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Diversity of Hymenoptera parasitoid species in rice cultivation and their correlation with environmental factors in tidal swamp land

ZAHLUL IKHSAN♥
Department of Agroecotechnology, Faculty of Agriculture, Universitas Andalas. Jl. Unand, Limau Manih, Padang 25163, West Sumatra, Indonesia.
Tel./fax.: +62-751-71181, ♥email: zahlul_ikh@yahoo.com

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Abstract. *Ikhsan Z. 2022. Diversity of Hymenoptera parasitoid species in rice cultivation and their correlation with environmental factors in tidal swamp land. Biodiversitas 23: 2262-2269.* Environmental factors can affect biodiversity in a landscape. Differences in microclimate conditions can affect the presence of parasitic Hymenoptera in rice cultivation. This study investigated: (i) Landscape structure and microclimate on tidal swamp rice; (ii) Diversity and abundance of parasitic Hymenoptera; (iii) Correlation of parasitic Hymenoptera with their landscapes and microclimate. Determination of sample plots was made using the line transect method in rice cultivation in four tidal swampland landscapes. Data analysis was performed by calculating the Shannon-Wiener diversity index (H'), the Margalef species richness index (D), and the Pielou species evenness index. The relationship between parasitic Hymenoptera and environmental factors was analyzed using Pearson correlation analysis, principal component analysis, and canonical correlation analysis. Based on the diversity index (H'), three rice fields in complex landscapes had a higher diversity of Hymenoptera parasitoid species than simple landscapes. The presence of Parasitic Hymenoptera on tidal swamp rice can be affected by the landscape's structure and microclimates. Humidity is the microclimate variable that most influences the abundance of Parasitic Hymenoptera in the tidal swamp landscape. Good microclimate management is needed to increase the presence of Parasitic Hymenoptera in tidal swamp rice.

Keywords: Biological agents, diversity, ecosystems, insects

INTRODUCTION

Indragiri Hilir District has the most extensive rice harvest area in Riau Province. In addition, Indragiri Hilir District is also the highest contributor to rice production in Riau Province in 2018-2019 (BPS 2020). However, an increase in the area of agricultural land will automatically increase the availability of food for pests, which also increases its population.

The decline in rice productivity must be anticipated. Unfortunately, farmers in Indonesia are very accustomed to using chemical pesticides excessively to control pest populations without paying attention to the natural enemies of pests in the fields. It is a dilemma for farmers not to rely on pesticides even though they have known negative impacts because pesticides will also inadvertently eradicate natural enemies of pests in agricultural ecosystems (Hidrayani and Martinius 2014). For example, Parasitic Hymenoptera has a higher diversity index in soybean agroecosystems without insecticide application compared to insecticide application. The value of the species richness index in soybean agroecosystems with insecticide application is also lower than that without insecticide application.

Hymenoptera is one of the four largest orders of insects. The other three are the orders Coleoptera, Diptera, and Lepidoptera (Aguiar et al. 2013). Hymenoptera is divided into two suborders, namely Symphyta and Apocrita, and consists of 132 families, 9108 genera, and 155,517 species that have been identified (Aguiar et al. 2013). Hymenoptera has many vital roles in ecosystems: parasitoids, predators, pollinators, detritivores, and phytophages (Rasplus et al. 2010; Anbalagan et al. 2015). Parasitoid species dominate Hymenoptera. About 80% of Hymenoptera are parasitoid (Rasplus et al. 2010). For example, some species from the Braconidae family are used as parasitoids to control various pests on crops (Tomanović et al. 2013), some species from the Ichneumonidae family as parasitoids in larvae and pupae of Lepidoptera pests in agroecosystems (Mason 2013), several species from the Scelionidae family parasitoids in rice and oil palm plantations Pebrianti et al. (2016) and several species from the Trichogrammatidae family as parasitoids to control pests in the agroecosystems (Sangha et al. 2018).

