Diversity of pests and natural enemies in rice field agroecosystem with ecological engineering and without ecological engineering

E Ibrahim and A Mugiasih
Tungro Disease Research Station
Bulo Street No.101 Lanrang, Sidrap South Sulawesi Indonesia 91651
Email: elisuryaibrahim@gmail.com

Abstract. Biodiversity is one measure of ecosystem balance, so that biodiversity is important to know the condition of the ecosystem in the fields. A high diversity index shows the high stability of the ecosystem because the food webs formed are more complex. The purpose of this study was to obtain information about the diversity of insects in the paddy ecosystem with ecological engineering and without ecological engineering. This research was conducted at the Experimental field of Tungro Disease Research Station, Lanrang Sidrap, South Sulawesi, Indonesia from June to August 2017 using the observation method by periodically observing each week starting at plants 2 weeks after planting. The design used a split-plot design consisting of 2 main plots, namely 1) Ecological Engineering Agroecosystem, using flowering plants (refugia) and pest control with andrometa which is a mixture of entomopathogenic fungus Metharizium anisopliae and bitter extract; 2) Conventional agroecosystems, without flowering plants and pest control using pesticides. The results show that the number of pests and natural enemies found in ecological engineering agroecosystem plots is higher than conventional plots. While the index value of pest diversity and natural enemies in both observation plots is classified as moderate. Therefore, the ecological engineering agroecosystem by planting refugia plants is needed to increase the number and types of arthropods of natural enemies.

1. Introduction
Biodiversity that exists in agricultural ecosystems such as rice fields can affect plant growth and production, namely in the system of nutrient cycling, microclimate changes, and detoxification of chemical compounds [2]. In the paddy agroecosystem, the insect groups based on diversity of functions include pest insects, natural enemies, and neutral insects [16]. Insect pests are a major causative factor in yield loss, either directly eating plant tissue or as a vector of plant pathogens. while natural enemies are biotic components that regulate pest insect populations in the agroecosystem, which consists of predators and parasitoids [4]. The diversity of insect species has a very important impact on stability in the paddy rice ecosystem.

The use of natural enemies as a component of integrated pest control needs to be developed. The natural enemy is an effective population regulator because it is density-dependent, if there is an increase in the pest insect population, it will be followed by an increase in natural enemy population (numerical response) and functional response, ie increase in feeding power or paracity [17].
Efforts to conserve natural enemies in paddy agro-ecosystems can be done by managing agricultural land (agroecosystems) or modifying environmental factors with ecological engineering, for example by planting flowering plants on paddy fields [7]. According to [8], the addition of flowering plants can attract useful insects and can reduce the level of pest attacks, because these flowering plants can be a habitat for natural enemies, including parasitoids and predators.

The purpose of this study was to obtain information about the diversity of insects in the paddy ecosystem with ecological engineering and without ecological engineering.

2. Materials and Methods

2.1 Study area
The test area is located in Lanrang, Sidrap at the Experimental field of Tungro Disease Research Station, Lanrang Sidrap, South Sulawesi, Indonesia from June to August 2017.

2.2 Experimental design
The experiment was carried out using a split-plot design consisting of 2 main plots, namely 1) Ecological Engineering Agroecosystem, using flowering plants (refugia) and pest control with andrometa which is a mixture of entomopathogenic fungus *Metharizium anisopliae* and bitter extract; 2) Conventional agroecosystems, without flowering plants and pest control using pesticides.

2.3 Observation contents and methods
Observations were made on the presence of natural enemies every week starting from two to eight MST. Arthropod sampling was carried out by sweeping method using 10 nets double swing diagonally, the captured arthropods were stored in plastic bags for storage and then counted and identified based on [13] and [15].

2.4 Data processing
The analysis used to determine the biodiversity of pests and natural enemies is by counting the total number of pests and natural enemies (N), species diversity index (H’), species richness index (R) and evenness index (E).

3. Results and Discussion

3.1 Number of Pests and Natural Enemies in Ecological Engineering Plots and Conventional Plots
Table 1 is the number of orders and family of pests and natural enemies in ecological engineering plots and conventional plots. The number of pests and natural enemies in the ecological engineering plot found 20 types of pests and natural enemies, while in conventional plots found 19 types of pests and natural enemies. In ecological engineering plots the population of pests and natural enemies is more diverse, this is consistent with the results of the study [9, 14] shows that the addition of flowering plants to plants with a low diversity source can increase the population of useful insects both predators and parasitoids.

