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# Satiation time and appetite revival of *Coccinella septempunctata* L. (Col., Coccinellidae), a predator of *Lipaphis erysimi* Kalt. (Hom., Aphididae)

**N. Kumar, A. Kumar and C. P. M. Tripathi**
Laboratory of Entomology, Department of Zoology, University of Gorakhpur, Gorakhpur, India

**Abstract:** After a 24 h period of starvation the *Coccinella septempunctata* grub satiated in 85 min after eating 31.57 ± 7.12 prey (aphids). After 6, 12, 18, 24, 30 and 36 h of prey deprivation, the grub consumed 14.31 ± 5.67, 22.05 ± 5.39, 27.10 ± 6.49, 31.57 + 7.12, 33.76 + 6.52, and 36.98 ± 8.56 prey, respectively. The voluntary intake (appetite) shows a sigmoid relationship with the time since the last meal, with an upper limit of 44.30 prey irrespective of the prey deprivation period. As maximum appetite was attained after 24–36 h of deprivation, it is recommended that *C. septempunctata* grubs should be starved for 24 h prior to release in the biological control programme of *Lipaphis erysimi*.

## 1 Introduction

An animal is considered to be satiated when it no longer accepts the offered food after a period of active feeding; the time from start of feeding to such a voluntary cessation is the satiation time (Brett, 1971). Voluntary food intake has been considered as a measure of appetite (Holling, 1966). Although, satiation time and appetite revival has been studied in detail in fishes (Ware, 1972; Elliott, 1975; Groove et al., 1978; Singh and Srivastava, 1985), there has been less attention given to insect predators (Mathavan, 1976; Hodek et al., 1984).

*Coccinella septempunctata* L. has been reported to be an effective biological control agent of *Lipaphis erysimi* Kalt. (Atwal et al., 1969; Sinha et al., 1982; Pandey et al., 1984), a serious pest of *Brassica campestris* L. (Pandey et al., 1984, 1986). The present study was undertaken to examine the effect of different periods of prey deprivation on the number of prey, as well as the time required to satiate the *C. septempunctata* grub and to determine the maximum appetite of the grub. The result are discussed within the context of how pre-release conditions may optimize predator efficacy in biological control programmes.

## 2 Material and methods

The aphid, *L. erysimi* and the predator, *C. septempunctata* were reared in the laboratory at 18 ± 4°C and 75 ± 8% relative humidity using the techniques of Wheeler (1923) and Singh and Malhotra (1979), respectively. Third instar nymphs of the aphids (the stage most preferred by the predators (Sinha et al., 1982) and third instar grubs (Hamalainen, 1977; Raychaudhary et al., 1981) of *C. septempunctata* were utilized as prey and predators.

### 2.1 Satiation time

To determine the satiation time, 200 third instar nymphs of the aphids were placed on a leaf of *B. campestris* (approximately 4 cm × 1. 6 cm) in a Petri dish (5 cm × 1. 7 cm) with moistened filter paper in the bottom. Before each test, the predator was starved for 24 h, before being placed in the Petri dish. The number of prey consumed by the coccinellid predator was recorded continuously. A constant density of 200 prey was maintained by adding the number of prey consumed in every 5 min period.

### 2.2 Appetite revival

To determine the appetite revival time, each grub was fed to their satiation and then deprived of prey for 6, 12, 18, 24, 30 and 36 h. Subsequently they were exposed to a constant supply of 200 prey and observations were taken as in the previous experiments. Both the experiments were replicated 20 times.

## 3 Results

### 3.1 Satiation time

Following a 24 h period of prey deprivation, the *C. septempunctata* grub consumed 31.57 ± 7.12 aphids in 85 min before becoming satiated (fig. 1). The rate of prey consumption decreased with time (fig. 2) with 23.15% of the aphids (7.31 ± 1.709) being consuming in the first 5 min.