Utilization and conservation of Parasitic Hymenoptera is one solution to minimize synthetic pesticides. Parasitic Hymenoptera can play an essential role as biological agents in sustainable agriculture. The parasitized host can certainly experience death because parasitoid larvae develop in the host's body. However, many parasitoids can only reach their full ecological and economic potential when they have a suitable nectar source (Géneau et al. 2012). Therefore, landscape structure and environmental factors can significantly influence the presence of Parasitic Hymenoptera (Anbalagan et al. 2015; Fliszkiewicz et al. 2015; Syahidah et al. 2020).

Many studies have shown that complex landscapes characterized by large portions of natural habitat can increase beneficial insect diversity (Luo et al. 2014; Martel et al. 2017). This is because the simple landscape cannot provide the needs of natural enemies, such as alternative hosts and feed for the imago (Géneau et al. 2012). The performance and abundance of parasitoids increased in complex landscapes characterized by a high proportion of natural habitats (Budiaman et al. 2017; Segoli et al. 2020).

Many studies have shown that complex landscapes characterized by large portions of natural habitat can increase the diversity and abundance of natural enemies (Luo et al. 2014; Martel et al. 2017). On the other hand, natural enemy abundance and diversity were lower in simple landscapes compared to complex landscapes. This is because the simple landscape cannot provide the needs of natural enemies, such as alternative hosts and feed for the imago (Géneau et al. 2012).

Ikhsan et al. (2020) reported that habitat diversity and agricultural landscape structure could affect the richness, diversity, and even distribution of Parasitic Hymenoptera species in the Cianjur watershed. The Nyalindung landscape with a more complex structure had higher species richness and diversity of Parasitic Hymenoptera than the Gasol and Selajambe landscapes. Herlina et al. (2011) showed that the habitat around rice fields and the age of rice plants affected the diversity of Parasitic Hymenoptera in it. Parasitic Hymenoptera was more abundant than Aculeata, both individual abundance (96%) and species richness (84%).

Each ecosystem has a different diversity and abundance of Parasitic Hymenoptera. A total of 25,951 parasitoid wasps (10,828 in the conventional and 15,123 in the organic crop area) were collected and were distributed in 11 superfamilies and 38 families. In the conventional management area, the most incredible abundance and richness of parasitoids were recorded in the adjacent forest, while, in the organic management area, the greatest abundance and richness were recorded in the crop-forest edge (Schoeninger et al. 2019). The diversity and abundance of Parasitic Hymenoptera in the forest were higher than in oil palm plantations and post-tin mining areas. The Braconidae family was more dominant in the forest, while in oil palm plantations and post-tin mining areas, the dominant family was Scelionidae.

The existence of the Parasitic Hymenoptera can also be influenced by climate. Temperature and humidity have a significant effect on the arthropod population. For example, Aranea showed a positive correlation in their abundance with an increase in temperature in all the agro-ecologies (Masika et al. 2017). In addition, Maulina et al. (2018) reported that the highest longevity for adult *Hadronotus leptocorisae* parasitoids is at a temperature of 25ºC. There was a correlation (0.636) between the maintenance tube size with the longevity of adult *H. leptocorisae* at room temperature but not at 25ºC.

The study of Hymenoptera parasitoid diversity and its relationship with environmental factors on tidal swamp rice is vital as fundamental knowledge. The difference in tidal swamp rice and non-tidal swamp rice will impact Hymenoptera diversity. In addition, this study is also needed as a basis for ecosystem management and integrated pest management planning in agroecosystems in tidal swamp rice. Based on this description, research has been carried out on the relationship of Parasitic Hymenoptera in rice cultivation with microclimate in tidal land, Indragiri Hilir District. The research aimed to study: (i) Landscape structure and microclimate on tidal swamp rice; (ii) Diversity and abundance of parasitic Hymenoptera; (iii) Correlation of Parasitic Hymenoptera with their landscapes and microclimate.

