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DIVERSITY OF THE ORDER HYMENOPTERA IN RICE PLANTATION IN MANEMBO-NEMBO DISTRICT AS AN ECOLOGICAL INDICATOR

Gulbudin Hikmatiar Idris*[1], Christny Ferdina Evie Rompas[2], Utari Satiman[3], Johanna Zusye Wantania[4]

[1] Biology Student, Faculty of Mathematics, Natural Sciences, Universitas Negeri Manado, Indonesia.
[2,3,4]Biology Departement, Faculty of Mathematics and Natural Sciences, Universitas Negeri Manado, Indonesia.

**Corresponding author: gulbudinidris6@gmail.com*

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Abstract

This research aims to determine habitat conditions as an ecological indicator and measure the level of diversity of insects of the order Hymenoptera on rice plantations in the Manembo-nembo sub-district. The method used in this research is quantitative descriptive. Insect samples were collected using the sweeping net and yellow pan trap methods. The Shannon-Wiener diversity index formula, Pielou's similarity index (E), and Simpson dominance index (C) are used to measure the level of diversity. The results of research on rice plantations found insects of the Hymenoptera order as many as 35 genera, 16 subfamilies and 14 families with a total of 470 individuals with normal habitat conditions where Hymenoptera insects can still carry out activities on rice plantations. Wasp insects from 24 genera also have functions as biological control agents, most of which are parasitoid and predatory wasps, which have potential as ecological indicators in rice plantations in the Manembo-nembo sub-district. The level of diversity is included in the medium criteria, as is the evenness index value. In contrast, the dominance index is included in the low criteria even though the Pimplinae family dominates rice cultivation in the Manembo-nembo sub-district.

Key words: Diversity, Ecological indicators, Hymenoptera order, Rice cultivation

INTRODUCTION

Insects are the dominant animal species on Earth, with the number of species reaching almost 80% of the total animals on Earth. A total of 1,413,000 species have been identified, and more than 7,000 species are discovered almost every year. This high number is because insects can survive in various habitats, have a high reproductive capacity, and have the ability to escape from predators Meilin and Nasamsir (2016). The insect class is a group of the Order Hymenoptera, which consists of several types of insects, such as ants, bees, wasps and sawflies. Hymenoptera is divided into two suborders: the Symphyta suborder and the Apocrita suborder. Insects of the order Hymenoptera have two pairs of wings shaped like membranes.

Rice plants in North Sulawesi Province are often hit by successive pest attacks, such as planthoppers, which damage rice plants. In the early 1990s, another problem also appeared with *Trypoza sp.*, which is a rice stem borer pest. Pest insects belonging to the Order Hemiptera, such as *Nezara viridula*, *Leptocorisa sp.* and *Paraecosmetus sp.,* often attack rice plants by sucking young grains. *Lygaeid* ladybug, *Paraecosmetus sp*., is a grain sucker that was first discovered in Bolaang Mongondow Regency but has now spread to Minahasa Regency and other areas in North Sulawesi Province. One way to overcome the pest problem is to use pesticides because they are more accessible and can kill insect pests without farmers realizing it. This can lead to the destruction of natural enemies of pests, leading to an explosion of pests population and damage to crops Sembel and Mangundap, in Moningka (2012).

To know environmental conditions and the existence of resources in a living creature's habitat, humans often need help to measure or monitor these conditions or resources directly. This may be due to various instrument limitations, limited costs, time and energy, or because it is technically challenging. Therefore, to overcome this, humans use the appearance of living creatures to indicate the conditions of their environment and the resources of the creature's habitat. Living creatures whose appearance is observed to be used to indicate the state of environmental conditions and help in their habitat are called bioindicators. Bioindicators also mean organisms or members of a community that can provide information about environmental conditions in whole or in part. Organisms can monitor biochemical, physiological, or behavioral changes that may indicate problems in their ecosystem Husamah *et al*. (2019). This study aims to determine habitat conditions as an ecological indicator and measure the level of diversity of insects of the order Hymenoptera on rice plantations in the Manembo-nembo sub-district.

