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Diversity of Parasitoids Hymenoptera in Agricultural Ecosystems and Primary Forest in Lubuk Kilangan District, Padang

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A B S T R A C T

Parasitoid Hymenoptera is an important natural enemy of most plant pests, and it can control pests specifically in the agricultural ecosystem. The study aimed to study parasitoid Hymenoptera diversity in agricultural and primary forest ecosystems. The research was conducted from March to June 2018 at Lubuk Kilangan Subdistrict, Padang. The research location was determined by purposive sampling, and sampling was taken using malaise and yellow traps. The results showed that the family of parasitoid Hymenoptera with dominant numbers of individuals and morphospecies were Braconidae, Ichneumonidae, and Scelionidae. The diversity index of both ecosystems is classified as high, with a value of 4,879 for primary forest ecosystems and 4,675 for agricultural ecosystems. The Evenness index of both ecosystems is classified in the high category, with a value of 0,905 for the primary forest ecosystem and 0,887 for the agricultural ecosystem. The similarity index of both ecosystems is classified in the high category with a value of 0,607.

INTRODUCTION

Indonesia is a country rich in biodiversity and has been recognized by the world as one of the mega biodiversity countries (Buchori, 2014). One of the natural ecosystems in Padang City is the Hatta Forest Park (TAHURA) tourist area. This area is located in Indarung Village, Lubuk Kilangan District, Padang City, and is managed by the Padang City Agriculture Office. TAHURA Hatta is a primary forest nature reserve area whose function is to preserve germplasm, protect natural resources, provide education and research, foster love for nature, and, simultaneously, a place for recreation. The area of Hatta Forest Park ± 240 Ha. Geographically, the Hatta Forest Park area is located between 100°17' - 100°42' East Longitude and 0°32'- 1°5' South Latitude (Fasandra, 2014). In addition to natural ecosystems, in Lubuk Kilangan District, Indarung can also be found in agroecosystems planted with rice.

According to Untung (2006), rice fields are an example of an artificial ecosystem, namely a rice-producing agroecosystem. An agroecosystem is a form of human-built ecosystem to obtain agricultural production of a certain quality and quantity. As an ecosystem, rice fields are composed of biotic and abiotic components that interact. Biotic components consist of plant and animal elements. In other words, rice fields are habitats (places of life) for various animals and plants that form biodiversity in rice field ecosystems. In natural ecosystems, herbivorous insects are controlled through ecological processes such as physical (humidity, light intensity) and biotic (parasitization and predation) factors. The natural pest control process in agroecosystems needs to run better due to declining habitat quality. Changes in natural ecosystems into agroecosystems change ecological processes and interactions between trophic levels, such as parasitoids/predators,

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herbivorous insects, and host plants (Sahari, 2012; Ikhsan et al., 2022). According to Gliessmann (2007), the negative impacts of artificial ecosystems (agriculture) are degradation and decrease in soil fertility, excessive water use and damage to the hydrological system, environmental pollution in the form of hazardous materials in the environment and food, dependence of farmers on external inputs, decrease in biodiversity including genetic sources of flora and fauna which are the principal capital of sustainable agriculture, increasing global inequality between countries industry and developing countries, and losing local communities' control over agricultural production. Agricultural practices, both annuals and annuals, are inseparable from the influence of insect diversity. The diversity of insects in a habitat is influenced by the surrounding environment and the vegetation that grows in it (Rohrig et al., 2008). Insects that cause damage and reduce the economic value of plants are known as pests (Purnomo, 2010). Farmers still use synthetic insecticides known to cause many negative impacts to control these pests.

