Insect management with refugia plant in upland rice 
(*Oryza sativa* L.)

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**Abstract.** Refugia is a microhabitat that provides spatial or temporal shelter for pest natural enemies, and supports biotic interaction components in ecosystems, such as pollinators or pollinating insects. The research objective was to study the best types of refugia plant in pest insect management. The treatments consisted of five plant refugia, R0 (control), R1 (*Ageratum conyzoides*), R2 (*Axonopus compressus*), R3 (*Cosmos caudatus*), and R4 (*Wedelia trilobata*) and each treatment was made in five replicates. This research is descriptive using the transect method and sampling is done using several tools, namely: *yellow traps*, *pitfall traps* and *sweep nets*. The findings indicate that the highest pest insect in refugia's composition is R0 as many as seven species, and R2 does not have the highest composition of insect pests due to predator domination over insect pests. The highest predator insects found in R2 is four species, while R1 didn't have the highest composition of predator insects. Data on morphospecies diversity index of pest and predator insect are moderate. Evenness index of morphospecies is in high criteria, ≥ 0.6.

1. **Introduction**

According to Law No. 12 /1992 concerning Plant Cultivation System in Indonesia the use of pesticides as a pest control system can only be used as the last effort. Non-pesticide pest control must take precedence and given priority [1]. Efforts to control crop pests in an agro-ecosystem can be increased by manipulating habitat (refugia). Refugia is a microhabitat that provides spatial and/or temporal shelter for pest natural enemies, such as predators and parasitoids, and supports biotic interaction components in ecosystems, such as pollinators or pollinating insects [2].

The role of weeds or other wild plants is linking between organism trophies both directly and indirectly which lives in an agricultural ecosystem. Besides the main crops, weed or non-cropping plants (main) is an alternative feed source for disturbing organism sand also as a place for natural enemies to get feed or hosts. In such case, weeds or wild plants act as anchors or links between various organisms involved in the ecosystem [3]. Weeds planted intermittently can increase the natural enemy population [4]. The numbers of arthropods that come to refugia plants is enough high and reduce arthropods population in red rice [5]. The number of arthropods who attracted to refugia is higher than on land without refugia [6]. Of this study, the objective was to evaluable the best types refugia weed in insects pest management.
2. Materials and Methods

2.1. Study Site
This research was carried out in farmer's field, at district of Percut Sei Tuan, Regency of Deli Serdang. This research was carried out from February to May 2018.

2.2. Procedures
The treatments consisted of five plant refugia, namely: R0 (control), R1 (A.conyzoides), R2 (A. compressus), R3 (C. caudatus), and R4 (W.trilobata) and each treatment was made in five replicates. This research is descriptive using the transect method and sampling is done using several tools, namely: yellow traps, pitfall traps and sweep nets. Observed parameters are insect composition present in refugia, index of insect morphospecies diversity and index of insect morphospecies evenness.

2.3. Data analysis
Diversity index \(H'\)
Data analysis on natural enemy morphospecies diversity index was measured using the Shannon-Wienner diversity index. The Shannon-Wienner diversity index uses formulas [7,8]

\[
H' = \sum_{i=1}^{s} p_i \ln\left(\frac{n}{N}\right)
\]

\[P_i = \frac{n}{N}\]  

Where: \(H = \) Diversity Index, \(p_i = \) Proportion of \(i^{th}\) species in the community, \(n = \) Individual abundance of morphospecies I, \(N = \) Total individual number of all species.

