The effect of *Crotalaria juncea* plant in coffee ecosystem to the diversity and abundance of predators and parasitoids insects

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Abstract. Agro-ecosystem of coffee adopts monoculture system that are less favorable to the development of natural enemies. However, only few studies examined the role of natural enemies in the ecosystem. This study examined the effect of flowering plant, *Crotalaria juncea* in coffee ecosystem to enhance the diversity and abundance of natural enemies; especially insect predators and parasitoids. The diversity and abundance of insect predators and parasitoids, both in coffee ecosystem with *C. juncea* and without *C. juncea* as a control plot were recorded. The result showed that the population abundance of insect predators and parasitoid on plot with *C. juncea* was 2.20 individuals, higher than on control plot (1.50 individuals/per branch/2 minutes). The Predatory insects found, both in coffee flowers and *Crotalaria* flowers were *Coccinellidae* (Coleoptera), *Vespidae* (Hymenoptera), *Mantidae* (Orthoptera), *Libellulidae* (Odonata), *Chrysopidae* (Neuroptera) and *Asilidae* and *Syrphidae* (Diptera), while the parasitic insects were *Ichneumonidae*, *Braconidae* and *Aphelinidae* (Hymeniptera). The abundance of insect predators and parasitoids on the coffee flower may decrease \( r = -0.366 \) by increasing the distance to *C. juncea*.

1. Introduction

The low average productivity of coffee in Indonesia is related to less intensive cultivation practices [1,2] and pests control [3,4,5]. The efforts to overcome these pests involve the utilization of pesticides, however, the misuse of pesticides cause residue problems [6]. Therefore, farmers should adopt eco-friendly agriculture practices, including improving ecological services, as conducted at coffee plantations in Mexico [7].

Management strategies for improving ecological services by enhancing the role of natural enemies of pest, especially predators and parasitoids insects in the coffee ecosystem in Indonesia are limited. The number insect predators and parasitoid, can be increased by planting flowering plants that produce nectar and pollen [8]. Nectar is a plant secretion composed mainly sugar and other compounds in low content [9], meanwhile pollen has a 2.5–60% protein content [10].

Nectar and pollen play important roles in the survival, lifespan, fecundity and progeny [11,12], flight capacity of females, population dynamics, and distribution [11] of parasitoids adult and predators. Therefore, the availability of flowering plant sis an important factor in the suppressive effect on pests, and low parasitism of pests in the field may be caused by the lack of nectar [11]. Based on these problems, this study was conducted to determine the effect of planting flowering plant, *Crotalaria juncea* in the coffee ecosystem to the diversity and abundance of predators and parasitoids insect.
2. Research methods

2.1. Study site
The research was carried out at Ngobo Coffee Plantation, PT. Perkebunan Nusantara IX, in Gebungan-Bergas, Semarang, Central Java, at 7°10'32.9 " S and 110°23'52.8" E, at an altitude of 515 m above sea level. The location has a climate type C (according to the Schmidt-Ferguson climate classification) with a range of daily rainfall, between 12.75-16.38 mm. The size of the plot (coffee plantations with flowering plant) and control (without flowering plant), each covering an area of 7200 m². Flowering plant of *Crotalaria juncea* were planted in the center of the treatment plot (size of 4 x 10 m), as a source of pollen and nectar for parasitoid and predator insects. There were no pesticides applied during the study.

2.2. Diversity and abundance of predators and parasitoids
The diversity and abundance of predators and parasitoids insect were recorded in coffee flowers, in both treatment plots (coffee with *C. juncea*), control plots (coffee without *C. juncea*) and also on *C. juncea* flowers. Insects were recorded on 30 coffee plants and *C. juncea* (two branches were selected per plant). Data were recorded every week following Klein *et al.* [13] between 08.30-10.30 AM, during the coffee flowering period (± 5 weeks) in two minute per sample unit by adopting scan sampling method. The effect of distance of *C. juncea* (as a source of pollen and nectar) to diversity and abundance of predators and parasitoids on coffee flowers were also recorded, following distances of 5 m, 10 m, 15 m, 20 m, 25 m and 30 m from *C. juncea* by the four transects [14]. The predators and parasitoids insect were recorded directly and also by using net for small insect by adopting the absolute method. The specimens of insects were identified to the genus, according to guidelines for insect identification by Borror *et al.* [15].

2.3. Percentage of pest parasitism
Percentage parasitism of coffee pest recorded on leaf bug, whitefly (Flatidae) and larvae of coffee fruit borer (*Hypothenemus hampei*) following method of Shoutwood [14], based on population index. Individually of pest insects collected from the field and then kept in the laboratory until the parasitoid emerged. The percentage of parasitism of coffee fruit borers was recorded by incubating holey fruit from coffee in treatment and control plots. The number of individual parasitoids was calculated to estimate the percentage of the parasitism. Hatching insect parasitoids were identified in the genus, following the identification guide by Borror *et al.* [15].