RESEARCH METHODS

This research was conducted on rice plantations in the Manembo-Nembo sub-district. Samples were collected four times and identified and counted. The study took place from April to May 2023.

The tools used in this research are a Thermohygrometer, Lux meter, and Soil tester for measuring environmental parameters. Plastic cups, jars, 10 ml glass vials, brushes, tweezers, filters and insect nets will be used as insect traps in rice plantings. Identify Hymenoptera insects using an insect identification book, smartphone, and magnifier. The materials used in this research were 70% alcohol, detergent and yellow paint.

This research uses quantitative descriptive methods; the samples studied are all insect specimens found in the research location. The models observed in research on rice plantations in the Manembo-nembo subdistrict were individual insects of the Hymenoptera order, which were caught using the Yellow pan trap and Sweeping net sampling techniques during sampling.

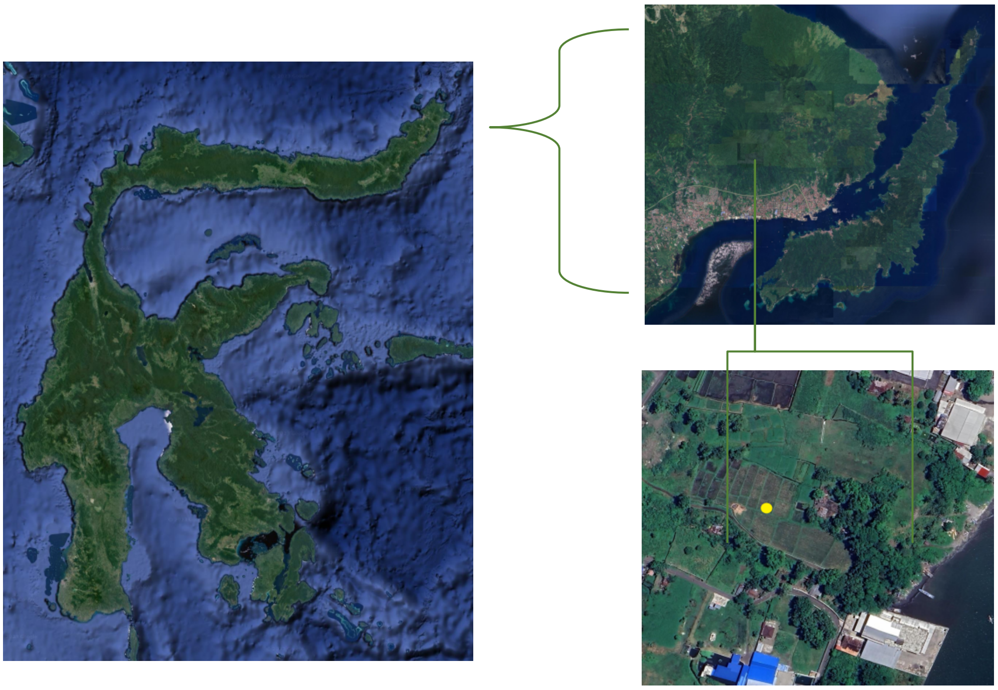

Figure 1. Map of the research location (locations marked with yellow circles)

The research procedure begins at the preparation stage. This stage includes field observations that will be used as locations to determine the research time, preliminary studies as a basis for conducting research, and preparation of materials and tools that will be used at the research location. The next stage was to take samples of insects perched or flying around the rice plants using net traps and yellow traps to catch insects attracted by the striking color and walking on the ground. The yellow traps were filled with detergent water to attract insects. Trapped, unable to escape, placed around the rice plant, and left for 24 hours. After that, the captured insects were placed in a jar containing 70% alcohol before environmental factors, such as air temperature, humidity, light intensity, soil pH, and soil moisture, were measured. Samples found in rice plantations were then counted and identified using the identification books Hymenoptera of the World: An Identification Guide to Families Goulet and Huber, (1993), A Guide to the Ants of Sabangau Schreven *et al*. (2014), and The Bees of the World Michener, (2007). Up to the family level, then continued to the genus level using the help of Google Images on a smartphone, and the results are seen in online data from the ITIS (Integrated Taxonomic Information System) website, GBIF, and other online data sources. After that, the number of individual insects of the Hymenoptera order was counted to determine the level of diversity.