The calculation results of insects’ abundance categorized into three [9] as follows:

| Diversity Value \((H')\) | Category        |
|------------------------|-----------------|
| \(H' \leq 2\)          | Low Diversity   |
| \(2 < H' \leq 3\)      | Moderate Diversity |
| \(H' \geq 3\)          | High Diversity  |

Evenness Index \((E')\)
Evenness index analysis of insect morphospecies was measured using Simpson’s evenness index which measures the proportion of each species in a population at a certain place and time.

\[
E' = \frac{H'}{\ln(S)}
\]

Where: \(E' = \) Evenness index, \(H' = \) Diversity Index, \(\ln = \) (natural logarithm), \(S = \) number of species found.

| Evenness Value \((E')\) | Category       |
|------------------------|----------------|
| \(E' \leq 0.3\)        | Low Evenness   |
| \(0.3 < E' \leq 0.6\)  | Moderate Evenness |
| \(E' \geq 0.6\)        | High Evenness  |
3. Results and Discussion

3.1. Composition of insects present in refugia

The results showed that there were 14 species, 11 families, 7 orders that acted as pests and 8 species, 6 families, 4 orders that acted as predators, and 1 species. The composition of pests and predators can be seen in Tables 1 and 2.

| No | Ordo     | Family         | Species                                      | Treatments* |
|----|----------|----------------|----------------------------------------------|-------------|
| 1  | Coleoptera | Chrysomelidae  | *Dicladispa armigera* (Rice Hispa Pest)       | R0          |
|    |          |                | *Pleuraltica cyanea* (Karamu leaf beetle)     | 82          |
|    |          |                |                                              | 63          |
|    |          |                |                                              | 48          |
|    |          |                |                                              | 62          |
|    |          |                |                                              | 69          |
| 2  | Diptera   | Muscidae       | *Hydrellia philippina* Ferino (Seed Fly)     | R1          |
|    |          |                |                                              | 146         |
|    |          |                |                                              | 89          |
|    |          |                |                                              | 66          |
|    |          |                |                                              | 83          |
|    |          |                |                                              | 118         |
| 3  | Hemiptera | Alydidae       | *Leptocorisa oratorius* Fabricius (Ladybug)  | R2          |
|    |          |                | *Nilaparvata lugens* (brown planthopper)     | 158         |
|    |          |                | *Scotinophara Lurida*                         | 102         |
|    |          | Delphacidae    |                                              | 73          |
|    |          | Pentatomidae   |                                              | 73          |
|    |          |                |                                              | 52          |
|    |          |                |                                              | 47          |
|    |          |                |                                              | 53          |
|    |          | Cicadellidae   | *Burmeister* (Kepinding Tanah)               | R3          |
|    |          |                | *Cofana spektra*                             | 92          |
|    |          |                |                                              | 94          |
|    |          |                |                                              | 78          |
|    |          |                |                                              | 91          |
|    |          |                |                                              | 97          |
|    |          | Cicadellidae   | *Nephettix virescens* (green planthopper)    | R4          |
|    |          |                |                                              | 129         |
|    |          |                |                                              | 82          |
|    |          |                |                                              | 84          |
|    |          |                |                                              | 94          |
|    |          |                |                                              | 96          |
| 5  | Hemiptera | Lygaidae       | *Paraeucosmetus pallicornis* Dallas           | R5          |
|    |          |                | (black ladybug)                              | 92          |
|    |          |                |                                              | 74          |
|    |          |                |                                              | 78          |
|    |          |                |                                              | 82          |
|    |          |                |                                              | 81          |
| 6  | Lepidoptera | Pyralidae     | *Cnaphalocrocis medinalis* Guenee (Leaf Folder) | R6          |
|    |          |                | *Melanitis leda ismene*                      | 135         |
|    |          |                |                                              | 98          |
|    |          |                |                                              | 82          |
|    |          |                |                                              | 107         |
|    |          |                |                                              | 116         |
| 7  | Orthoptera | Acrididae      | *Acrida conica* (Grasshopper)                | R7          |
|    |          |                |                                              | 90          |
|    |          |                |                                              | 79          |
|    |          |                |                                              | 87          |
|    |          |                |                                              | 97          |
|    |          |                |                                              | 82          |
|    |          | Tettonioidae   | *Conocephalus fuscus* Fabricius (Grasshopper) | R8          |
|    |          |                |                                              | 62          |
|    |          |                |                                              | 63          |
|    |          |                |                                              | 70          |
|    |          |                |                                              | 76          |
|    |          | Gryllotalpidae | *Gryllotalpa hirsuta* (stray dogs)            | R9          |
|    |          |                |                                              | 137         |
|    |          |                |                                              | 96          |
|    |          |                |                                              | 51          |
|    |          |                |                                              | 91          |
|    |          |                |                                              | 105         |

*R0 (control), R1 (Ageratum conyzoides), R2 (Axonopus compressus), R3 (Cosmos caudatus), and R4 (Wedelia trilobata).*

Table 3 shows that the highest insect pests present are R0 (control), R1 (A. conyzoides), R3 (C. caudatus), and R4 (W. trilobata), while R2 (A. compressus) has no composition of the highest insect pest.

