Diversity of flower visitor insects in monoculture of luffa [Luffa acutangula L.] and intercropping of luffa and bitter melon [Momordica charantia L.]

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Abstract. Insects play important roles in pollinating flowers. The success of a plant to produce fruit depends more on the pollinating insects than other factors. This research aimed to study the diversity of species of flower-visiting insects and their role in monoculture and intercropping systems. The research was conducted on luffa [Luffa acutangula] and intercropping between luffa and bitter gourd [Momordica charantia] in a vegetable crop center in Tanjung Pering Village, Inderalaya District, Ogan Ilir Regency, South Sumatera. Insects observations were carried out visually [scan sampling] and insects behavior was documented. The observations indicated in intercropping plants the number of insects visiting flowers was more than in monocultures, both in terms of species and numbers. The monoculture system was visited by 4 orders, 5 families, and 7 species, whereas the intercropping system was visited by 6 orders, 12 families, and 16 species. Insects visiting flowers, both adult and larva/nymph, acted as flower eaters, predators, parasitoids, and pollinators. The visit times varied with an intercropping range of 10 seconds to 3 minutes. The order of Hymenoptera dominated the presence of insects both in monoculture and intercropping systems.

Keywords: behaviors, cucurbitaceae, pollinators, population

1. Introduction

Farmers generally plant crops with a monoculture system. Also, there is another planting system, namely intercropping i.e. by planting two or more species of plants in one land during a similar cropping season [1]. This system is quite beneficial for farmers because, in one crop season, farmers will be able to harvest more than one type of commodity [2]. Intercropping system showed productivity and yield stability, pest reduction, and high soil health. Monoculture and intercropping planting of vegetables are ways that are mostly applied by farmers [18]. There are several reasons for choosing plants to be planted with an intercropping system, including belonging to the same family of plants so that it is easier to grow and maintain the crops. Plants belonging to one family have similarities in terms of plant morphology. For example, the Cucurbitaceae family has the same characteristics of creeping plant bodies, secondary metabolite content, and the same flower color. Insects have an almost similar interest in the same flower color [3]. Luffa [Luffa acutangula L.] and bitter melon [Momordica charantia L.] plants are vegetable plants in the Cucurbitaceae family and have almost the same plant morphological characteristics. During the flowering phase, many insect species visit the flowers. In general, insects have a role as herbivores, predators, parasitoids, and pollinators [4]. In terms of cropping systems [monoculture and intercropping], it will affect the arrival
of species and the number of insects visiting plant flowers [5]. Therefore, this study was conducted to study insect species visiting flowers and their role in the cropping system.

2. Materials and Methods
The research was conducted at a vegetable center in Tanjung Pering Village, Ogan Ilir, South Sumatera from June to September 2020. The plants used were luffa plants [monoculture] and luffa and bitter melon plants [intercropping]. Each planted area is 0.5 ha.

2.1. Plant preparation
Luffa was planted by a monocultural system while luffa and bitter melon were grown by the intercropping system. The mounds were prepared for both systems. The distance between mounds was 0.5 m, and the length of the beds was 10 m. In one bed there were 10 plants with a distance between plants of 0.5 m. Each mound was covered with plastic mulch. When the plant was in the flowering phase, the activity of observing insects visiting the flower was carried out.

2.2. Observation of flower visitors insects
The insects visiting flowers were observed every day, at 7 - 9 am and 3 - 5 pm while the flowers were blooming [14 observations]. Observations were made by scanning [visual] sampling. One individual of the crop was observed for 5 minutes. During this time, the number and species of insect were noted. Insect's behavior and duration of visits to flowers were recorded and videotaped.

2.3. Insects identification
Insects that have been observed visually and photographed were identified based on morphological characteristics such as color, size, and morphological shape. The identification books used were [7], and [8].

2.4. Data analysis
Data on insect diversity were calculated using the Shannon-Weiner diversity index, dominance index, and evenness index [9]. Analysis of insects diversity was calculated using the Shannon-Wiener diversity index [9], with the following formula: 

\[ H' = -\sum P_i \ln P_i \]

Where: 

- \( H' \) = Shannon-Wiener diversity index, 
- \( P_i \) = number of individuals of the i-type 
- \( N \) = number of individuals of all species.