In ecological engineering plots whose embankments are planted with flowering plants (refugia) and pest control with andrometa show a higher and more diverse number of natural enemies, namely 10 types of predators and 3 types of parasitoids, compared to conventional plots, only 9 types of predators and 3 types of parasitoids. The results of [3] research show that rice plants whose embankments are planted with refugia plants show a natural enemy population that has increased along with the flowering of the refugia plants. Likewise [1] suggested that this refugia plant has a function that can be used as a microhabitat which is also expected to be able to contribute in the effort to conserve natural enemies for plant pests.
Table 1. Number of orders and family of pests and natural enemies in ecological engineering and conventional plots in one planting season

| Insect name              | Ecological Engineering Plot | Conventional plot |
|--------------------------|-----------------------------|-------------------|
|                          | Order | Family | Individual | Ordo | Famili | Individual |
| 1. Pest                  | 3     | 7      | 99         | 3    | 7       | 91         |
| 2. Natural enemies:      |       |        |            |      |         |            |
| - Predator               | 4     | 10     | 245        | 4    | 9       | 192        |
| - Parasitoids            | 1     | 3      | 23         | 1    | 3       | 36         |
| Total                    | 8     | 20     | 367        | 8    | 19      | 319        |

3.2 Types of Pests and Natural Enemies in ecological engineering plots and conventional plots

Table 2 shows that in general species of pests and natural enemies have higher populations in ecological engineering plots than conventional plots. The application of insecticides is effective in controlling partial pests, but at the same time against predators that oppose biological pest control [6].

The type of pest with the highest population in the two observation plots was *Cnaphalocrocis medinalis* (Lepidoptera, Crambidae). This type of pest is not the main pest in rice plants, but its existence can disrupt the growth and development of rice plants. The attack can reduce production if the damage to the leaves in the maximum tillering phase and maturation phase reaches > 50%. Damage due to attacks of fake white pest larvae can be seen in the presence of white on the rice leaves [10]. The type of predator with the highest population in both observation plots is round spider (Araneae: Araneidae) which preys on small insects in the form of green leafhopper, brown plant hopper and fly [15].

3.3 Pests and natural enemies fluctuations in ecological engineering and conventional plots

In ecological engineering, pest population fluctuations show the same pattern as natural enemies both predators and parasitoids (Fig 1a). When the pest population increases in week 7, the natural enemy population also automatically increases. This shows that environmental conditions are stable because natural enemies play an optimal role because naturally every type of pest is controlled by various types of natural enemies. According to [16] that natural enemies are biotic components that regulate pest insect populations in agroecosystems.