To determine the level of diversity of Hymenoptera insects, alpha diversity is used, which consists of the Shannon-Wiener diversity index (H'), which shows the richness and balance of a species in a community:

$$H' = -\sum(Pi \ln Pi)$$ Magurran, (2021)

When H' is the Diversity index, ∑ is the Number of species; Pi is In/N; In is the Number of

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individuals of the i-th species; N is the Total number of individuals. Test criteria for determining diversity index values: H < 1 = Low diversity, 1≤ H ≤ 3 = Medium diversity, H > 3 = High diversity Sumarmiyati, (2019)

Pielou's evenness index (E) shows the pattern of evenness of one species with other species in a community:

E = H'/ln (s) Mulyowati, (2018)

When E is the Type Evenness Index; S is the Number of types; H' is the Species evenness index; ln is Natural logarithm. Test criteria for determining the evenness index value: e' = 0 < 0.3 : Low evenness, e' = 0.3 < 0.6 : Medium evenness, e' = > 0.6 : High evenness Sumarmiyati, (2019)

Simpson's dominance index (C) shows whether or not a species is dominant over other species in a community:

D = ∑[ni/N]^2 Dabkowska et. al (2017)

C = 1 – D Okasanen et. al. (2018)

When C is the Dominance index; In is the Number of individuals; N is the Total number of individuals. The criteria for determining the dominance index value is 0 < C ≤ 0.5 = low dominance; 0.5 < C ≤ 0.75 = moderate dominance; 0.75 < C ≤ 1.0 = high dominance Tustiyani, (2020)

RESULTS AND DISCUSSION

Insect Specimens of the Order Hymenoptera on Rice Crops

The results of research on insects of the Hymenoptera order in rice plantations which was carried out on 25 - 26 April 2023 and continued on 6 - 7 May 2023 in Manembo-nembo using sweeping net traps (insect nets) and yellow pan traps (yellow traps) totaling 470 individuals where each specimen consists of 14 families and 16 subfamilies with 35 genera. Specimens of Hymenoptera Order insects on rice plantations in Manembo-nembo can be seen in Table 1

Based on the data in Table 1, the insects of the Hymenoptera order found in rice plantations in Manembo-nembo all fall into the sub-order Apocrita. In Table 1, the dominant Hymenoptera insects are in the Genus Pimpla with a total of 363 individuals, where this genus is included in the pimplinae subfamily of the Ichneumonidae family. In this study, the family of parasitic wasp insects was the most commonly found specimen, of which there were 24 genera.

Families that have various types are from the families Formicidae, Ichneumonidae, Pompilidae, Sphecidae, and Vespidae, while the families Halictidae, Sapygidae, Megastigmidae, and Chalcididae only have one type of genera. Other families such as Apidae, Braconidae, Bethylidae, Megachilidae, and Scolidae only have two genera. Each family is represented by several subfamilies except for the families Torymidae, Scoliidae, and Chalcididae whose genus members are not represented by subfamilies. The subfamily consists of Apinae, Braconinae, Epyrinae, Formicinae, Ponerinae, Ichneumoninae, Phygadeuontinae, Pimplinae, Tryphoninae, Megachilinae, Pepsinae, Ammophilinae, Sphecinae, Eumeninae, Polistinae, and Halictinae. Each Hymenoptera insect found has a diverse

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number of individuals, where wasp insects have the largest number of individuals and genera in rice plantations.

