Research Article

Comparison of Feeding Ability between *Ischiodon scutellaris* (Diptera: Syrphidae) and *Menochilus sexmaculatus* (Coleoptera: Coccinellidae) on *Aphis craccivora* (Hemiptera: Aphididae)

Perbandingan Kemampuan Makan antara *Ischiodon scutellaris* (Diptera: Syrphidae) dan *Menochilus sexmaculatus* (Coleoptera: Coccinellidae) terhadap *Aphis craccivora* (Hemiptera: Aphididae)

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ABSTRACT

Study on the feeding ability of two predators of *Aphis craccivora* (Koch), i.e. larvae of syrphid fly, *Ischiodon scutellaris* and coccinellid beetle, *Menochilus sexmaculatus* has been done in the laboratory. The study was conducted to determine the impacts of prey densities on larval development time, and the survival rate of larval stage. The results showed that *M. sexmaculatus* larvae required more prey than *I. scutellaris* in the 1st instar, but *I. scutellaris* ate more prey than *M. sexmaculatus* in the 3rd instar. Furthermore, addition of prey number shortened significantly the development time of the larvae stage, almost all of 1st and 3rd instars *M. sexmaculatus* and *I. scutellaris* were able to develop into pupae, whereas, only 45% out of total 1st instar provided with 20 prey individuals succeed to pupate. The impact of the number of prey on the biology of aphidophaga in relation to their role as controlling aphid in nature is discussed in this paper.

Keywords: *Aphis craccivora*, feeding ability, *Ischiodon scutellaris*, *Menochilus sexmaculatus*

INTRODUCTION

*Aphis craccivora* (Koch) is noted as an important pest on legume and ornamental crops in the world (Kalshoven, 1981). Feeding activity directs damage the plant directly due mechanical injury and loss of phloem sap. In addition, it has long history for transmitting viruse diseases on many cropspecies, for example on *Vicia fabae* (Allam & El-Kady, 1966; Nuessly et al., 2004), *Vigna unguiculata* (Atiri & Thottappilly, 1985; Damiri et al., 2013), and citrus (Satar & Onelge, 2009). The use of natural enemies is one of the best alternative for controlling this aphids, since many species of predator and parasitoid often naturally present in fields. Among the huge number of aphidophagous insects, ladybeetle (Coleoptera: Coccinellidae) and hover fly (Diptera: Syrphidae) are noted as important predators due to their ability to consume a high number of aphids.
Menochilus sexmaculatus (Coleoptera: Coccinellidae) is a common aphidophagous beetle which has a wide range of preys (Rajamohan & Jayaraj, 1973; Mari et al., 2004; Rana, 2006). This species also has a wide distribution area, so its ability to prey upon different species of prey has been received much attention. In general, M. sexmaculatus showed a good response to prey densities, although apparently it more likely to forage on a smaller number of prey density, as showed in a study by Agarwala et al. (2001). In addition, the female of coccinellid shows resource partitioning in terms of body size and density, as showed in a study by Agarwala et al. (2001). Chaudary et al. (2015) revealed that small and big female of M. sexmaculatus tended to prey on small and big instars of aphids, respectively.

Meanwhile, Ischiodon scutellaris (Diptera: Syrphidae) is also well known as aphid predator. However, it has received only a few attention by ecologist. In general, several studies have been showing the importance of predatory syrphids to suppress the populations of aphids. For example, Gilbert (2005) noted that predatory syrphids having many types prey species and each species might has prey specificity. Thus, in terms of shaping community structure, the occurrence of predatory syrphids is very important. In addition, Tenhumberg and Poehling (1995) showed that population of syrphid reached maximum number at prey density of 100 aphids per day at temperature above 22°C, indicating that it is a potential prodator that has positive response to aphid population.

Furthermore, although studies on the feeding ability of I. scutellaris and M. sexmaculatus on Aphis craccivora and other aphids are numerous, study to compare their feeding ability on the same prey is rare. This experiment was done to determine the feeding ability of the two predator species, and its ecological consequence to suppress the population of aphid in field based on their response to prey density.

