an important role in the number of prey consumed, (b) the relative ease with which the prey is handled and caught. The feeding preference of *C. septempunctata* was found to be: *M. persicae* > *M. rosae* > *R. maidis*, while *C. transversalis* preferred *M. persicae* the most followed by *R. maidis* and *M. rosae*. The maximum consumption of *M. persicae* by both predators could be a result of its suitability in terms of nutritive value to the predators as well as its moderate size. The change in the preference of both the predators for the aphids, *R. maidis* and *M. rosae* may be a combined result of their nutritional contents and relative sizes. *M. rosae* is a large sized aphid and *R. maidis* is smaller in size, with *M. persicae* being of moderate size. These

differences in sizes indicate that ease in handling by the predators should follow the sequence *R. maidis*, *M. persicae* and *M. rosae*. However, this was not the trend observed in case of both the ladybird beetles. The maximum consumption of *M. persicae* can be attributed to its moderate size with its nutritive quality fulfilling the needs of both the predator. *M. rosae* with its large size should have been consumed the least but it was second in the preference list of *C. septempunctata*. The probable reason could be its increased nutritive value for *C. septempunctata*. While in *C. transversalis* the increased consumption of *R. maidis* could have been the result of both its nutritive value and small size. The success or failure of a predator is dependent on the relative sizes of the prey and predator (Klingauf, 1967).





The area of discovery of *C. septempunctata* (Fig. 1) and *C. transversalis* (Fig. 2) decreased for *M. persicae*, *M. rosae* and *R. maidis* when prey density increased from 25 to 800. The area of discovery of *C. septempunctata* (Fig.3) and *C. transversalis* (Fig. 4) decreased for *M. persicae*, *M. rosae* and *R. maidis*, respectively, when the predator density increased from 1 to 8.

The decrease in the area of discovery of fourth instar grubs of both the coccinellid species with increased prey and predator densities was possibly because of the fact that with increase in prey and predator densities, the predator turns from extensive search for prey to intensive search, which leads to decrease in the area of discovery. Increased prey density resulted in reduction in the searching arena for predators, increasing the chance of prey-predator interaction. At low prey densities, aphids were spaced out due to which the predators spent most of their energy and time in foraging. Scarce prey density possibly stimulates the foraging behaviour of predators. Thus, at higher prey density the need to search the prey by the predator decreased. Higher densities of prey and predator have an inverse effect on the searching efficiency of the predator (Hassell and Varley, 1969; Ofuya and Akingbohunge, 1988; Tripathi *et al.*, 2000).

The area of discovery of both the predators differed more at lower densities (25, 50, 100) of prey species than at higher densities (200, 400 and 800). This suggests that above a certain level of prey density there was no difference in the searching efficiency of the predator in relation to various prey species. Interference by the prey was so high above this threshold level that searching efficiency of the ladybird beetles was governed only by prey density and not by prey species.

Thus investigation on prey consumption and searching efficiency of fourth instar of *C. septempunctata* and *C. transversalis* at different prey and predator densities indicates that: (1) prey consumption of predators increased with increase in prey density, (2) searching efficiency of predators decreased with increase in prey density; (3) the order of prey preference of *C. septempunctata* was

M. persicae > *M. rosae* > *R. maidis* and of *C. transversalis* was *M. persicae* > *R. maidis* and *M. rosae*, (4) the larvae of *C. septempunctata* more frequently attacked relatively bigger aphids than *C. transversalis*, (5) prey suitability and capacity to capture prey govern prey consumption, (6) *C. septempunctata* is a more voracious and potent predator of *M. persicae* and *M. rosae* than *C. transversalis* but *C. transversalis* is more effective than *C. septempunctata* against *R. maidis*.

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