To more clearly see the composition of each member of the genus in each family, the following will be presented through graphic displays and diagrams based on members representing each type in the order Hymenoptera, where in this order there are three types of insects, namely ants, wasps and bees.

Table 1. Insect Specimens of the Order Hymenoptera On Rice Plantations in Manembo-nembo District

No.	Family	Subfamily	Genus	Number of Individuals
1.	Apidae	Apinae	*Apis*	14
			Amegilla	2
2.	Braconidae	Braconinae	*Bracon*	1
			Opius	2
3.	Bethylidae	Epyrinae	*Cephalonomia*	5
			sclerodermus	1
4.	Chalcididae		*Brachymeria*	2
5.	Formicidae	Formicinae	*Formica*	1
			Polyrhachis	10
			Anoplolepis	5
			Camponotus	4
			Oecophylla	4
		Ponerinae	*Odontomachus*	2
6.	Ichneumonidae	Ichneumoninae	*Coelichneumon*	1
		Phygadeuontinae	*Lissonota*	7
		Pimplinae	*Pimpla*	363
		Tryphoninae	*Netelia*	1
			Acrotaphus	1
7.	Megachilidae	Megachilinae	*Coelioxys*	1
			Megachile	1
8.	Torymidae		*Megastigmus*	1
9.	Pompilidae	Pepsinae	*Auplopus*	2
			Dipogon	5
			Priocnemis	1
10.	Specidae	Ammophilinae	*Ammophila*	1
			Sceliphron	2
		Sphecinae	*Sphex*	3
11.	Scoliidae		*Scolia*	1
			Micromeriella	5
12.	Sapygidae		*Sapyga*	11
13.	Vespidae	Eumeninae	*Abispa*	1
		Polistinae	*Ropalidia*	1
			Vespa	1
			Delta	6
14.	Halictidae	Halictinae	*Sphecodes*	1
	Total number			470

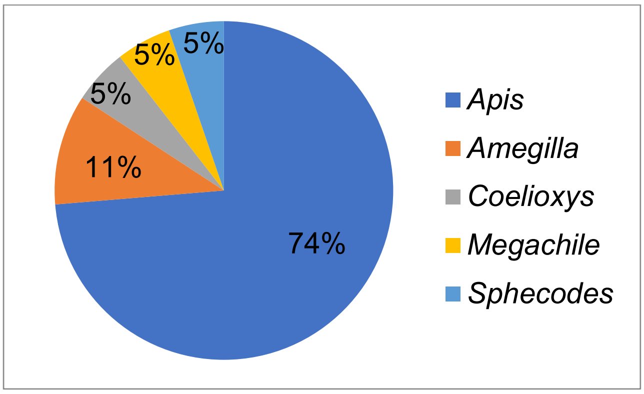

Figure 2. Diagram of Bee Population Composition (Hymenoptera: Apidae, Megachilidae, Halictidae: Halictinae).

Based on the diagram above, there are differences in the individual composition of each member of the bee genus (Hymenoptera), which is spread into several families. The *Apidae* family, such as the *Apis* genus, has the highest percentage (74%) because *Apis sp*. are eusocial insects that often travel in large groups—then followed by the genus Amegilla in the same family, namely (11%). The Megachilidae family, represented by the genus Coelioxys and Megachile, has the same percentage, namely (5%), and the subfamily Halictinae with the genus Sphecodes with a rate of (5%) and other bee insects found in rice plantations are solitary bees, so only a few individuals are located at a time study.