MATERIALS AND METHODS

Insect Culture

Cultures of Ischiodon scutellaris, Menochilus sexmaculatus, and Aphis craccivora were maintained at the Laboratory of Basic Entomology, Faculty of Agriculture, University of Gadjah Mada at room condition (temperature 24–26.5°C and relative humidity 67%–85%).

Aphid as prey for both predators were fed with yardlong bean (Vigna unguiculata subsp. sesquipedalis), seedlings were grown on soil prepared in small plastic tray (28.5 cm × 21 cm). Larvae of I. scutellaris were collected from yardlong bean in Magelang and Sleman Regency, then were placed in petri dishes (5.5 cm in diameter and 1 cm in height) and were provided with A. craccivora as prey until pupal stage. Pupae were placed in mushlin cages (30 × 30 × 30 cm) under 16 light :8 dark hours of photoperiod until emerged into adult. Cutsings of yardlong bean seedling with a colony of A. craccivora were placed into the cage to collect the eggs of syrphids. A bamboo stick was smeared with the mixture of bee pollen and honey (ratio 1 g/10 mL) as feed for flies. Whereas, M. sexmaculatus was reared by collecting larvae and placed in the petri dishes (5.5 cm in diameter and 1 cm in height) with paper tissue and provided with Aphis craccivora as prey until pupation. Pupae were placed in another petridishes under 16L:8D of photoperiod until emerged into adult. The seedling with a colony of A. craccivora and a pair of M. sexmaculatus was placed into petrideshies until females lay eggs.

Feeding Performance of Predators

The experiment was done at the Basic Entomology Laboratory at temperature 24°C–25°C and relative humidity of 66–85% (similar to methods by Saleem et al., 2014 and Jalilian, 2015). Four densities of aphid, i.e. 20, 40, 60, and 80 individu as treatment were each arranged in small plastic petridish (5.5 cm in diameter and 1 cm in height) prior to placement of a single individu of 1rd and 3rd instars of I. scutellaris or M. sexmaculatus. The number of A. craccivora consumed by either predator was recorded 24 hours after trial starts, and feeding rate of each predator was calculated by using formula proposed by Jalilian (2015):

Each treatment was replicated 20 times, and observed daily until entered the pupal stage. The feeding rate of predators was determined by counting the number of prey eaten on each prey density by the 1st and 3rd instar of predators, and the pattern of functional response of these two predators was determined by using Holling equation (Holling, 1965; Spring, 2001). T-test analysis was done to compare the feeding rate of both predators at the same instar (1st instar of I. scutellaris vs 1st instar of M. sexmaculatus, and at the 3rd instars as well).
Correlation test was also performed to calculate the equation and to determine the type of functional response of each predator. All of statistical analysis were done by using SAS 9.1.3 software (SAS Institute Inc., 2013).

RESULTS AND DISCUSSION

Prey Consumption of the Two Predators

The results showed that the two predators responded positively on prey. Either predator increased prey consumption with the increase of the prey densities (Figure 1). However, this experiment also revealed that the larvae of *I. scutellaris* and *M. sexmaculatus* have different responses to prey densities, coccinellid larvae were more voracious then were syrphid larvae at 1\textsuperscript{st} instar, but it was less voracious when they were at the 3\textsuperscript{rd} instar.

The number of prey consumed by the 1\textsuperscript{st} instar larva of *I. scutellaris* never exceed 21 individuals (Table 1) on all prey densities, while 1\textsuperscript{st} instar larva of *M. sexmaculatus* seemed to follow the density of preys offered. The 3\textsuperscript{rd} instar of both predators increased with the increase of prey densities. But, the 3\textsuperscript{rd} instar larva of *I. scutellaris* consumed little higher number of prey individuals than *M. sexmaculatus* at all prey densities.

The 1\textsuperscript{st} instar of *M. sexmaculatus* had linear response to the increase of prey densities, while *I. scutellaris* seemed to consume lower number of prey at 60 and 80 prey densities (Figure 1). In contrast, the number of prey consumed by the 3\textsuperscript{rd} instar larva of *I. scutellaris* followed the increase of prey number, while the 3\textsuperscript{rd} instar larva of *M. sexmaculatus* tended to follow the type II of Holling’s functional response. Figure 1 also showed the superiority of *M. sexmaculatus* preyed on aphid as compared to *I. scutellaris* at 1\textsuperscript{st} instar larvae. However, the predation ability of 3\textsuperscript{rd} instar of *M. sexmaculatus* larvae was inferior when compared to *I. scutellaris*.