The number of successful attacks expressed as a percentage of total number of prey consumed by predator is termed as 'predator efficiency' (Mathavan, 1976). This efficiency decreased from 23.15% during the first 5 min to 4.43% in the last 5 min. These

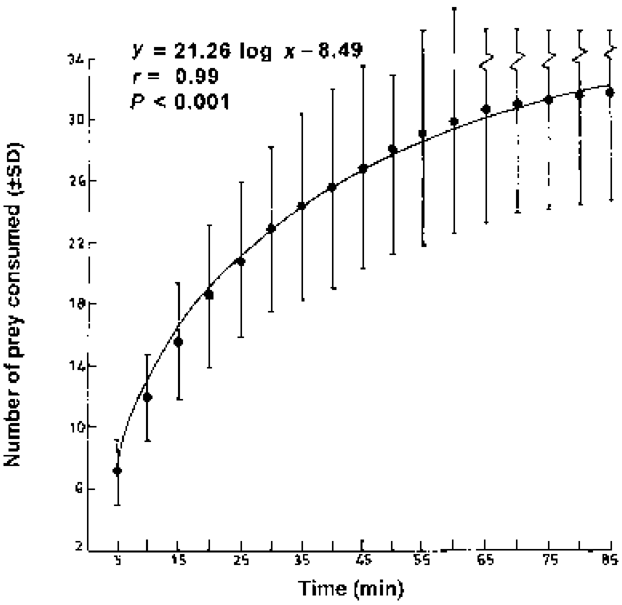


***Fig. 1.*** *The cumulative number of* L. erysimi *consumed by* C. septempunctata *larvae over 85 min, following a 24 h period of host deprivation*

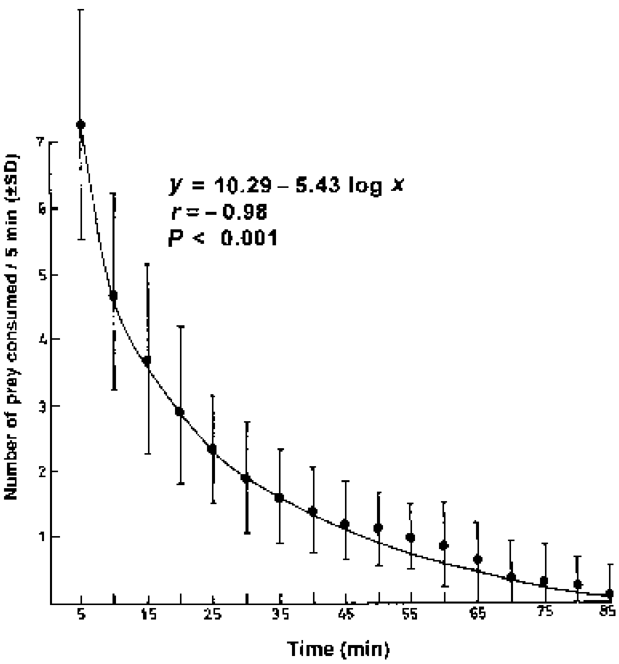


***Fig. 2.*** *The number of prey consumed in consecutive 5 min intervals by* C. septempunctata *larvae following a 24 h period of host deprivation*

observations indicate that within a period of about 85 min the predator is fully satiated.

### 3.2 Appetite revival

The total number of prey consumed and time required to reach satiation, increased with the time elapsed since the last meal (table 1, fig. 3). Predators that had been starved for 6 h, satiated after consuming 14.30 ± 5.67 prey in 35 min. These values progressively increased

***Table 1.*** *The number of prey (aphids) consumed and the time taken to reach satiation by* Coccinella septempunctata *larvae as a function of the time elapsed since the last meal*

| Starvation period (h) | Total prey consumed (± SD) | Time (min) to satiate |
|---|---|---|
| 6 | 14.30 ± 5.67 | 35 |
| 12 | 22.05 ± 5.39 | 60 |
| 18 | 27.10 ± 6.49 | 75 |
| 24 | 31.57 ± 7.12 | 85 |
| 30 | 33.76 ± 6.52 | 90 |
| 36 | 36.98 ± 8.55 | 95 |