MATERIALS AND METHODS

Research location

Sampling was carried out in four sub-districts of rice production centers in Indragiri Hilir District, Riau, Indonesia with different landscapes and microclimates. The four sub-districts are Batang Tuaka (0º20'19" S, 103º2'53" E), Reteh (0º40'04" S, 103º08'06" E), Tembilahan Hulu (0°24'05" S, 103°04' 06" E), Keritang (0º42'29" S, 103º0'28" E). Insect identification was carried out at the Insect Bioecology Laboratory, Faculty of Agriculture, Andalas University, and the Zoology Laboratory of the Biology Research Center, National Research and Innovation Agency, Cibinong, Bogor, Indonesia.

Samplings and collecting technique

Research in surveys and sampling was carried out using the purposive sampling method. At each study site, two-line transects with a length of 1000 meters. Two transect lines were made in the rice field with a distance between the transects of 300-400 m. Along the transect line, sampling points were determined ±100 m apart so that on each transect, there were 10 sample plots. So, there are 20 sample plots at each research location.

A sampling of Parasitic Hymenoptera was carried out in the 2018 and 2019 growing seasons. Sampling was carried out three times per growing season, namely before planting, once during the vegetative period, and once during the generative period. The trapping tools used to trap Hymenoptera parasitoid were sweep net, yellow pan trap, malaise trap, and pitfall trap. Microclimate observation variables measured were air temperature, humidity, and soil temperature. Measurements were made on each sample plot on the line transect.

Observation of landscape structure and microclimate

The observed landscape is 1.5 Km^2. Observation of landscape type begins with determining the coordinates of each research location. The coordinates and altitude of each research location were determined using a global positioning system (GPS).

The components of the landscape structure observed were rice fields, other food crops, plantation crops, horticultural crops, wild plants, forests, rivers, and settlements. The land cover area of each landscape component was processed using ArcGIS 10.6 software. Persson et al. (2010) have grouped landscapes based on the share of natural habitat. Simple landscapes are characterized by the portion of natural habitat, which is only 1%, and the portion of agricultural habitat reaches 90%. In comparison, complex landscapes are characterized by the portion of natural habitats by 8% and farming habitats by 80%. Landis et al. (2000) grouped landscapes with 71.4% agricultural and 11.2% natural habitats as simple landscapes, while complex landscapes had 59.4% farming and 14.3% natural habitats.

Microclimate observation variables measured were air temperature, humidity, and soil temperature. Air temperature and humidity were measured using a thermohygrometer, and soil temperature was measured using a soil thermometer. Measurements were made on each sample plot on the line transect.

Identification of parasitic Hymenoptera

The identification of Parasitic Hymenoptera was carried out based on the morphological characteristics of the venation of the wings, legs, mouth apparatus, thorax, abdomen, antennae, and color. Identification and grouping of Hymenoptera based on their function was carried out using various references, namely the introduction to insect lessons by Hymenoptera of The World by Goulet and Huber (1993), the official website http://www.bugguide.net and related articles.

Statistical analysis

Data processing was carried out to see the diversity of Parasitic Hymenoptera and its correlation with the microclimate. The diversity observed in this study was the Shannon-Wiener species diversity index (H'), the species richness index (d) Margalef, and the species evenness index (J). The data were calculated and analyzed using Primary Application V5.2 and EcoMethods Application V7.2 (Colwell and Elsensohn 2014).

Furthermore, an analysis of environmental factors consisting of the microclimate and components of the landscape structure was carried out. This analysis was based on a multivariate technique using Pearson correlation analysis, Principal Component Analysis, and Canonical Correspondence Analysis (Janekovi and Novak 2012). The Pearson correlation analysis value (r) between (-0.3)-(-1.0) indicates a negative correlation, while the r value between 0.3-1.0 indicates a positive correlation between the two variables (Mukaka 2012). The analysis was carried out using the software R statistics Version 3.6.3.