![Figure 1. Relationship between prey density and number of prey eaten per day per single larva of Ischiodon scutellaris (IS) and Menochilus sexmaculatus (MS)](image)

| Prey density | Average of prey consumed (n=20) |
|--------------|---------------------------------|
|              | Ischiodon scutellaris          | Menochilus sexmaculatus         |
|              | 1\textsuperscript{st} instar larval | 3\textsuperscript{rd} instar larval* | 1\textsuperscript{st} instar larval* | 3\textsuperscript{rd} instar larval |
| 20 individual| 12.55 ± 0.68                  | 19.72 ± 0.72                   | 15.80 ± 1.31                  | 18.92 ± 2.35                  |
| 40 individual| 20.85 ± 1.85                  | 38.35 ± 1.14                   | 24.98 ± 3.38                  | 36.19 ± 2.34                  |
| 60 individual| 17.12 ± 0.72                  | 38.08 ± 1.26                   | 36.22 ± 4.16                  | 55.88 ± 5.38                  |
| 80 individual| 18.38 ± 0.78                  | 70.89 ± 4.16                   | 44.40 ± 4.76                  | 64.20 ± 4.30                  |

Remark: *show the significant difference on feeding capacity between *Ischiodon scutellaris* and *Menochilus sexmaculatus* at the same instar
Survival Rates

Based on two *A. craccivora* predators survival trial, all larvae of both aphidophagous species survived and succeeded entering pupal stage at prey densities of 40, 60, and 80 individuals. Except *M. sexmaculatus* at prey density of 20 individuals, there were only 45% of *M. sexmaculatus* completed larval stage when they are provided with 20 individuals of prey. In comparison, all *I. scutellaris* successfully entered pupal stage at the same prey density. This statement is accordance with the Rudiyanto *et al.* (2011) research concluded that *M. sexmaculatus* had a maximum point of prey capacity at around 20 up to 50 aphids if compared with *I. scutellaris* / Syrphidae larvae had an ever-increasing prey on each instar and was able to adjust its feeding abilities (Amiri-Jami & Sadeghi-Namaghi, 2014). These in accordance with the results of research Edwards *et al.* (1979) which states that monophagus predators have an increased survival rate in every available prey population compared to polyphagus predators that have a saturation point in the number of prey. If both of these predator placed in the same placed, then syrphidae has greater survival rate than coccinellidae because syrphidae can adjust the predation ability to their prey body size.

Developmental Time of Larval Stage

Developmental time of larval stage is significantly affected by prey densities ($F_{(df=3)} = 2.75; P<0.001$ for *M. sexmaculatus* and $F_{(df=3)} = 2.72; P<0.001$ for *I. scutellaris*). In general, the development time was shorter when both predator species fed on higher prey densities (Table 2). *I. scutellaris* have the average development time 1−2 days shorter than *M. sexmaculatus* above 20 individuals of prey and significantly on 80 individuals of prey. Some factors may contribute to the performance of aphidophagous insects when feeding on their prey, i.e. optimum foraging behavior by larvae, degree of voraciousness of larvae, the availability of prey (prey density), and larval stage of predator as also shown in other studies by Ofuya (1986) and Chaudary *et al.* (2015) on coccinellid, and Putra and Yasuda (2006) on predatory syrphid. In this study, larvae of *M. sexmaculatus* tends to be more voracious than *I. scutellaris* at the 1st instar larva, although a contrary result was shown at the 3rd instar.

| Prey density | Developmental time (days) |
|--------------|----------------------------|
| M. sexmaculatus | I. scutellaris |
| 20          | 8.00 ± 0.00 | 8.45 ± 0.11 |
| 40          | 7.25 ± 0.10 | 6.00 ± 0.00 |
| 60          | 7.45 ± 0.10 | 6.00 ± 1.00 |
| 80          | 7.00 ± 0.00 | 5.25 ± 0.10 |

Some studies suggest that the searching ability of predators on prey may contribute to the number of prey consumed. In addition, oviposition behavior of adults may also determine the ability of larvae to find prey. Evans (2003) showed that female aphidophagous ladybird beetles lays their eggs patchily, and does not always correlate with aphid density. In other study, Evans and Dixon (1986) showed that the coccinellids use both individual aphid as well as its odor and honeydew as their cues for oviposition, although the odor and honeydew are proven to be more interesting for the beetle, as was also showed by Das and Dixon (2011) on *Adalia bipunctata*. However, the searching ability of coccinellid is relatively high, although mostly at random. Thus, the effect of oviposition behavior of coccinellid may not strongly correlated with the searching ability of the larva.