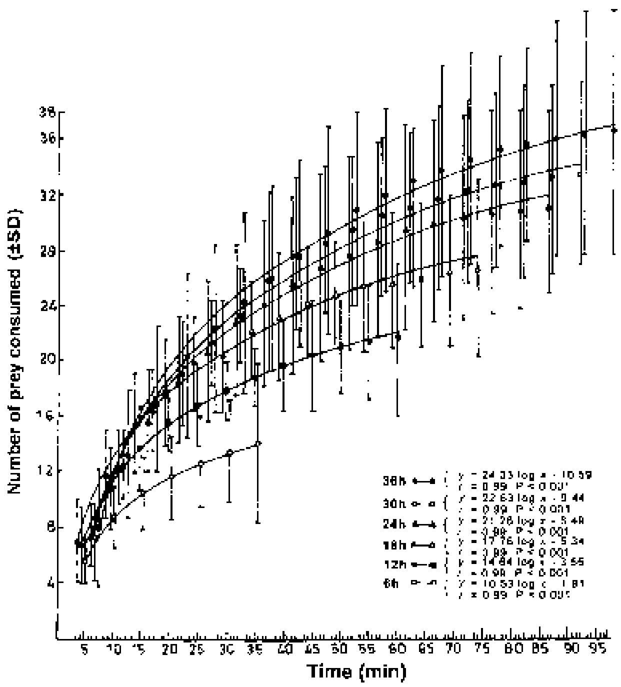


***Fig. 3.*** *The cumulative number of* L. erysimi *consumed by* C. septempunctata *larvae in function of the duration of host deprivation*

for the predators starved for 12, 18 and 24 h after consuming 22.05 ± 5.39, 27.10 ± 6.49, 31.57 ± 7.12 prey and satiated in 60, 75 and 85 min, respectively. As no significant differences were observed between predators starved for 24, 30 and 36 h, it may be concluded that maximum appetite is reached after a 24 h period of prey deprivation. From our data the measure of appetite in function of host deprivation time is best described by the exponential equation:

$$y = K(10)^{\left(\frac{c}{a+x^2}\right)}$$

where $K$, $c$, and $a$ are constants. The equation describes a steadily rising curve which approaches a limit or asymptote $y = K$, as the value of $x$ increases indefinitely (Rosander, 1957). The maximum value of $K$, regardless of the period of prey deprivation, is 44.30 aphids (fig. 4), which is the maximum limit of $y$ (prey consumption).

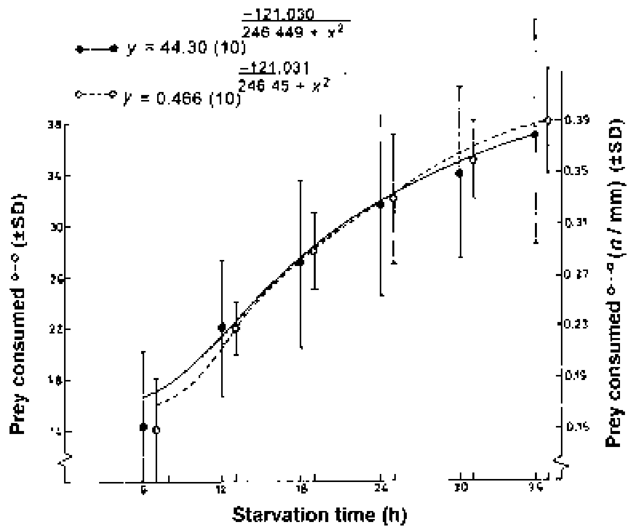


***Fig. 4.*** *The number of prey required to satiate* C. septempunctata *larvae in function of the duration of host deprivation*

Considering the initial predation period of 95 min, the mean number of prey consumed by a predator exposed to a constant supply of 200 prey after a period of 6, 12, 18, 24, 30 and 36 h of starvation was also calculated and plotted against the different starvation periods (fig. 4). The typical sigmoid curve was also obtained by the above-mentioned equation. The value of $K$ in this case was 0.466 which represents the maximum consumption/min. The prey consumption was 0.14/min for the predator fed after 6 h of deprivation and increased to 0.33/min for a predator fed after 24 h of deprivation and levelled off at 0.39/min for 36 h of deprivation. Therefore, it is concluded that after between 24 and 36 h of deprivation, the maximum appetite of C. *septempunctata is* restored.