RESULTS AND DISCUSSION

Landscape structure and microclimate

The research was carried out on four rice fields in the tidal swamp landscape of Indragiri Hilir District. The landscape types for each research location are (i) Simple landscape in the Reteh sub-district and (ii) Complex landscape in Keritang, Tembilahan Hulu, and Batang Tuaka sub-districts. Agricultural landscapes are grouped into simple and complex landscapes based on cultivated plants and natural habitats.

The four landscapes of the research location have the same matrix, namely rice plantations. Simple landscapes are only dominated by rice and oil palm plantations, while complex landscapes have various components that make up a more varied landscape. The difference between the four agricultural landscapes in the tidal swampland of Indragiri Hilir District lies in the proportion of the land area used as farmland and natural habitat. However, there are similarities in land use and the broadest landscape element (the matrix). In the four landscapes, land use consists of rice cultivation, other food crops, horticultural crops, plantation crops, natural habitat for shrubs and settlements. The landscape element that acts as a matrix in the four types of the landscape is rice cultivation. According to Martin and Fahrig (2015), the matrix is the most extensive landscape element and has a dominant role in the overall function of the landscape. Rice cultivation is the most extensive landscape element in the four types of landscapes, ranging from 45.64-63.79%.

The average microclimate in each rice field landscape in tidal swampland can be seen in Table 1. Air humidity in tidal swamp rice cultivation ranges from 55-71.5%. Rice cultivation in the simple landscape has a lower average humidity (60.67%) than the three complex landscapes (69.08%; 64.33%; 66.83%). The air temperature in rice cultivation in tidal land landscapes ranges from 29.8-31.9ºC. Rice cultivation in the simple landscape had a higher average air temperature (31.55ºC) than the three complex landscapes (30.50ºC; 31.00ºC; 30.68ºC). Soil temperatures in the four cropping landscapes in tidal land ranged from 27.3-30.1ºC. Rice cultivation in the simple landscape had a higher average soil temperature (29.47ºC) than the three complex landscapes (27.58ºC; 28.28ºC; 28.32ºC).

Diversity and abundance of parasitic Hymenoptera on tidal swamp rice

The abundance of Parasitic Hymenoptera from four rice fields in four tidal swamp landscapes in Indragiri Hilir District was 5777 individuals consisting of 28 families and 315 morphospecies. The three complex landscapes had a higher diversity index of Parasitic Hymenoptera than the simple landscapes. Complex landscape 2 (CL2) has the highest diversity index (4.73) and the highest abundance of individuals (1897 individuals). Complex landscape 3 (CL3) has the highest species richness index (27.93) and the highest number of species (200 species). Simple landscapes had the lowest number of species, individual abundance, species richness index, and species diversity index compared to the three complex landscapes (Table 2.). The existence of the parasitic Hymenoptera is influenced by the type of agricultural landscape in each region. Different landscape structures can form complex and straightforward landscapes, the more types of ecosystems in the landscape. The more complex the landscape structure will be. Thies et al. (2005) state that the share of natural habitat in a landscape can affect the complexity of the landscape. This natural habitat serves as a source of food, alternative hosts, shelter, and the creation of a microclimate of agricultural land suitable for developing parasitic Hymenoptera (Gagic et al. 2011).

Table 1. The average microclimate of rice cultivation landscape in tidal swampland

Type of landscape	Microclimate		
	Air humidity (%)	Air temperature (C)	Soil temperature (ºC)
Simple landscape	60.67	31.55	29.47
Complex landscape (CL1)	69.08	30.50	27.58
Complex landscape (CL2)	64.33	31.00	28.28
Complex landscape (CL3)	66.83	30.68	28.32

Table 2. Diversity of Parasitic Hymenoptera on rice cultivation in each tidal land landscape

Indicator/type of landscape	Simple landscape	CL1	CL2	CL3
Number of morphospecies	120	197	173	200
Individual abundance	763	1873	1897	1244
Species richness index (D)	17.93	26.13	22.79	27.93
Species evenness index (J)	0.88	0.87	0.92	0.86
Species diversity index (H’)	4.19	4.58	4.73	4.54

In Dramaga rice fields, Bogor, 1763 individuals consisted of 182 species of Parasitic Hymenoptera (Herlina et al. 2011). A total of 3151 individuals of Parasitic Hymenoptera consisting of 28 families were obtained from various agroecosystems of rice cultivation in Tamil Nadu, India (Daniel and Ramaraju 2019). This proves that the abundance of Parasitic Hymenoptera obtained in rice cultivation in the tidal land of Indragiri Hilir District is relatively high.