For this reason, environmentally friendly alternative controls are needed, including biological control, one of the components of Integrated Pest Control (IPM). Biological control is controlled by utilizing natural enemies in pest control. One of the natural enemies that can be exploited is parasitoids. As biological control agents, parasitoids are very well used and are the most successful in controlling insect pests compared to other control agents (Untung, 1993;). Most parasitoids belong to the order Hymenoptera. Hymenoptera is one of the four most significant orders in the class Insecta, besides Coleoptera, Diptera, and Lepidoptera. Hymenoptera in nature has many roles, including as biological control agents of agricultural and forestry pests, pollinators, and producers of commercial products such as honey and wax (LaSalle & Gauld, 1993). Parasitoid Hymenoptera are Hymenoptera that part of their life cycle hitchhikes on another organism (host) and causes the host to die. The hosts of parasitoid Hymenoptera are generally the eggs and larvae of other insects. Long-term use of parasitoids can reduce treatment costs usually incurred for pesticide and worker costs to increase profits (Hidrayani et al., 2005). Information on the diversity of parasitoid Hymenoptera in agricultural ecosystems and primary forests in Lubuk Kilangan District, Padang City, still needs to be improved. Therefore, researchers conducted a study entitled "Diversity of Hymenoptera Parasitoids in Agricultural Ecosystems and Primary Forests in Lubuk Kilangan District, Padang City."

METHODS

This study used a survey method, and sampling was carried out by the Purposive Sampling method. The location was chosen according to the criteria: areas with natural ecosystems in the Hatta Forest Park and agricultural ecosystems in Lubuk Kilangan District, Padang City.

The materials used in the study were detergent, water, label paper, raffia rope, 96% alcohol, plaster, and plastic bags. The tools used in this study were yellow pan trap, malaise trap, sickle, machete, tweezers, sample bottle, scissors, binocular microscope, brush, filter, Hymenoptera of the World identification book, stationery, and camera. Other tools used are GPS to measure altitude and latitude.

Collection and collection of parasitoids is carried out for two months. Sample collection uses traps; traps used are malaise traps and yellow pan traps. Sample collection using yellow trays is carried out twice at the beginning and end of sampling, referring to installing malaise traps. Sample collection using malaise traps is carried out once a week.

Untuk mengetahui keanekaragaman serangga parasitoid serta pengelompokannya, seluruh serangga yang diperoleh diidentifikasi dengan memperhatikan ciri-ciri morfologi menggunakan mikroskop binokuler lalu dicocokkan menggunakan buku kunci identifikasi Hymenoptera of The World (Goulet dan Huber, 1993) .

Data analysis

Diversity index

To determine the species diversity index is calculated using the Shannon-Wienner formula (Krebs, 1978):

$$H' = -\sum_{i=1}^{s} Pi(\log ePi)$$

where $Pi = ni/N$

Information:
H' = Diversity index
Pi = ni/N
Ni = Number of individuals of each type
N = Total Number of individuals

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Table 1. Benchmark values of species diversity index (Fachrul, 2007)

Value	Information
H' < 1.5	low diversity
1.5 < H' < 3.5	Moderate diversity
H' >3.5	high diversity

Species evenness index

The evenness of parasitoid Hymenoptera species is measured using the Simpson Evenness Index, which measures the proportion of each species in a population at a given place and time. Simpson Evenness Index using Krebs (2000) formula:

$$e = \frac{H}{Log\ S}$$

Information:
e = Simpson evenness index
S = Proportion of species in the community.

The value of evenness ranges from zero to one; if the value is close to zero, then the distribution of insects in an ecosystem is uneven, but if the value of evenness is close to one, then the distribution of insects is more even (Elkie *et al*., 1999).

Table 2. Evenness index benchmark value (Krebs, 2000)

Value	Diversity
E < 0.4	low evenness
0.4 < E < 0.6	medium evenness
E > 0.6	high evenness

Species similarity index

The species similarity index determines the proportion of species similarity between two communities. The species similarity index is measured using the Jaccard species similarity index (Barbour *et al*., 1987) as follows:

$$Is = \frac{2\ C}{A + B}$$

Information:
Is = Species similarity index
A = number of species found in community A
B = Number of species found in community B
C = the same Number of species found in communities A and B.

Table 3. Benchmark values of species similarity index (Barbour et al., 1987; Ratnasari, 2014)

Value	Information
Is < 0,25	very low
0.25 < < 0.5	low
0.5 < < 0.75	tall
0.75 < Is < 1	very high

Accumulated value of species

Calculating the accumulated value of species aims to determine the increase in the Number of morphospecies obtained at each sampling. This calculation is performed using the Estimates software program.

