The diversity of insects in West Sumatera's local rice by planting refugia as an effort to conserve natural enemies

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Abstract. Refugia cultivation refers to a place provided for insects in flower plants, especially for habituating the natural enemies of pests. The purpose of this research is to study the effect of refugia plants on insect diversity during rice cultivation, using a survey method. This experiment was conducted in the Solok area of West Sumatra, in July-September 2019, followed by insect identification at the Insect Bioecology Laboratory of the Department of Pests and Plant Diseases, Faculty of Agriculture, Andalas University. Furthermore, the observations were made in the paddy fields within the early generative phase, and when the panicle has emerged on each sample plot, using insect nets. These samples were taken from places with only refugia plants, as well as rice fields with and without refugia. The results showed a variation in the number of orders, families, and individuals in all samples, which were 3, 6 and 9, respectively for refugia plants, 6, 9 and 133, respectively on the edges of paddy fields with refugia plants, then 4, 7 and 213, were recorded in the areas without refugia. Besides, the highest insect diversity index value was identified in the rice plants with refugia at the edges of the fields [1.87]. At the same time, 1.39 was reported in its absence and 1.58 in areas with the refugia plant itself. Conversely, the dominance index values recorded were 0.20 and 0.58 for rice with, and without refugia, and 0 was reported in the area with refugia alone. Therefore, it is possibly concluded that refugia plants possess the capacity to influence insect diversity and dominance. This necessitates the conduction of further observations in the aspect of functions, as well as the ability to control rice pests.

Keyword: insects diversity, refugia, rice

1. Introduction

Sustainable farming systems are highly recommended. Efforts toward sustainable agriculture include organic farming practices. Organic farming is a system of agricultural cultivation that relies on natural ingredients without synthetic chemicals. These pesticides are avoided in the control of pests and possibly used as the last alternative because the process is aimed at plant protection and optimal production.

An increase in the production of food crops [rice and vegetables] demands a strategy with efforts towards the attack plant pests organism, initiated with proper agroecosystem planning. Besides, the presence of these natural enemies has been affiliated with the weakened and reduced reproductive phase. However, they are probably not a factor in suppressing the development of pest populations due to the unavailability of food and shelter [refugia] [1]. Refugia are microhabitats that provide spatial or temporal shelter for the natural pest enemies, consisting of predators and parasitoids, therefore...
enhancing the support component provision of biotic interactions in ecosystems, encompassing pollinators or pollinating insects [2].

The technology developed to control pests and promote rice cultivation is based on the concept of Integrated Pest Management by considering ecosystems, stability, and sustainable production following the demands of good agricultural practices [3]. The balance of a farming ecosystem is known by observing the diversity and abundance of insects, Tauruslina et al. [4], reported this stability as a factor of the relationship between insect diversity and organic rice plants. These are determined by diversity, community structure, component properties and interactions between ecosystem components. Planting refugia plants around the land is a practice aimed at stabilizing and restoring balance.

The planned agroecosystem on plantations provides an opportunity for the Biological Control Agency to work optimally, which makes the development of pests in the field manageable. Furthermore, refugia plants possess the potential to support system mechanisms, including improving the availability of alternative feeds, consisting of nectar, pollen, and honeydew. These refugia are capable of providing shelter or microclimate, used by predatory insects to survive, and also as a refuge from extreme environmental factors, consequently providing alternative host or prey habitat [5].

Some reports have been made regarding the types of plants with the ability to serve as potential refugia, including flowering plants, broadleaf weeds, as well as planted or manually grown wild plants in the area of planting, and vegetables [6]. Furthermore, the criteria for being selected as a refugia vegetation strips comprise of those planted from seed without the need for a transplant, fast-growing and characterized with the ability to compete with weeds, and easy to manage, fast flowering plants, typified by the possession of fruit or vegetative structures of economical value to farmers both for consumption or commercial, distinguished by the capacity to produce in minimum cultivation, expelled or hated by significant plant pests, and also possess the ability to attract beneficial Arthropods, both as a microhabitat and as a source of nectar.

Iqbal and Sekar [7] reported the tendency for Cosmos caudatus and paper flowers planted along the rice field to serve as refugia, to consequently become a host for and increasing the population of natural enemies, and suppressing that for a pest. Also, the total natural enemies with refugia plants identified were 43 individuals and 305 for those. Iqbal et al. [8], reported the influence of using Marigold and Ornamental Beans on arthropods in rice plants on the population of natural enemies, which was 156 and 217, respectively, and as many as 140 individuals without refugia.