The landscape structure could cause the high abundance of Parasitic Hymenoptera in tidal swamp rice cultivation. The diversity and abundance of Hymenoptera in an agricultural habitat can be influenced by landscape structure (Susilawati 2016). Ikhsan et al. (2020) also reported that the abundance of Parasitic Hymenoptera in tidal swamp rice was higher in complex landscapes than in simple landscapes.

Based on the research results, the simple landscape type has the lowest number of morphospecies, individual abundance, species richness index (d), and species diversity index (H') compared to the three complex landscapes. The complex landscape has many cultivated and wild plants near agricultural ecosystems. There are always available sources of food and suitable living habitats. Meanwhile, the simple landscape is dominated by farming plants that are not varied, coupled with the lack of natural plants. The type of agricultural landscape influences the diversity of parasitoids. Agricultural landscapes with complex structures have a higher abundance, richness, and diversity of parasitoid species than landscapes with more superficial structures (Ikhsan et al. 2021)

The abundance of individuals of the Eulophidae family found in tidal swamp rice cultivation was 526 individuals consisting of 27 species. The abundance of the family Eulophidae correlates with plantation crops and humidity. The Eulophidae species found were *Aprostocetus javanicum, Aprostocetus deobensis, Platyplectrus nr. orthocraspedae, Euplectrus nr. laphygmae, Aprostocetus (Oetetrastichus) nr theioneuru, Pnigalio flavipes, Platyplectrus nr. peculiar, Tetrastichus schoenobii, Euplectrus xanthocephalus*, *Aprostocetus fidius*, and 17 other unidentified species. In another study, Lotfalizadeh et al. (2016) found five species of the family Eulophidae in rice cultivation in Iran.

Correlation of parasitic Hymenoptera with their landscapes

Presence of Parasitic Hymenoptera on tidal swamp rice can be affected by the structure of the landscape. The landscape structure and habitat conditions can influence the diversity and abundance of Hymenoptera in an agricultural habitat (Susilawati 2016). Lizmah (2015) reported that the abundance of Hymenoptera parasitoid in cucumber (*Cucumis sativus*) cultivation was higher in complex landscapes than in simple landscapes. Changes in land-use patterns also affect the diversity of Hymenoptera parasitoid (Bennett and Gratton 2012).

The components that make up the landscape can affect the presence of Parasitic Hymenoptera in an agroecosystem. There can also be differences in the abundance of Parasitic Hymenoptera in the same landscape type. This condition is caused by differences in microclimate conditions in each landscape. The results of the Pearson correlation test show that there is a relationship between the proportion of components that make up the landscape and microclimate with the abundance of Parasitic Hymenoptera in the tidal swampland of Indragiri Hilir District (Figure 1).

Location differences in a wide range can cause differences in abiotic and biotic conditions, such as latitude, demographics, climate, rainfall, temperature, habitat vegetation, and landscape forms. Abiotic and biotic conditions can affect the development of organisms and food networks in the ecosystem, thus affecting flora and fauna species (Herlina et al. 2011). The value of Pearson correlation analysis (r) between (-0.3 and -1.0) indicates a negative correlation, while the r-value between 0.3-1.0 indicates a positive correlation between the two variables (Mukaka 2012). The Pearson correlation test results showed a positive and negative correlation between environmental factors (X) and the abundance of Parasitic Hymenoptera (Y) in the tidal swampland of Indragiri Hilir District. This can be seen from the visualization of Figure 1. which shows that the color that dominates is the color with a value above 0,4 and below -0,4.