In contrary, Kan (1988; 1989) showed that aphidophagous syrphid, *Episyrphus balteatus*, tends to lay eggs on young, small, or early population of aphids; and neglects large colonies and including ones of winged adults. In addition, Tenhumberg and Poehling (1995) revealed that the number of eggs laid by syrphid is positively correlated with aphid abundance. Thus, the oviposition preference-larval performance seems to be strong correlated in syrphid as shown in Putra *et al.* (2009). They found that the number of eggs laid by adult of syrphids was significantly fewer when faced to higher risk of aphid colony with the presence of intraguild predators.

Furthermore, the mechanism of larval movement may also contribute to the success of predation. For example, Rotheray (1987) explained the moving mechanism used by syrphid larvae to reach prey which is determined by the morphological traits of...
larvae and the shape and structure of plant, although the larvae is acepala, syrphidae larvae move use their stomachs can find the prey use the seta around their cuticles (sensillium). On the other hand, a coccinellid larva has true legs by which they move around the surface of plant to find prey much more easily (Hodek & Honek, 1996). Syrphid larvae have more restricted movement than coccinellid. However, study by Bargen et al. (1998) showed that prey finding by the 1st instar of syrphid larvae is guided by aphid-borne volatiles which enabling larvae to locate prey more precisely.

This study was also showed that prey availability determined the performance of larvae including the survival rate and development time of larvae. In general, this study showed that the development time of larval stage was shorter when they prey on more dense prey, supporting previous study by other researchers. For example, Schaffner and Anholt (1998) showed that growth of damselfly larvae, Ischnura elegans was significantly reduced on lower density of prey. Other study by Putra and Yasuda (2006) revealed that two aphidophagous syrphids, E. balteatus and E. corollae, the development time more briefly when fed on denser preys and enabled them to survive better.

There are some advantages of using predatory syrphid and coccinellid to control aphid populations. Aphidophagous syrphids enable to suppress the aphid population at early colony development (Kan, 1998; 1989), while coccinellids occupy patches spaces with denser individuals of aphids to fulfill the needs of the larvae (Evans & Dixon, 1986; Hemptinne et al., 2000; Das & Dixon, 2011). It’s based on the studies about the maximum A. craccivora population are able to deplete by first instar Syrphidae amount 20 (Amiri-Jami & Sadeghi-Namaghi, 2014), when the last instar Coccinellidae have ability to deplete every amount of aphids population (Wagiman, 1996). The results from this study are also complementing previous results on the beneficial function of aphidophagous syrphid and coccinellid to control aphid. Thus, efforts to maintain their presence in field should be done, for example with providing extrafood from flowering plants to increase the settlement of natural enemies. Extra food is non-prey foods are important for the insect survival life and recovery metabolism energy after hibernate on the pupal phase (Gurr & Wratten, 1999). Generally, this food are cover crop pollen (Bugg et al., 1996) and many of predator insect such as: Syrphidae (Gilbert, 1981), Carabidae (Ahmad et al., 2006), Coccinellidae (Lundgren & Wiedenmann, 2004), Chrysopidae (Villenave et al., 2005), and Formicidae (Wheeler & Bailey, 1920) use them as their extra food.

CONCLUSION

The results showed that M. sexmaculatus larvae required more prey than I. scutellaris in 1st instar, but I. scutellaris ate more prey than M. sexmaculatus in the 3rd instar. The results also showed that the addition of prey also reduce significantly the development time of the larvae into pupae. Almost all of 1st and 3rd instar M. sexmaculatus and I. scutellaris were able to develop into pupae, whereas, only 45% of the 1st instar larvae of M. sexmaculatus succeeded to develop into pupae when they were given prey at 20 individuals.

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