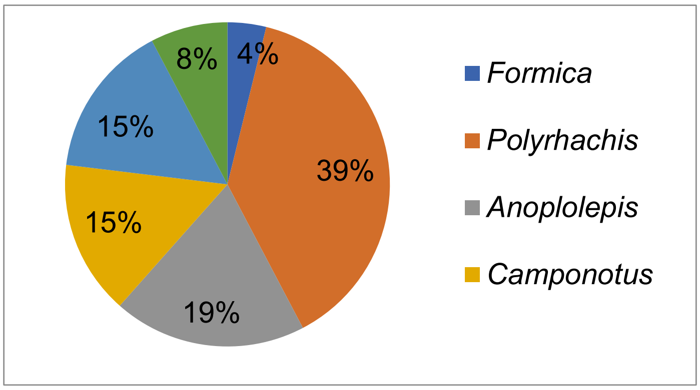

Figure 3. Ants Population Composition Diagram (Hymenoptera: Formicidae)

In the diagram above, the composition of each genus in the Formicidae family is very diverse and the highest percentage is in the Polyrhachis genus (39%). Then the one with the lowest percentage is the genus Formica at (4%) and the genera Oecophylla and Camponotus have the same percentage at (15%). For the genus Anoplolepis, it has the second highest percentage after Polyrhachis, namely (19%),

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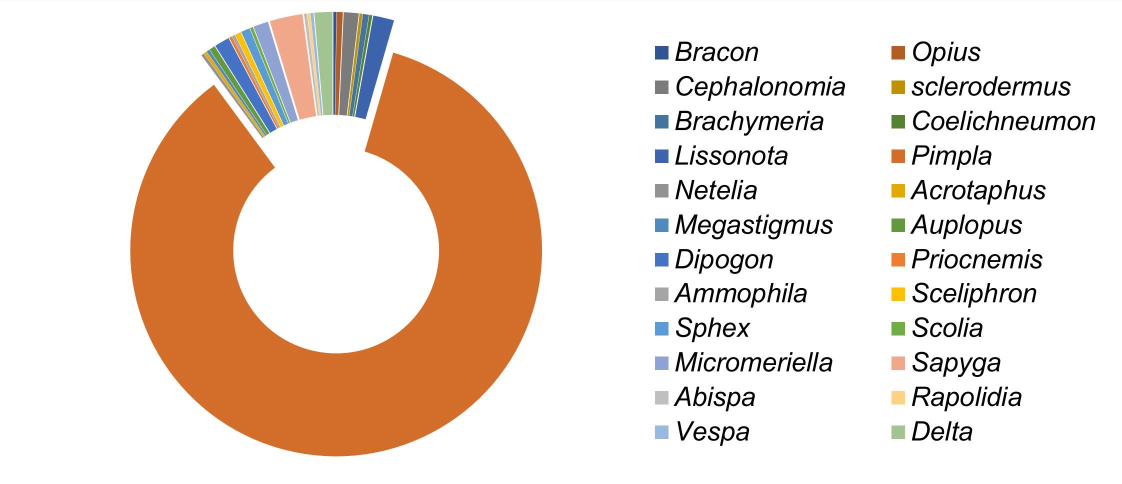

Figure 4. Wasp Number Composition Diagram

Based on diagram above, there is a significant difference between the percentage of one genus and another, where the genus from the Pimplinae subfamily is Pimpla sp. has a percentage of (85%). Meanwhile, the remaining number (15%) is represented by several wasp genera from various families. Based on Figure 6, it can be seen that the Pimpla genus dominates the number of individuals with 363 individuals. Some genera are only represented by one individual and others are represented by two individuals. For the genus Sapyga there were 11 individuals, while in the genera Cephalonomia, Dipogon, and Micromeriella there were 5 individuals. Furthermore, there are 6 individuals in the genus Delta, 7 individuals in Lissonota, and 3 individuals in Sphex. The composition of Hymenoptera insect species found in rice plantations is diverse and dominated by parasitic wasp insects. The Pimpla genus in the Pimplinae subfamily has the highest number of individuals compared to other types of insects, where Pimpla are found in yellow traps in agricultural areas.