Table 3. The variable family group of Parasitic Hymenoptera in tidal swamp rice

Variable group	Symbol	Family
PCA 1	U1	Braconidae, Ichneumonidae, Scelionidae
PCA 2	U2	Scelionidae, Tiphiidae, Scoliidae
PCA 3	U3	Diapriidae, Evaniidae
PCA 4	U4	Braconidae, Bethylidae, Chrysididae, Embolemidae, Drynidae
PCA 5	U5	Eulophidae, Mymaridae
PCA 6	U6	Scelionidae
PCA 7	U7	Ichneumonidae
PCA 8	U8	Figitidae, Eucoilidae
PCA 9	U9	Ceraphronidae, Elasmidae
PCA 10	U10	Pteromalidae
PCA 11	U11	Encyrtidae
PCA 12	U12	Ceraphronidae
PCA 13	U13	Eurytomidae
PCA 14	U14	Chalcididae, Mymarommatidae, Platygastridae
PCA 15	U15	Aphelinidae, Eupelmidae,
PCA 16	U16	Megaspilidae
PCA 17	U17	Torymidae

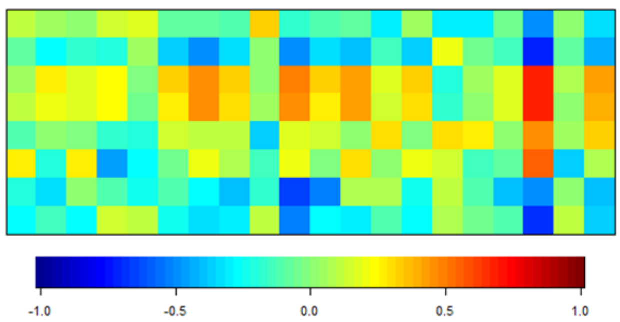

Figure 1. Correlation of environmental factors with the abundance of Parasitic Hymenoptera in tidal land

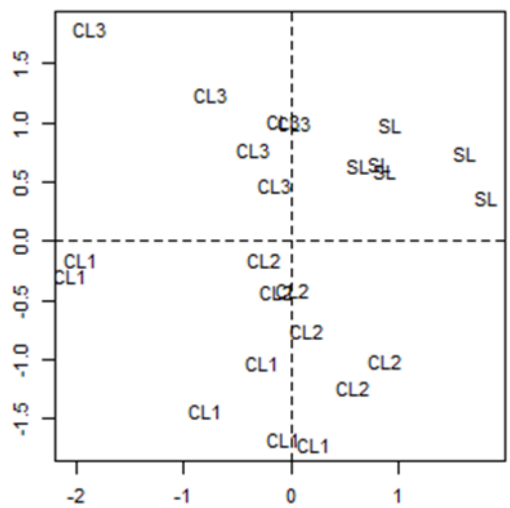

Figure 2. Canonical correlation diagram of landscape type and abundance of Parasitic Hymenoptera in tidal land

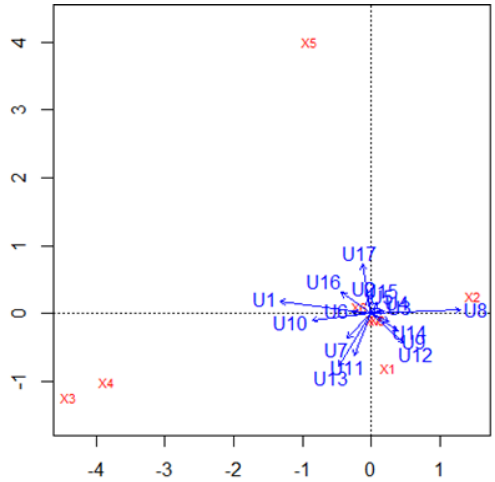

Figure 3. The canonical correlation of environmental factors with the abundance of Parasitic Hymenoptera in the tidal land

Analysis of the relationship of Parasitic Hymenoptera in rice cultivation with environmental factors consisting of predictor variables and response variables. The predictor variables consist of 8 environmental factors (5 broad landscape components and three microclimate variables). The five variables that make up the landscape consist of an area of rice planted, area of plantation, area of horticultural crops, area of other food crops, area of natural habitat. Three microclimate variables consist of air humidity, air temperature, and soil temperature. Furthermore, the response variables consisted of 17 groups of variables from Parasitic Hymenoptera (Table 3).