Insect diversity has not been widely reported on local rice variety, planted with refugia in paddy fields in West Sumatra. This research is, therefore, conducted to observe the diversity of insects in rice fields with and without planted refugia.

2. Material and Methods

2.1. Samples collection

The determination of the sample area was based on the presence of refugia plants in paddy fields, and Solok Regency, West Sumatera province was identified as the center of rice production with its substantial growth. Therefore, the samples were determined to consist of paddy fields with and without refugia in plots of 1x1 m². The age of rice that has been used as sampling is in the early generative period. The age of rice that has been used as sampling is in the first generative period. With the flowering plant's refugia growing along the rice field bunds, and insect retrieval required the use of nets [insect net diametre 35 cm]. Insect net is used with a swing movement to the left and right [double swing] 20 times in the sample area. The trapped insects were put in a collection bottle containing 90% alcohol.

Insect sampling was conducted in 3 locations, including rice fields with and without refugia, and also areas with refugia plants alone. Subsequently, the identification of insect samples was conducted based on morphospecies, followed by the population determination from each location, and analysis to determine the diversity index [H] and the dominant index [C].
2.2. Insect identification

The collected insects were then taken to the laboratory and identified by order, while the recognition at the family level was based on morphology. Furthermore, classification involved the use of an Insect Learning Introduction handbook and the Insect Determination Key [9].

Insects were identified up to the specie level, and then the number of individuals counted in each order and family, as well as the sum of individuals in each location, which was calculated based on the morphospecies.

2.3. Data Analysis

2.3.1. Diversity Index [H]

The formula for species diversity based on Shannon-Wiener [1963], is:

\[ H = - \sum_{i=1}^{n} p_i \log_2(p_i) \]

Description:

- \( H \) = Shannon-Wiener diversity index
- \( n \) = Number of individuals of type \( i \)
- \( N \) = The total number of individuals in all types

The magnitude of species diversity index according to Shannon-Wiener is defined as follows:

- A value of \( H > 3 \) indicates that species diversity in a location is abundantly high.
- The value of \( 1 \leq H \leq 3 \) indicates a moderate amount.
- A value of \( H <1 \) indicates little or low species diversity.

2.3.2. Dominance Index [C]

Simpson's dominance index values range from 0-1, and 1 is attributed when there are only a single species in the community. In contrast, values approaching 0 are assigned on instances of abundant and equal distribution. Therefore, dominance is indicated by the Simpson dominance index formula [C], which is:

\[ C = \sum \left[ \frac{n_i}{N} \right]^2 \]

Description:

- \( C \) = Simpson dominance index
- \( n_i \) = Number of individuals of a species \( i \)
- \( N \) = The total number of individuals in all species

3. Result and Discussion

3.1. Sampling Location

The sampling location was in Nagari Saok Laweh, Kubung District, Solok Regency, West Sumatra Province [Fig. 1], and the rice fields used are owned by local farmers, with rain-fed irrigation, which is typical, due to the availability of water.
3.2. Types of flower plants around rice plants
The types of flowering vegetation planted by farmers in rice field bunds include paper flowers and tagetes, including corn plants that were around rice fields. Besides these flowering functions, there is also an expectation of enhanced productivity and suspension from weeds. [Fig. 2]. Refugia plants identified during sampling were generally already flowering, and several types of grasses or flowering plants present were deliberately allowed to grow.

Figure 1. Map of sampling location

Figure 2. Examples of refugia plants in rice fields [a, b, c, d, flower plants and e, corn plants]
3.3. **Insects found in the field**

Within the fields with and without refugia, 16 species of insects were identified, consisting of 6 orders [Fig. 3].