R0 (control) has the highest composition of insect pests. There are seven species namely *Dicladispa armigera*, *Hydrellia Philippine* Ferino, *Leptocorisa oratorius* Fabricius, *Nephettix virescens*, *Paraeucosmetus pallicornis* Dallas, *Cnaphalocrocis medinalis* Guenee, and *Gryllotalpa hirsuta*. Abundance of insect pests from seven species is found from upland rice fields without refugia.
This is due to the lack of predatory insect populations so that suhinsect pests increase. Low predatory insect populations are unable to prevent and balance the number of insects that damage rice due to absence of shelter and hiding place for predatory insects.

In R4 (W.trilobata), the highest composition of insect pests are 5 species namely Nilaparvata lugens, Scotinophara lurida Burmeister, Cofana spectra, Melanitis leda ismene Cramer, and Conocephalus fuscus Fabricius.

W.trilobata are flowering plants that have specific attraction for insects, among others, due to flowers color, namely yellow which is preferred by insects. Most of insects prefer small-sized flowers, tend to be open, and long flowering time which is usually found in the family Compositae or Asteraceae (e.g. W. trilobata) [10].

In R1 (A.conyzoides) and R3 (C.caudatus), each composition of the highest insect pests has 1 species namely Cyanea pleuraltica and Acrida conica. The R2 (Axonopus compressus) does not have the highest composition of insect pests because there are many predatory insects such as Oxyopes javanus Thorell, Cheilomenes sexmaculata, Coelophora inaequalis, and Coccinella transversalis hal as shown in Table 2.

| Table 4. Composition of Predator Insect in Upland rice (Oryza sativa L.) |
|---|---|---|---|---|---|
| No | Ordo | Famili | Spesies | Treatments* |
|---|---|---|---|---|
| 1. | Araneae | Tetragnathidae | Oxyopes javanus Thorell (Spider) | R0 120 | R1 124 | R2 155 | R3 137 | R4 147 |
| 2. | Coleoptera | Coccinellidae | Cheilomenes sexmaculata Fabricius (Koksi Beetle) | R0 61 | R1 77 | R2 116 | R3 91 | R4 67 |
| 3. | Coleoptera | Coccinellidae | Coelophora inaequalis (Koksi Beetle) | R0 64 | R1 76 | R2 104 | R3 79 | R4 68 |
| 4. | Coleoptera | Coccinellidae | Coccinella transversalis (Koksi Beetle) | R0 117 | R1 137 | R2 154 | R3 122 | R4 124 |
| 5. | Carabidae | Ophionea interstitialis (karabit Beetle) | | R0 91 | R1 44 | R2 57 | R3 82 | R4 63 |
| 6. | Staphylinidae | Paederus fuscipes (Tomcat) | | R0 113 | R1 115 | R2 121 | R3 126 | R4 125 |
| 7. | Hymenoptera | Formicidae | Solenopsis geminata (Ant) | | R0 94 | R1 67 | R2 87 | R3 79 | R4 77 |
| 8. | Orthoptera | Gryllidae | Eunemobius carolinus (Cricket) | | R0 80 | R1 73 | R2 68 | R3 68 | R4 109 |

*R0 (control), R1 (Ageratum conyzoides), R2 (Axonopus compressus), R3 (Cosmos caudatus), and R4 (Wedelia trilobata).

Table 4 shows that the highest predatory insects present are R0 (without refugia), R2 (A. compressus), R3 (C.caudatus), and R4 (W.trilobata), whereas R1 (A.conyzoides) has no composition of the highest predator insect.