The canonical analysis was then carried out between the predictor and response variables. The correlation diagram of the canonical analysis shows a grouping of Parasitic Hymenoptera abundance based on the type of landscape in tidal swampland (Figure 2.). Simple landscapes are clustered in the quadrant I, CL1 is clustered in quadrant III, CL2 is clustered in quadrant IV, and CL3 is clustered in quadrant II. The grouping of landscape types in the canonical correlation diagram shows a similar abundance of Parasitic Hymenoptera in each landscape type grouped or adjacent to each other.

The canonical correlation between each environmental factor parameter and the abundance of the Parasitic Hymenoptera family in tidal land is presented in Figure 3. The presence or absence of a correlation can be seen from the direction of the Y vector line. The Y vector line leading to the position of the X variable indicates a correlation-the closer the direction of the vector, the stronger the correlation, and vice versa. Figure 3. shows the correlation between environmental factors and the abundance of the family Parasitic Hymenoptera in tidal land.

Each component of the landscape correlates with the abundance of each family Parasitic Hymenoptera. Rice cultivation which acts as a matrix in the landscape, correlates with the abundance of 5 families of Parasitic Hymenoptera. The five families are Ceraphronidae, Elasmidae, Chalcididae, Mymarommatidae, and Platygastridae. The research results support Pebrianti et al.

(2016), which revealed that the abundance of Ceraphronidae, Elasmidae, and Chalcididae was relatively high in rice cultivation.

Plantation crops correlated with the abundance of 9 families of Parasitic Hymenoptera. The nine families are the Figitidae, Eucoilidae, Diapriidae, Evaniidae, Braconidae, Bethylidae, Chrysididae, Embolemidae, and Drynidae families. In line with these results, the abundance of Eucoilidae is very high in plantation crops in Brazil. At the same time, the abundance of Figitidae is very low (Mata-Casanova et al. 2016). Pebrianti (2016) also revealed a high abundance of Braconidae, Eulophidae, Diapriidae, Evaniidae, and Mymaridae in the oil palm and rice agroecosystems in Bogor District.

Horticultural crops and other food crops in the agroecosystem area of the tidal swamp landscape correlate with the abundance of 4 families of Parasitic Hymenoptera. The four families are Ichneumonidae, Pteromalidae, Encyrtidae, and Eurytomidae. Polyculture vegetable ecosystems consisting of various habitats form a more complex agricultural landscape structure than monoculture ecosystems. These habitats provide various resources such as alternative hosts, food for adult insects such as pollen and nectar, other plant habitats as shelter, continuity of food availability, and a suitable microclimate for the survival and diversity of parasitoids. These resources are only obtained in polyculture farming systems (Masika et al. 2017).

The presence of natural habitat in the tidal swamp landscape correlated with the abundance of 11 families of Parasitic Hymenoptera. The eleven families are Braconidae, Ichneumonidae, Scelionidae, Tiphiidae, Scoliidae, Megaspilidae, Torymidae, Eulophidae, Mymaridae, Aphelinidae, and Eupelmidae. Thus, natural habitat is the most dominant component of landscape structure, influencing the abundance of Parasitic Hymenoptera. Natural habitats in landscape agroecosystems can serve as shelters and refuges for Parasitic Hymenopteras. Natural habitats can also provide alternative hosts or prey that act as "natural enemy bridges" connecting the two growing seasons and as sinks for Parasitic Hymenoptera derived from newly harvested cultivated plants. In addition, natural habitats can be a source of natural enemies in the next growing season (Ikhsan et al. 2020).