![Insect samples found in fields with a local variety of rice](image)

- a. *Blastobasini sp.*
- b. *Chylizai sp.*
- c. *Eumenes sp.*
- d. *Conocephalus sp.*
- e. *Megachile sp.*
- f. *Euchistus sp.*
- g. *Micraspis sp.*
- h. *Myrmosa sp.*
- i. *Macrosteles sp.*
- j. *Nephrotoma sp.*
- k. *Melanoplus sp.*
- l. *Spharagemon sp.*
- m. *Siretrus sp.*
- n. *Opharella sp.*
- o. *Stenocoris sp.*
- p. *Oebalus pugnax*

**Figure 3.** Insect samples found in fields with a local variety of rice

3.3.1. **Insects in rice plants with refugia**

Classification of insect species found at each sample location with refugia was based on morphospecies [Table 1]. Based on insect identification, a total sample at all locations were six orders, 13 family, and 17 species. These include *Micraspis frenata, Megachile sp., Stenocoris sp., Oebalus pugnax, Macrosteles sp., Melanoplus sp., Paropomala sp., Chyliza sp., Nephrotoma sp., Sharagemon sp., Conocephalus sp., Megachile sp., Eumenes sp., Blastobasini sp., Ophraela sp., Myrmosa sp.*, and *Siretrus sp.*, with a total population of 352 individuals.
Table 1. Morphospecies of insect orders found in rice plants with refugia

| Ordo   | Family       | Species        | Role     |
|--------|--------------|----------------|----------|
| Coleoptera | Coccinelidae | Micraspis sp. | Predator |
|         | Chrysomelidae| Ophraella sp.  | Predator |
| Hemiptera | Alydidae    | Stenocoris sp. | Herbivora|
|         | Pentatomidae | Oebalus sp.    | Herbivora|
|         |              | Eichistus sp.  | Herbivora|
|         |              | Stiretrus sp.  | Herbivora|
|         | Cicadellidae | Macrosteles sp.| Herbivora|
| Orthoptera | Acrididae  | Melanoplus sp. | Herbivora|
|         |              | Paropomala sp. | Herbivora|
|         |              | Sphragemon sp. | Herbivora|
|         | Tetrigoniidae| Conocephalus sp.| Herbivora|
| Diptera | Psilidae     | Chyliza sp.    | Predator |
|         | Tipulidae    | Nephrotoma sp. | Predator |
| Lepidoptera | Blastobasida | Blastobasini sp. | Polinator|
| Hymenoptera | Megachilidae | Megachile sp.  | Polinator|
|         | Vespidae     | Eumenes verticalis | Polinator|
|         | Myrmosidae   | Myrmosa sp.    | Polinator|

Several orders were identified, dominantly in the group of herbivores, followed by pollinators and natural enemies of rice plant pests. Specifically, the herbivorous consist of the order Hemiptera and Orthoptera, encompassing more populations, in contrast with others, and Hymenoptera as the dominant insect population in rice plants with refugia.

3.4. Types of insects in refugia plants

The order of insects found in refugia plants on the sample location is lesser than the population in rice fields with refugia, although it contains Coleoptera, Lepidoptera, and Hymenoptera [Table 2]. From the table, it is seen that the types of insects in refugia plants consist of 3 orders, six families, six species, and with a population of 9 individuals, dominated by the Hymenoptera order. Hymenoptera known to function as a pollinator, and possibly because the sampling process was conducted in the early generative period of rice, characterized by an increase in its amount hovering around the plants.

Table 2. Morphospecies of insects found in refugia plants surrounding rice plants.

| No | Ordo       | Family       | Number of individuals |
|----|------------|--------------|-----------------------|
| 1  | Coleoptera | Coccinelidae | 1                     |
|    |            | Chrysomelidae| 1                     |
| 2  | Lepidoptera| Blastobasida | 1                     |
| 3  | Hymenoptera| Megachilidae | 4                     |
|    |            | Vespidae     | 1                     |
|    |            | Myrmosidae   | 1                     |
3.4.1. Types of insects in rice plants without refugia

Insects collected from rice fields without refugia are characterized by several varying orders and families, with a different number of individuals in each. Table 3 shows the existence of several insect types found in rice plants without refugia.

| No | Ordo    | Family       | Number of individuals |
|----|---------|--------------|-----------------------|
| 1  | Coleoptera | Coccinellida | 29                    |
| 2  | Hemiptera   | Pentatomidae | 11                    |
|    |           | Cicadellida  | 3                     |
|    |           | Alydidae     | 18                    |
| 3  | Hymenoptera | Megachilida  | 125                   |
| 4  | Orthoptera  | Tettigoniida | 18                    |
|    |           | Acrydida     | 9                     |

These consist of 4 orders, seven families, nine species, and a population of 213 individuals, which is dominated by the Hymenoptera order. The second-largest population found was the family of Coccinellidae, which functions as a natural enemy [predator] against rice plant pests. Agung *et al.* [10] reported predatory insects as an essential factor in maintaining ecosystem balance, which also serves as biological controllers of natural enemies of pests. Annisa [11] reported the possibility for predators to use flower plants as an area to lay eggs, and a hiding place for predators while preying on other insects.