Dominance index \([D]\) is calculated using the dominance index formula from Simpson [9], 

\[ D = \frac{\sum [n_i / N]^2}{N} \]

Where: 

- \( D \) = Simpson dominance index, 
- \( N_i \) = number of individuals per species, 
- \( N \) = number of individuals all species [9].

Species evenness index: 

\[ E_1 = H' / \ln S \]

Where: 

- \( S \) = number of species, 
- \( H' \) = Shannon-Wiener index. The closer to number 1, the more complex and stable the community is.

3. Results and Discussions
Temperature and relative humidity at the vegetable center in Tanjung Pering Village were 28.6 °C and 85.5%, respectively.

3.1. Insects species at monocultural and intercropping system
In the luffa plantations grown in a monocultural system, it was found that insects visiting luffa flower were quite varied. Insects identified were 4 orders, 5 families, and 7 species. In the intercropping of luffa and bitter melon, the insects visit their flowers were more varied [6 orders, 12 families, and 16 species]. Some species visited both systems due to a similar crop planted, namely luffa. One species was dominated namely Camponotus sp. [Hymenoptera: Formicidae] [Table 1].

Insects visiting flowers were in stadia of larva and adult. They played a role as pests [herbivores] or as pollinators. Insects with larval stage were longer stayed in the flower, compared to an adult. This was consistent with research [10] who reported the life phase of an insect influences its activities in
finding a host. It is thought the color of the plant's flowers attracted insects. As stated by [11] Syrphidae flies were very active in visiting flowers on Alpine plants because of their color.

The number of insects observed and identified was more in intercropping. There was an assumption in the intercropping system, the number of flowers was higher than in monoculture. Therefore insects have the opportunity to visit flowers. This was consistent with the report of [5] who also studied insect flower visitors in intercropping and found that the number of insects visiting the intercropping system was higher than that of monoculture. The adult activity was shorter [3-40 seconds] compared to a larval phase which has 1-3 minutes of activity. Adults acts as a herbivore took less time for activity. Pollinators have varying visit periods of 0.25-10.00 minutes [12].

**Table 1. Insects of flower visitors on monoculture and intercropping systems of luffa and bitter melon**

| Order      | Family       | Species               | Monoculture | Intercropping | Stadia | Duration   | Status       |
|------------|--------------|-----------------------|-------------|---------------|--------|------------|--------------|
| Coleoptera | Chrysomelidae| Aulocophora sp        | +           | +             | Adult  | ± 5 sec    | Herbivore    |
|            |              | Aulocophora similis   | +           | +             | Adult  | ± 5 sec    | Herbivore    |
|            |              | Aulocophora levisii   | -           | +             | adult  | ± 5 sec    | Herbivore    |
| Lepidoptera| Noctuidae    | Spodoptera litura     | +           | +             | Larva  | ± 1-3 min  | Herbivore    |
|            |              | Phalaena sp           | +           | +             | Larva  | ± 1-3 min  | Herbivore    |
| Coleoptera | Coccinellida | Coccinella transversalis | -           | +            | Adult  | ± 4 sec    | Predator     |
| Coleoptera | Chrysomelidae| Aulocophora similis   | +           | +             | Adult  | ± 5 sec    | Herbivore    |
| Coleoptera | Chrysomelidae| Aulacophora levisii   | -           | +             | Adult  | ± 5 sec    | Herbivore    |
| Diptera    | Tephritidae  | Bactrocera dorsalis    | -           | +             | Adult  | ± 5 sec    | Visitor      |
| Diptera    | Syrphidae    | Helophilus pendulus   | -           | +             | Adult  | ± 7 sec    | Predator     |
| Hemiptera  | Pentatomidae | Halyomorpha halys     | -           | +             | Adult  | ± 3 sec    | Herbivore    |
| Hemiptera  | Miridae      | Nesidiocoris tenuis   | +           | -             | Adult  | ± 1 min    | Herbivore    |