Correlation of parasitic Hymenoptera with their microclimates

The surrounding climatic conditions can influence the presence of parasitic Hymenoptera on tidal swamp rice. Climatic factors in an agroecosystem can affect the behavior and population of natural enemies such as the Hymenoptera parasitoid. Cox and Moore (2000) stated that changes in the earth's climate can affect distribution patterns and the life of organisms such as animals and plants. Changes in distribution patterns can lead to the diversity of organisms. In essence, climatic factors can directly affect species composition, breeding habitat, survival, and population of Hymenoptera insects (Pillai et al. 2016; Masika et al. 2017; Maulina et al. 2018).

Based on this research, the microclimate was also correlated with the abundance of each family Parasitic Hymenoptera. Air humidity correlated with the abundance of 12 families of Parasitic Hymenoptera. The twelve families are Braconidae, Ichneumonidae, Scelionidae, Tiphiidae, Scoliidae, Pteromalidae, Megaspilidae, Torymidae, Eulophidae, Mymaridae, Aphelinidae, and Eupelmidae. Soil temperature and air temperature correlated with the abundance of 9 families of Parasitic Hymenoptera. The nine families are Diapriidae, Evaniidae, Ceraphronidae, Elasmidae, Encyrtidae, Chalcididae, Mymarommatidae, Eurytomidae, and Platygastridae.

Humidity is the most dominant parameter affecting the abundance of Parasitic Hymenoptera. This follows Potts and Willmer (1997) opinion that climate is one of the most important factors in life. Climate affects life, growth, reproduction, and abundance of insects and natural enemies. Temperature and humidity had a significant effect on the arthropod population. For example, Aranea showed a positive correlation in their abundance with an increase in temperature in all the agro-ecologies (Masika et al. 2017)

Superfamily Chalcidoidea had the highest species diversity (4.05) in rice cultivation in the tidal swamp landscape of Indragiri Hilir District, followed by Ichneumonoidea (4.02) and Platygastroidea (3.24). Families Ichneumonidae and Braconidae have the highest diversity index in rice cultivation. The abundance of the family Ichneumonidae correlates with horticultural crops, other food crops, natural habitats, humidity, soil temperature, and air temperature. The abundance of the family Braconidae correlates with natural habitat and humidity. According to Goulet and Huber (1993), Ichneumonidae and Braconidae are the families with the largest members and are found throughout the world. Triplehorn and Johnson (2005) add that these two families have the highest number of species compared to other families and almost dominate the entire ecosystem. In monoculture and polyculture vegetable ecosystems. The same thing was also obtained by Yaherwandi (2012), who revealed that Braconidae and Ichneumonidae are families of Parasitic Hymenoptera dominant in agricultural ecosystems in West Sumatra.

The Scelionidae family has the third-highest diversity index in the tidal swampland of Indragiri Hilir District. The abundance of the family Scelionidae correlates with natural habitat and humidity. Herlina et al. (2011) reported that in lowland rice, the parasitoids found were generally egg parasitoids and parasitoids from the Scelionidae family. Furthermore, Sahari et al. (2020) reported that in Central Kalimantan, several families of Parasitic Hymenoptera were dominant in oil palm plants, namely Scelionidae, Chalcid Braconidae, Ichneumonidae, and Evaniidae.

In conclusion the landscape types in Indragiri Hilir District are (i) Simple landscape in the Reteh sub-district and (ii) Complex landscape in Keritang, Tembilahan Hulu, and Batang Tuaka sub-districts. The three rice fields in complex landscapes had a higher diversity of Parasitic Hymenoptera (4.54; 4.58; 4.73) than simple landscapes (4.19). Presence of Parasitic Hymenoptera on tidal swamp rice can be affected by the structure of the landscape. Rice cultivation which acts as a matrix in the landscape, correlates with the abundance of 5 families of Parasitic Hymenoptera. The microclimate was also correlated with the abundance of each family Parasitic Hymenoptera. Air humidity correlated with the abundance of 12 families of Parasitic Hymenoptera.

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