## 4 Discussion

### 4.1 Satiation time

Satiation time varies from species to species. *Coccinella septempunctata* consumed prey slowly for 85 min before it was satiated. *Trachurus japonicus*, *Salmo gairdneri* (Ishiwata, 1968), *Oncorhynchus nerka* (Brett, 1971) and *Mesogomphus lineatus* (Mathavan, 1976) took 65, 60, 43 and 50 min, respectively, whereas *Fugi vermicularis* and *Stephanolepis cirrhifer* (Ishiwata, 1968) satiated in 6 and 13 min.

Several factors are responsible for variation in the consumption and consequently can affect the satiation (Sailer and Lienk, 1954; Mayr, 1955; Rozin and Mayr, 1961; Hati and Ghosh, 1965; Ellis and Borden, 1970; Lovell, 1976; Brett, 1979; Holmgren et al., 1983; Hodek et al., 1984; Singh and Srivastava, 1985). However, the gradual decrease in consumption of prey by *C. septempunctata* with approaching satiation suggests that the distention of the stomach due to accumulation of food is an essential element for satiation.

In prey–predator interaction in which both the predator and the prey are mobile, as in the case of *C. septempunctata* and *L. erysimi*, satiation time involves two important aspects: (1) predation, and (2) consumption (= handling time). Handling time has been considered as one of the most important factors in satiation time (Rashesky, 1959; Holling, 1966; Ware, 1972; Hassell et al., 1977; Hodek et al., 1984; Singh and Srivastava, 1985). It was frequently observed that at these high prey densities the predator captured either two prey at a time or captured one while a previously captured one was being consumed. Therefore, the time required for predation and consumption could not be recorded separately.

### 4.2 Appetite revival

A steep decline of predation rate after 5 min of consumption is typical of many predators (Beukema, 1968; Ellis and Borden, 1970; Mathavan, 1976). Holling (1966) observed that, as flies were eaten by the preying mantis, *Iarodula crassa*, there was a decrease in mantis hunger, which in turn caused a sharp decline in attack rate until the hunger was established. In other words, when the stomach of the predator is full, it ceases feeding and attacking the prey. The predator renews attack on the prey when the appetite is partially or fully returned. The mechanisms known to regulate the return of appetite in predators are: (1) stomach (Pandian, 1967; Windell, 1970) or intestinal evacuation (Mayr, 1955), (2) blood glucose level (de Ruitner, 1963) and (3) physiological changes such as those caused by sex hormones (Kleerekoper and Mogensen, 1963).

The appetite increased slowly in the beginning and then rapidly up to a maximum at 24 h of deprivation. Thereafter it increased so slowly that an asymptote was obtained (fig. 4). There was a slight increase in the consumption of predators after between 24 and 36 h of deprivation. Possibly the content from the stomach moved out during this period. Apparently gastric evacuation facilitates the transfer of a part of the chyme from the stomach to the intestine (Mathavan, 1976). Stomach evacuation has been shown to play a major role in appetite return (Pandian, 1967; Brett and Higgs, 1970; Ware, 1972; Singh and Srivastava, 1985).

The results of this study have revealed that *C. septempunctata* is a predator that is well-suited to capturing the prey *L. erysimi*. The maximum appetite in *C. septempunctata* is produced after 24–36 h of starvation. Therefore, 24 h of deprivation is recommended prior to release of *C. septempunctata* for the purpose of controlling *L. erysimi* in the field.

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**Authors' address:** N. Kumar, A. Kumar, Dr C. P. M. Tripathi (corresponding author), Laboratory of Entomology, Department of Zoology, University of Gorakhpur, Gorakhpur-273 009, India