2.4. Data analysis
Data on the diversity and abundance of predator and parasitoid insects are presented in the form of tables and mean graphs using Excel 2013 (Window 10). Simple linear regression and correlation were done to examine the effect of the distance of flowering plant (as independent variable) with the abundance of parasitoid and predator insects that visit flowers (as dependent variable).

3. Results and discussion

3.1. Diversity and abundance of predators and parasitoid
Overall predators and parasitoids insects that visit coffee flowers, both in plots with flowering plant and without flowering plant of *C.juncea* consist of 8 orders with 11 families and 13 genera. The diversity predators insect consists of *Coccinellidae* (Coleoptera), *Vespidae* (Hymenoptera), *Chrysopidae* (Neuroptera) and *Diptera* (Asilidae, Syrphidae) and also parasitic insect of *Hymenoptera* (*Table 1*). Meanwhile, the diversity of parasitoids insects consists of *Ichneumonidae*, *Braconidae*, *Aphelinidae* (*Hymenoptera*). Abrol and Shankar [16] also recorded that the insect orders of *Diptera* and *Hymenoptera* use nectar as food resources of flowering plants.
Meanwhile, this study also recorded the predatory insect of Orthoptera (Mantidae) and Odonata (Libellulidae), which do not directly use the flower products of nectar and pollens as a source of food. On the other hand, the predatory insects of Hymenoptera, Coleoptera and Diptera need additional food sources of nectar and/or pollen produce by the flowering plants [17,8,18]. The abundance of predators and parasitoid insects visitors on coffee flower in plots with C. juncea was higher than in the plot without C. juncea. The predators and parasitoid insects in the control plot was 1.50 individual/plant/2 min (40.54%) was lower than 2.20 individual/plant/2 minutes (59.46%) in the plot with C. juncea.

**Table 1.** The diversity and abundance of predators and parasitoid visitor on flower of coffee in plot with and without of flowering plant of C. juncea

| Order          | Family     | Genera        | The abundance of predatory and parasitic insects (per plant/2 minutes) |
|----------------|------------|---------------|---------------------------------------------------------------------|
|                |            |               | Control                | Plot with C. juncea                           |
| Predators      |            |               | Σ | % | Σ | % |
| Coleoptera     | Coccinellida| Cryptolaemus  | 0.1 | 0.1 | 0.1 | 0.1 |
|                |            | Curinus       | 0.2 | 66.67 | 0.1 | 33.33 |
|                |            | Menochilus    | 0.2 | 50 | 0.2 | 50 |
| Orthoptera     | Mantidae   | Mantis        | 0.1 | 50 | 0.1 | 50 |
| Odonata        | Libellulida| Orthetrum     | 0.2 | 66.67 | 0.1 | 33.33 |
| Hymenoptera    | Vespidae   | Vespa         | 0.2 | 50 | 0.2 | 50 |
| Neuroptera     | Chrysopidae| Chrysophila   | 0.1 | 25 | 0.3 | 75 |
| Diptera        | Asilidae   | Leptogaster   | 0.1 | 33.33 | 0.2 | 66.64 |
|                | Syrphidae  | Ischiodon     | 0.2 | 40 | 0.3 | 60 |
| Parasitoids    | Hymenoptera| Xanthopimpla  | 0 | 0 | 0.2 | 100 |
|                |            | Braconidae    | 0.1 | 50 | 0.1 | 50 |
|                |            | Braconidae    | 0.1 | 50 | 0.1 | 50 |
|                |            | Apanteles     | 0 | 0 | 0.2 | 100 |
|                |            | Diachasmimorpha | 0 | 0 | 0.2 | 100 |
|                |            | Encarsia      | 0 | 0 | 0.2 | 100 |
| Total          |            |               | 1.50 | 40.54 | 2.20 | 59.46 |

The study also recorded 5 orders, 7 families of predators and parasitoid insects were visiting C. juncea flower, namely Coleoptera, Hymenoptera, and Diptera. The Vespidae and Syrphidae were the most common predatory insect visitor on C. juncea flower, especially Menochilus sp. (Table 2). In addition, among the flower visitors on C. juncea, recorded the parasitoid insect of Ichneumonidae and Scoliidae and also predator insects of Halictidae, which are not natural enemies of coffee pests. This study also showed that the coffee pests do not use C. juncea as a plant host. Thus the flowering plant C. juncea can be used for the predator and parasitoid insects conservation programs in the field.