In conventional plots fluctuations in populations of pests and natural enemies show different or incompatible patterns (Fig 1b). In the 7th week of observations when the pest population increased, the predator population declined even though it was not followed by a pattern of parasitoid population fluctuation. This is thought to be caused by the application of insecticides in conventional plots which can cause the death of predators. Similarly, [5] reported that the toxic from the insecticide could kill several arthropods species caused the abundance and species diversity of spiders and predatory insects were the lowest on the rice sprayed with synthetic insecticide.
| No | Arthropods | Ordo            | Family        | Species                  | Ecological Engineering Plot | Conventional plot |
|----|------------|-----------------|---------------|--------------------------|-----------------------------|-------------------|
| 1. | Pest       | Hemiptera       | Cicadellidae  | *Nephrotettix virescens* | 15.66                       | 26.32             |
|    |            | Hemiptera       | Delphacidae   | *Nilaparvata lugens*     | 4.33                        | 7.99              |
|    |            | Hemiptera       | Alydidae      | *Leptocoriza acuta*      | 3.33                        | 10.32             |
|    |            | Lepidoptera     | Phyrallidae   | *Scirophaga innotata*    | 0.33                        | 1.00              |
|    |            | Lepidoptera     | Noctuidae     | *Spodoptera litura*      | 7.33                        | 3.00              |
|    |            | Lepidoptera     | Crambidae     | *Cnaphalocrocis medinalis* | 48.65                      | 39.67             |
|    |            | Ortoptera       | Acrididae     | *Valanga nigricornis*    | 19.66                       | 3.67              |
|    |            |                |               | **Total**                | **99.31**                   | **91.97**         |
| 2. | Predator   | Coleoptera      | Coccinellidae | *Micraspis sp*           | 13.33                       | 17.67             |
|    |            | Coleoptera      | Carabidae     | *Ophionea nigrofasciata* | 0.33                        | 0.33              |
|    |            | Odonata         | Coenagrionidae| *Agriocnemis spp.*       | 29.34                       | 38.33             |
|    |            | Odonata         | Libellulidae  | *Pantala flavescens*     | 5.32                        | 7.67              |
|    |            | Ortoptera       | Tettigonnidae | *Conocephalus longipennis* | 1.33                       | 5.00              |
|    |            | Araneae         | Araneidae     | *Araneus inustus*        | 92.67                       | 76.33             |
|    |            | Araneae         | Tetragnathidae| *Tetragenatha maxillosa* | 80.34                       | 31.66             |
|    |            | Araneae         | Oxyopidae     | *Oxyopes javanus*        | 14.33                       | 12.99             |
|    |            | Araneae         | Lycosidae     | *Lycosa pseudoannulata*  | 7.00                        | 2.66              |
|    |            | Araneae         | Salticidae    | *Phidippus sp*           | 1.33                        | 0.00              |
|    |            |                |               | **Total**                | **245.33**                  | **192.64**        |
| 3. | Parasitoids| Hymenoptera     | Brachonidae   |                         | 1.67                        | 12.67             |
|    |            | Hymenoptera     | Ichneumonidae |                         | 20.67                       | 23.67             |
|    |            | Hymenoptera     | Scelionidae   |                         | 0.67                        | 0.33              |
|    |            |                |               | **Total**                | **23.01**                   | **36.67**         |
|    |            |                |               | **Total Number**         | **712.28**                  | **605.88**        |
3.4 Community Analysis

Based on Table 3, the number of pests and natural enemies in ecological engineering plots is higher than in conventional plots. This shows that the existence of ecological engineering by planting refugia plants in paddy fields can attract insects including natural enemies to come and settle on these refugia plants. By the opinion of [18] refugia plants around agricultural land can be used as an alternative habitat for many insects including predators and parasitoids. Similarly, [12] that planting plants on the edge of this land can function as a temporary shelter (refugia) as well as a food source for both parasitoids and predators.

Based on the results of the analysis of diversity index (H’) in both medium-sized agroecosystems with a value of 2.247-2.418 including moderate diversity and stability of the moderate community shows that the condition of the paddy ecosystem is relatively stable where natural enemies can still control the pest population. In stable agroecosystems, natural enemies are effective population regulators because they are density-dependent. If there is an increase in the pest insect population, it will be followed by an increase in the population of natural enemies (numerical responses) and functional responses, namely an increase in feeding power [17].

Species richness index (R) is the simplest measure of biodiversity because it only takes into account differences in the number of species in a particular area. The value of species richness in both agroecosystems is included in the medium value of wealth, with the value of species richness in ecological engineering plots is higher (3, 216) compared to conventional plots (3,118). Based on [11] value of R1 smaller than 3.5 indicates a species richness that is classified as low, R1 value of 3.5 to 5.0 indicates a species richness that is moderate, while an R1 value of more than 5.0 indicates a species richness that is classified as high.

The Evenness Index (E) value can be used as an indicator of the presence of dominance symptoms between each type in the community. Evenness Index values obtained ranged from 0.750 - 0.821, this indicates that there are still types or families that dominate in both agroecosystems. From the analysis, it is known that the species that predominate are round spider predators (*Araneus inustus*) and long limb spiders (*Tetragnatha maxillosa*).
4. Conclusion
The biodiversity index is moderate which shows that the condition of the paddy ecosystem is relatively stable where natural enemies can still control the pest population. The number of pests and natural enemies found in organic plots is more numerous and varied compared to conventional plots. Therefore, the ecological engineering agroecosystem by planting refugia plants is needed to increase the number and types of arthropods of natural enemies.

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