Environmental Parameters of Rice Cultivation In Manembo-nembo District

Variations in the number and diversity of individuals and the presence of specimens that dominate in numbers are influenced by environmental factors and traps used in research on rice plantations in Manembo-nembo. The results of ecological factor measurements taken at rice plantations in Manembo-nembo are shown in Table 2

Table 2. Results of Measuring Environmental Parameters In Rice Plantations

Environmental Parameters				
Air Temperature (˚C)	Air Humidity (%)	Light Intensity (Lux)	Soil pH	Soil Moisture
32.6 °C	75%	6651 lux	8	6
32.2 °C	78%	4585 lux		
33.7 °C	81%	5347 lux		
30.9 °C	72%	8801 lux		

Diversity of Hymenoptera Order in Rice Cultivation

Data analysis of insect diversity of the Hymenoptera order uses Microsoft Excel. It is measured using alpha diversity, which is the most superficial level. It can be defined as the number of species in a habitat using the diversity index, evenness index and dominance index as measurement data.

Table 3. Results of Calculating The Diversity of Insects of the Hymenoptera Order in Rice Plantations

Mark	Diversity of the Order Hymenoptera		
	Diversity Index (H')	Evenness Index (E)	Dominance Index (C)
	1,248	0.351	0.4

Discussion

Wasp insect species vary in number and size, and some types are parasites for other insects where parasitic wasps lay eggs in their hosts as a food source for the next generation. This type of wasp in the Ichneumonidae family is the most common specimen found in rice plantations, where the number reaches 373 individuals. This is in line with research from Moningka (2012), where the results of this research found that Hymenoptera insects from the families Ichnemumonidae, Braconidae, and Chalcididae are included in the parasitoid insects. Insects of the Hymenoptera order from the Chalcididae family, *Brachymeria sp.* is a larval parasitoid also found in rice crops.

In rice plantations in the Manembo-nembo sub-district, predatory Hymenoptera insects were also found. This is based on the results of previous research in which the families of Formicidae, Sphecidae, and Vespidae are predatory types, and these three groups also have variations in number and diversity at planting locations rice Ikhsan *et al*. (2020). Not all insects are harmful because there are also insects that have a positive impact. Some insects are predators and parasitoids or are often called natural enemies. According to references from Sumarmiyati (2019), its role as a natural enemy really helps humans in pest control efforts. Apart from that, insects also help maintain the stability of food webs in an agricultural ecosystem. Natural enemies are effective population regulators because they depend on density. Suppose there is an increase in the population of insect pests. In that case, it will be followed by the rise in the population of natural enemies (numerical response) and a functional response, namely an increase in their eating power or parasitization power. In a reference still being discussed by Sumarmiyati (2019), predatory rice pest insects are generally more abundant in rice fields where synthetic insecticides are not applied. Still, using bioinsecticides does not reduce the abundance or diversity of predatory insect species.

In rice plantations in Manembo-nembo District, insects of the Hymenoptera order, which have roles as predators and parasitoids, and some also act as pollinators, are still found. Parasitic and predatory wasp-type insects dominate rice planting habitats where these insects can function as biological control agents, especially pests detrimental to farmers. This large number of wasp insects indicates that in this habitat, the role of insecticides does not affect the activity of these insects.

In Table 2, the environmental parameters measured in the morning during the four days of the study, where the air temperature ranged between 30 - 33ºC, which is still within the tolerance limit of Hymenoptera insects because temperature plays a role in the rate of chemical reactions and controls metabolic activity in the animal's body as a compensation mechanism. In adapting to nature, Rahayu (2018). Even though this temperature is relatively high, the Hymenoptera insects are still quite diverse at this temperature. Data on air humidity in rice plantings in the Manembo-nembo sub-district ranges from 72% - 81%; in terms of air humidity, it can still be tolerated by insects, which in the range of 55% to 85% is the limit where insects can still carry out activities, weather conditions also influence this in rice fields Rahmata *et al*. (2021).