Arthropods are generally attracted to refugia plants, as observed by Wardani *et al.* [12]. Hence it was recommended as a place for habitat manipulation. Also, the functional status of arthropod consists of herbivores [54.14%], pollinators [28.72%] and predators [17.13%], while Sari and Yanuwiadi [13] reported Acrididae as the most abundant insect family in rice fields and refugia blocks. Therefore, the diversity of herbivorous in the paddy fields and refugia blocks is concluded as low to moderate.

Some related insects, encompassing *Melanoplus* sp., *Paropomala* sp., *Spharagemon* sp., *Oebalus* sp., tend to have a lower population in contrast with natural enemies and pollinators. Untung [14] reported herbivores as insects with the propensity to eat plants, and occupy the second trophic in the agroecosystem, hence it is termed the first consumer, while the first trophic is called the plant or producer. In addition, certain herbivorous insects possess the capacity to eat several types of plants, depending on their adaptability, and the type and amount determine their diversity value in an agroecosystem.

3.5. The diversity and importance of insects in rice fields with and without refugia

Differences were observed in the diversity index value and the dominance index value of rice with and without refugia, as well as in the refugia plants itself, as shown in Table 4.

| No | Location of Observation | Diversity index | Total of Ordo |
|----|--------------------------|-----------------|---------------|
| 1  | Rice with refugia        | 1.87            | 6             |
| 2  | Refugia                  | 1.58            | 3             |
| 3  | Rice without refugia     | 1.39            | 4             |

The highest diversity index value was demonstrated in rice with refugia at 1.87, while the lowest was in those without refugia at 1.39, and an amount obtained refugia itself was 1.58. The highest
diversity index \([H]\) value of 1.87 was attained in rice plants with refugia because it contained 11 species, showing the interaction between insects, refugia, and rice plants. The existence of refugia, flowering plants invite insects. Insects will look for nectar for food. The more insects that come the higher the \(H\) index value. Qomariyah [15] stated that a higher amount of diversity in a community is indicative of higher complexity, and interaction within a community involves the transfer of energy, predation, competition, and division of more complex niches.

Therefore, low diversity occurs due to the dominance of one species. The number of species determines the dominant index \([C]\). This was following the explanation provided by Shannon-Wiener's, where the diversity index values at each location were categorized as moderate [Table 5].

**Table 5. Index of the dominance of rice with refugia, rice without refugia and on refugia plants**

| No | Location of Observation | Dominance index | Total of Ordo |
|----|------------------------|-----------------|---------------|
| 1  | Rice with refugia      | 0.20            | 6             |
| 2  | Refugia                | 0.25            | 3             |
| 3  | Rice without refugia   | 0.38            | 4             |

Table 5 shows that rice plants without refugia at 0.38 possess the highest dominance index value, and those with refugia were identified as the lowest, at 0.20, and 0.25 was recorded for the refugia plants itself. This was also by Simpson's explanation, where the presence of only one species in the community is ascribed the dominance index value of 1, and values closer to 0 denote abundant and equal distribution. Therefore, a lower value indicates the absence of specie dominance in an ecosystem.

The dominance index \([C]\) at the three smallest locations was 0.20 in rice plants with refugia, and according to Suheriyanto [16], the Simpson dominance index range from 0-1, with a value of 1 in communities with a single species. However, values approaching 0 are attributed to the occurrence of abundant and equally distributed species. Therefore, an index value is closer to 1 indicates the existence of more dominant species in a community, while values closer to 0 demonstrates the occurrence of a rich and more even distribution. This means that a lower value indicates the enhanced diversity of insects existing in an ecosystem.

4. **Conclusion**

Insects identified in the studied area were classified into orders, families, species, and the sum population of individuals and the values obtained for paddy fields with refugia were 5, 8, 11, and 130, respectively. This was recorded as 4, 7, 9, and 213 in fields without refugia, and 3, 6, 6, and 9 in the area with refugia plants alone. The diversity index \([H]\) was identified as 1.87 and 1.39 in rice plants with and without refugia, respectively, hence all locations were classified as abundant. The dominance index \([C]\) in rice plants with and without refugia were 0.20 and 0.38, respectively. It is possible to attribute planting refugia in paddy fields with a comparable increase in the diversity of insects.

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