

Predatory response and performance of
Coccinella septempunctata L.
(Coleoptera:Coccinellidae) to alternative prey
Epilachna vigintioctopunctata (Coleoptera:
Coccinellidae)

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Title : Predatory response and performance of *Coccinella septempunctata* L.
(Coleoptera: Coccinellidae) to alternative prey *Epilachna*
vigintioctopunctata (Coleoptera: Coccinellidae)
(代替獲物ニジュウヤホシテントウに対するナナホシテントウ(甲虫目: テン
トウムシ科) の捕食反応とパフォーマンス)

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Thesis Summary

Epilachna vigintioctopunctata is an economically significant voracious pest in some important crop families worldwide. Application of synthetic pesticides is the most common method to suppress the *Epilachna* beetles leading to resistance development. Therefore, safer and eco-friendly biological control measures are necessary to manage this pest, reducing the pesticide risk for sustainable crop production. Although a few natural enemies have been recorded, intensive study of predators attacking *E. vigintioctopunctata* is critical to establish effective pest management programs with the aid of natural enemies.

Coccinella septempunctata is generally considered as a specialist predator for aphids but is also a voracious predator of alternative prey where essential prey is absent or scared. The present study aimed to reveal the importance of this ladybird beetle as a natural enemy of *Epilachna* and to lead a better understanding of the predator-prey interaction between *C. septempunctata* and *E. vigintioctopunctata*. For this purpose, predation and performance of *C. septempunctata* were investigated to assess the potential of a biological agent to control *E. vigintioctopunctata*. Specifically, the present study addressed (1) behavioral response of *C. septempunctata* to plant volatiles induced by two co-occurring pests; chewing herbivore, *Epilachna vigintioctopunctata* versus a sucking pest, *Aphis gossypii* in four vegetable cropping systems, (2) functional response and predatory efficiency of all stages of *C. septempunctata* to 6 densities of *Epilachna* larvae, and (3) the development and reproductive consequence of alternative and mixed prey diets on the fitness of *C. septempunctata*.

Chapter 1 mainly focused on the general information of *C. septempunctata* and *E. vigintioctopunctata*. It described the importance of Coccinellidae in biological control, dietary range, the rationale of the study, and the objectives.

Chapter 2 examined whether *C. septempunctata* could be attracted to herbivore-induced plant volatiles emitted by plants damaged by single or multiple herbivores and whether these volatiles could have a vital role in tri-trophic interactions. Experiments were carried out to investigate the behavioral response of *C. septempunctata* to odors from cucumber, bean, potato, and brinjal leaves infested by essential prey aphid, *Aphis gossypii* and/or alternative prey, *Epilachna vigintioctopunctata* through an olfactometer bioassay. The results demonstrated that *C. septempunctata* attracted selectively to leaves damaged by either aphids or *Epilachna* over undamaged leaves, but the magnitude of attraction depended on plant species. In terms of selectiveness, the ladybird did not distinguish between leaves infested by the two herbivores, however, it responded more quickly to aphid-infested plants than plants infested by the alternative prey. Plants infested simultaneously by both herbivores were more attractive in terms of readiness than those damaged by *A. gossypii* or *E. vigintioctopunctata* alone in three plants except bean plants. Thus, it was evident that the ladybird beetle uses volatiles emitted from damaged plants to locate its prey. This study highlighted that the behavioral response of *C. septempunctata* to herbivore-induced plant volatiles is complex and can depend on plant species and herbivore types and suggested the potential of *C. septempunctata* as a predator in the biological control of *E. vigintioctopunctata* for cucumber and potato fields.

In Chapter 3, functional response and searching efficiency were quantified to reveal the predatory potential of *C. septempunctata*. The feeding potential and functional response of all growth stages of *C. septempunctata* were examined under different densities of first instar *Epilachna*. The results revealed that type II functional response was exhibited for all stages except the 1st instar. The feeding potential and functional response curve depended on the development stage and gender. The attack rate was not a good indicator of predator efficiency. The 4th instar required minimum time to search their prey and showed the highest predation rate. Hence, based on three key

parameters in functional response, the 4th instar of *C. septempunctata* was superior to other developmental stages. The mean prey consumption increased with increasing prey densities, regardless of the developmental stage. Predatory efficiency did not differ significantly among 4th instar, adult females, and males. However, the feeding percentage was inversely related to the density and higher at low prey densities which indicated that this predator would be more effective at lower *Epilachna* densities. It was thus concluded that 4th instar and adults (male and female) of *C. septempunctata* were most influential in suppressing *E. vigintioctopunctata* and identified as a potential candidate in biological control.

Chapter 4 addressed the fitness of the predators when feeding on the two prey species. Tests were conducted to evaluate the suitability and effectiveness of *Epilachna* larvae over cotton aphids in sole or mixed prey diet as prey for the development, survival, and reproductive parameters of *C. septempunctata*. Although *Epilachna* was not toxic to or rejected by *C. septempunctata*, *A. gossypii* was the essential prey for full development and successful reproduction of *C. septempunctata*. The alternative prey diets caused significantly lower performance (long development time and great mortality and low adult weight) compared to those fed on essential aphid prey. *C. septempunctata* that fed on only *E. vigintioctopunctata* did not finish development because *Epilachna* did not have adequate nutrition. The adult emergence rate, longevity, and fecundity of *C. septempunctata* fed on a mixed diet were significantly lower than those fed on aphids only. Experiments also confirmed that oviposition of *C. septempunctata* was only stimulated in the presence of aphids while ceasing *Epilachna* diet. The present study suggests that *C. septempunctata* may benefit from balancing its nutritional requirements through the mixed diet but the dietary mixing may not always be beneficial enough for this generalist predator.

The results of this dissertation included several new discoveries on alternative prey use and foraging tactics of *C. septempunctata*. The use of *Epilachna* prey was previously unknown for *C. septempunctata* and it was also first documented in this study. Also, 4th instar, males and females of *C. septempunctata* stages were identified as potential candidates for low prey densities or early population dynamics in *E. vigintioctopunctata*. Therefore, *C. septempunctata* can be used as a biocontrol agent in controlled conditions where *Aphis gossypii* and *Epilachna vigintioctopunctata* are concurrently infested in cucumber and potato cropping systems expanding the prey plasticity response of *Coccinella septempunctata* in tri-trophic interactions.