Hymenoptera insects also need sunlight to be active because most are diurnal animals or active during the day (Campbell, 2008). The light intensity measured during research ranged from 4585 to 8801 lux; in this condition, Hymenoptera insects can still be active, but at 8801 lux, the light intensity has exceeded the optimal conditions for insects to be involved because excess sunlight can affect insect activity. The optimal light intensity for insects to survive is 2000 to 7500 lux Nurhikmah (2019). This measurement was carried out in the morning, and only a few Hymenoptera insects were active. The condition of the soil in the rice plantations in Manembo-nembo by looking at the soil pH data is 8, which means that the soil condition in the rice plantations is in normal condition because the rice fields have moist soil for the growth of rice plants where the Hymenoptera insects that live in the soil only inhabit certain parts of the rice plantations, which is in Manembo-nembo. Apart from that, the soil moisture in rice planting is 7, where the soil condition is still normal; apart from the influence of the rice field habitat, it is also related to the weather conditions in Manembo-nembo.

In Table 3, the Shannon-Wiener diversity index (H') shows that the level of diversity in the rice planting habitat is within the medium criteria where the community is in an unstable condition between one insect species and another and does not dominate each other. According to references from Sumarmiyati (2019), the diversity of insects in a habitat can influence the diversity of parasitoid and predatory Hymenoptera insects, which is closely related to the fulfillment of food needs for Hymenoptera insects. The results of the Hymenoptera insect evenness analysis use the Pielou's evenness index (E), which is included in the medium criteria. This means that the community in the habitat tends to be evenly distributed, where there is still variation in the number of Hymenoptera insect species. Previous research stated that species diversity is influenced by the proportion of individuals of each type because even if a community has many species, if the distribution of individuals is not evenly distributed, then the diversity is low. The dominance index analyzed using the Simpson formula (C) falls into low dominance even though there are Hymenoptera insects that dominate, namely *Pimpla sp*., but does not directly affect the level of prevalence of Hymenoptera insects in rice plantings.

High diversity in a habitat indicates that the community has high complexity. Long-standing and stable communities will be very diverse. Meanwhile, a community still developing at the level of succession has fewer species than a community that has reached its peak. Highly diverse communities are less susceptible to disruption from existing environmental influences. Thus, in highly diverse communities, species will have more complex interactions involving energy transfer, predation and competition Irni *et al*. (2021).

Apart from the factors above, the diversity of Hymenoptera insects is also influenced by the habitat around the rice fields, as reported in a study which stated in its conclusion that the habitat around the rice fields and the age of the rice plants influence the diversity of the parasitic Hymenoptera within them. Parasitic Hymenoptera is often found in rice planting areas, while other Hymenoptera are more active in flying across rice plantations in search of nectar Herlina *et al*. (2011). According to other references, different seasons also affect the diversity of parasitoids in rice fields.

CONCLUSION

Habitat conditions in rice plantations in the Manembo-nembo subdistrict by looking at environmental parameters are in normal conditions where insects of the Hymenoptera order can still be active. The highest temperature in rice planting reached 33.7°C, and the highest light intensity was 8801 lux. In rice plantations, there are 24 genera of wasps consisting of parasitoids and predators, which have the potential to be used as ecological indicators and biological control agents.

The diversity of the Hymenoptera order in rice plantations in the Manembo-nembo subdistrict, as measured using the diversity index, is in the medium criteria where the community is in an unstable state, the evenness index is in the medium standards where the community in the ecosystem tends to be evenly distributed, and the dominance index is in the low criteria where between There are no species that dominate each other. However, there are members of the wasp insect from the ichneumonidae family, namely Pimpla sp., which has 363 individuals. There are 35 genera of Hymenoptera insects spread across 16 subfamilies and 14 families, and apart from wasps, insects such as ants and bees are also found which are interrelated in the rice field ecosystem in the Manembo-nembo sub-district.

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