**Table 2.** Diversity and abundance of the parasitoid and predator-visitors on Crotalaria juncea

| Group of natural enemies | Order          | Family     | Genera        | The abundance of predatory and parasitic insects (per plant/2 minutes) |
|--------------------------|----------------|------------|---------------|---------------------------------------------------------------------|
|                          |                |            |               | The abundance | Proportion (%) |
| Predatory insects        | Coleoptera     | Coccinellida| Cryptolaemus  | -             | -             |
|                          |                |            | Curinus       | -             | -             |
|                          |                |            | Menochilus    | 3.7 | 37.4 |
| Hymenoptera              | Vespidae       | Vespa      | 4.5 | 45.5 |
| Neuroptera               | Chrysopidae    | Chrysophila| 0.8 | 8.01 |
| Diptera                  | Asilidae       | Leptogaster| 0.4 | 4.04 |
|                          | Syrphidae      | Ischiodon  | 1.9 | 19.19 |
| Parasitoids              | Hymenoptera    | Ichneumonida| Xanthopimpla | 0.8 | 8.01 |
|                          | Braconidae     | Telenomus  | 1.2 | 12.12 |
| Total                    |                |            | 9.9 | 100  |
3.2. The effect of the distance to C. juncea

The abundance of predator and parasitoid insects visitors on coffee flowers are also influenced by the distance to C. juncea. The relationship between the distance of C. juncea (X) and the abundance of predator and parasitics insects visitors on coffee flowers showed a negative correlation (r = -0.336). Thus, the population of the insects in coffee flowers will decrease by increasing (longer distance) to C. juncea (Figure 1). Regression test with a value of $\alpha = 5\%$ showed significant results ($R^2 = 0.6801$; $F = 7,504$; $n = 48$; $P < 0.05$). Rezende et al. [19] also recorded that the presence of flowering plant may increase the abundance of predators and parasitoids insects.

![Figure 1](image.png)

**Figure 1.** The relationship between the number of predatory and parasitic insects visitor on coffee flower with the distance of flowering plant of C. juncea ($y = -3,2129x + 99,475$; $R^2 = 0.6801$; $F = 7,504$; $n = 48$; $P < 0.05$)

3.3. The percentage of parasitism on coffee pest

Two kinds of parasitoids were recorded, namely *Telenomus sp.* (Hym: Braconidae) and *Encarsia sp.* (Hym: Aphelinidae), each hatched from eggs of leaf bug (Hemiptera) and whitefly (Homoptera). The parasitism of *Telenomus sp.* on leaf bug's eggs was not affected by the C. juncea. The parasitism in plots with C. juncea was 70%; lower than 82.9% in the control plot. However, the parasitism of *Encarsia sp.* on white fly was 18% in control plots, lower than 44.4% in plots with C. juncea. No parasitoid was found on coffee fruit borer larvae, *Hypothenemus hampei* (Table 3). Sulistyowati [20] also reported that the percentage parasitism of coffee fruit borer by *Cephalonomia stephanoderis* was very low, ranging from 0.51-2.22%. Jaramillo et al. [21] also recorded that 97% of parasitism by the *Proropsnasuta* (Hymenoptera: Bethylidae) were found in coffee that had fallen to the ground. In this study, holey fruit of coffee which were attacked by borers were collected from plants.

Management strategies for controlling coffee pests in the future needs to be encouraged to implement agricultural practices which were friendly to predators and parasitoids insects by utilizing flowering plants, such as C. juncea. However, flowering plant must invite many predators and parasitoids, but are not suitable for coffee pest [11,22].
Table 3. The percentage of coffee’s pests parasitized in plot of coffee with and without of flowering plant of Crotalaria juncea.

| Parasitic insect | Number of samples | The number of parasitized | The percentage of parasitized (%) |
|------------------|-------------------|---------------------------|----------------------------------|
|                  | Plot without C.  | Plot with C.              | Plot without C.  | Plot with C.  | Plot without C. | Plot with C.  |
|                  | juncea            | juncea                    | juncea            | juncea        | juncea          | juncea        |
| Telenomus sp. on | 70                | 65                        | 58                | 46            | 82.9            | 70.8          |
| leaf bug         |                   |                           |                   |               |                 |               |
| Encarsia sp. on  | 161               | 160                       | 29                | 71            | 18              | 44.4          |
| whitefly         |                   |                           |                   |               |                 |               |
| Parasitation on  | 63                | 60                        | 0                 | 0             | 0               | 0             |
| Fruit borer      |                   |                           |                   |               |                 |               |

4. Conclusion
The flowering plant Crotalaria juncea in the coffee ecosystem can encourage an increase in the abundance of predators and parasitoids insects in coffee ecosystem. The predators and parasitoid visitors on coffee flower in control plot was 1.50 individual/ plant/ 2 min (40.54%), lower than 2.20 individual/ plant/ 2 minutes (59.46%) in coffee plot with C. juncea. Flowering plant of C.juncea were also visited by predators and parasitoids insects, so it can be used in conservation programs of the insects. Coffee plot with flowering plant C.juncea also was able to increase the parasitism percentage of Encarsia sp. (Hym: Aphelinidae) on whitefly, but did not increase to the parasitism of Telenemus sp. (Hym: Braconidae) and percentage of parasitism on coffee fruit borer.

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