In the treatment of R2 (A.compressus), the highest composition of insect pests is consisted of five species, namely Oxyopes javanusThorell, Cheilomenes sexmaculata, Coelophora inaequalis, and Coccinella transversalis.

In the treatment of R0 (without refugia), the highest composition of insect pests is consisted of 2 species, namely Ophionea interstitialis and Solenopsis geminata. In the treatment of R3 (C.caudatus) and R4 (W.trilobata), each treatment has one highest composition of insect namely Paederus fuscipes and Eunemobius carolinus, respectively.
High population of Coccinellidae (Cheilomenes sexmaculata, Coelophora inaequalis, Coccinella transversalis) in R2 (A. compressus) in upland rice is because predator Coccinellidae has oligophageal properties, that is eating certain types of small insects, such as aphids and mites from various stages of egg, nymph or imago. Besides the coccinellidae imago, the larvae are also actively looking for prey and usually greedy than imago. The body fluids of captured prey will be sucked; the carcass will be discarded in dry state [11]. In a farm that does not use pesticides, type and population of arthropods are more than apply pesticides. Such case applies both in simultaneous planting and non-simultaneous planting area [12]. One of the pest predators of rice is Koksi beetle. Koksi beetles of Coccinellidae family are commonly found in cultivated plants and weeds that produce nectar and pollen [13].

The highest composition of predator insects on R2 (A. compressus) is spider (Oxyopes javanus Thorell). Spiders (Oxyopes javanus Thorell) are important predators for leafhoppers, stem borer, and other pests. Spiders are important predators in regulating insect pest populations [14].

3.2. Data analysis of insect morphospecies diversity index

| Treatments* | Diversity Index($H'$) | Criteria |
|-------------|-----------------------|----------|
|             | Pest                  | Predator |          |
| R0 (control)| 2.59                  | 2.05     | Moderate |
| R1 (Ageratum conyzoides) | 2.62                  | 2.02     | Moderate |
| R2 (Axonopus compressus) | 2.61                  | 2.03     | Moderate |
| R3 (Cosmos caudatus) | 2.62                  | 2.05     | Moderate |
| R4 (Wedelia trilobata) | 2.62                  | 2.03     | Moderate |

Table 5 show that the value of pest insect and predator insect morphospecies diversity is fall in $2 < H' \leq 3$, which means the pest and predator diversity index classified as moderate. Such condition shows that the productivity is high enough, pest and predator is in balance and moderate ecological pressure.

3.3. Data Analysis of insect morphospecies evenness index

| Treatment* | Evenness index($E'$) | Criteria |
|------------|----------------------|----------|
|            | Pest                | Predator |          |
| R0 (control) | 0.98                | 0.99     | High     |
| R1 (Ageratum conyzoides) | 0.99                | 0.97     | High     |
| R2 (Axonopus compressus) | 0.99                | 0.98     | High     |
| R3 (Cosmos caudatus) | 0.99                | 0.99     | High     |
| R4 (Wedelia trilobata) | 0.99                | 0.98     | High     |

Table 6 shows distribution index of insect morphospecies. Both pest and predatory insects in he rice ecosystem fall in high criteria, namely $\geq 0.6$, which means there is even distribution of individual species and no species dominance over other species. They can use the rice plant to build large populations together with equal opportunities, thus there is no dominance of one type against another.

4. Conclusions

Abundance of pest insect in control (R0) shows the lack of predatory insect populations so increase the pest insect. Low predator insect populations mean unable to prevent and make a balance with the number of pest insect that damage rice due to the absence of shelter and hiding. High population of Coccinellidae and spiders in R2 (A. compressus) means that the treatment recommended both for
upland and lowland rice, to attract predatory insect populations as natural enemies of pests insect. The diversity index of pest and predatory insects is moderate, shows that the productivity is high enough, pest and predator is in balance and moderate ecological pressure. High evenness index explained that the distribution of individuals is relatively even so that there was no dominance of species to other types. They can use the rice plant to build large populations together with equal opportunities, thus there is no dominance of one type against another.

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