3.2. *Insects based on their role*

In monoculture, there were only two roles of insects, namely pollinators and herbivores, while in intercropping there were 4 roles [pollinators, herbivores, predators, and visitors] [Figure 1].
Analyzing the role of flower-visiting insects in monoculture and intercropping, it appeared that the percentage of pollinators was similar. This was following [13] who reported pollinators were dominant when plants in the stadium of flowering. At the time of flowering, the color and ingredients of the flowers were the most influential attractions. Yellow was the color most preferred by insects [11]. Besides, the material contained in flowers in the form of nectar and pollen was also the goal of insects [14].

3.3. Diversity index, dominance index, and evenness index

The Shannon-Wienner diversity index \( [H'] \) in the monoculture cropping system \( 0.618 \) was lower than the index in intercropping \( 1.203 \). The evenness index is low below 1 in both habitats [Table 2].

| Index               | Monoculture | Intercropping |
|---------------------|-------------|---------------|
| Diversity index \( [H'] \) | 0.618       | 1.203         |
| Dominance index \( [D] \)   | 3.00        | 3.983         |
| Evenness index \( [E1] \)    | 0.852       | 0.689         |

In the diversity index, the monocultural crop showed a value of 0.618 \(<1\), while the intercropping was 1.203 \(>1\). This showed in monoculture, the diversity of insects visitors to flowers was lower than in intercropping. This was following the report submitted by [5] who stated the diversity of insects in intercropping crops was higher than in monoculture. Dominance index stated that species were dominating habitat or community. Both habitats showed almost similar data \( [\text{index value } 3] \). This means two habitats were dominated by one species, namely *Camponotus* sp \( [\text{Hymenoptera: Formicidae}] \). This species was ants found both on luffa plants grown in monoculture and in intercropping. The evenness index, different results were obtained, namely, in monoculture planting the figure was 0.852, while in intercropping, it was 0.689. Both numbers were below 1. The evenness index was a value that is closer to one, the better [15]. In this case, monoculture showed a higher evenness compared to intercropping.

3.4. Intercropping species visitors to flowers

Intercropping visiting insects, whether they act as pollinators, herbivores, or predators, were documented. [Figure 2]. Also, insects with a larval stage generally stay longer than the adult phase.
Insects visiting flowers are found in monoculture and intercropping systems. Notes: a] Helophilus pendulus [Diptera: Syrphidae], b] Aulocophora similis [Coleoptera: Crysolomidae], c] Hexacentrus japonicus [Orthoptera: Tettigoniidae], d] Coccinella transversalis [Coleoptera: Coccinellidae], e] Trigona sp [Hymenoptera: Apidae], f] Apis mellifera [Hymenoptera: Apidae], g] Aulocophora lewesii [Coleoptera: Crysolomidae], h] Lipotriches sp [Hymenoptera: Halictidae], i] Camponotus sp [Hymenoptera: Formicidae], j] Plutella xylostella [Lepidoptera: Plutellidae], k] Nesidiocoris tenuis [Hemiptera: Miridae], l] Spodoptera litura [Lepidoptera: Noctuidae].

The color of luffa and bitter melon’s flowers was an attraction for insects who will visit these flowers. Yellow was the dominant color preferred by insects [16]. However, some insects come to visit flowers not because of their color. Plutella and Spodoptera larvae come to the plant to eat parts of the plant. It has been recognized that these two species are polyphagous pests and their existence was cosmopolitan [17].

4. Conclusion
The number of insects visiting flowers in intercropping systems was higher than in monocultures, both in terms of species and numbers. The monocropping system was visited by 4 orders, 5 families, and 7 species, whereas in the intercropping system were visited by 6 orders, 12 families, and 16 species. Insects visiting flowers, both adult and larva/nymph, acted as flower eaters, predators, parasitoids, and pollinators. Visit time varied with a range of 10 sec to 3 minutes. The order of Hymenopteran dominated the presence of insects both in monoculture and intercropping systems.
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