RESULTS AND DISCUSSION

Result

Description of the research location

Table 4. Description of the research location on primary forest and agricultural ecosystems in Lubuk Kilangan District, Padang City.

Parameters	Primary forest ecosystems	Agricultural ecosystem	information
Location coordinates	0º 56'39" LS 100º 31'10" E	0º 57'15" LS 100º 28'47" E	-
Height	653 m above sea level	220 m asl	-
Vegetation	Forest pandanus, fir, areca nut, andaleh, surian, teak, areca rajo, resin, oil palm, banyan, angsano, dulang - dulang, paga - paga, tin - tin, dalok, pine, ketapiang, sibaranak, aren, dadok, sengon, sipadiah, juluak antu,	Bitter melon, kale, spinach, corn, peanuts, chickpeas, chilies, coconut, papaya, guava, avocado, cassava, jackfruit, cocoa, banana, areca nut, pineapple, pandanus, banto grass,	-

	sungkai, merantiah, sago, tamasu, sengon merah, durian, ambacang, bamboo, pine, sepat	Kalyan, puzzle grass	
Use of synthetic chemicals		Fertilizer: Phonska, Urea, SP36, KCL Pesticides: Niten Traco, Roundup, Dharmabas, Decis, oil and kerosene	Applied 7 and 40 HST. Applied if there are symptoms of an attack

Annual-aged forest plants dominate plants in primary forest ecosystems, and agricultural ecosystems are dominated by cultivated plants with monthly to year-old age (Figure 2). Based on the results of interviews with farmers and observations on rice field ecosystems, farmers apply pesticides when symptoms of pest attacks have appeared on plants. Farmers carry out land sanitation in 1 x 25 days.

Number of Hymenoptera individuals and morphospecies in agricultural and primary forest ecosystems

Based on sampling in agricultural ecosystems and primary forests, non-parasitoid Hymenoptera and parasitoid Hymenoptera groups were obtained. In agricultural ecosystems, 1,406 individuals and 62 non-parasitoid Hymenoptera morphospecies were found, while 2,262 individuals and 194 morphospecies were found for parasitoid Hymenoptera. In primary forest ecosystems, 1,195 individuals and 55 non-parasitoid Hymenoptera morphospecies were found, while for parasitoid Hymenoptera, 1,684 individuals and 219 morphospecies were found (Figure 1).

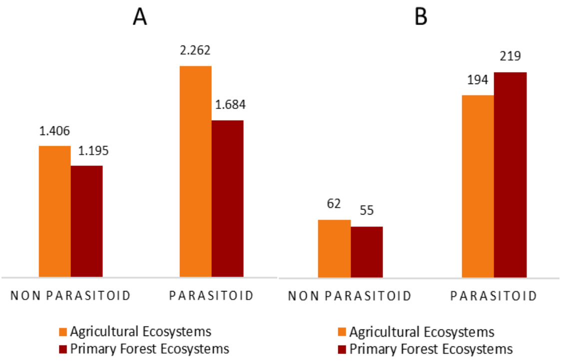

Figure 1. Number of parasitoid Hymenoptera and non-parasitoid Hymenoptera in agricultural and primary forest ecosystems: (A) Individuals and (B) Morphospecies

Number of families, individuals, and morphospecies of parasitoid Hymenoptera in agricultural ecosystems and primary forests

From the morphospecies of Hymenoptera parasitoids found in both ecosystems, 36 families were obtained, and six were unknown. Several families are not found in agricultural ecosystems. However, they are found in primary forest ecosystems: Family F, Family I, and Leucospidae. In contrast, families not found in primary forest ecosystems but in agricultural ecosystems are Family B, Family D, and Aphelinidae. The Number of parasitoid Hymenoptera individuals found in agricultural ecosystems is the families Scelionidae 528, Braconidae 319, and Diapriidae 190 individuals. In primary forest ecosystems, the highest number of individuals were found, namely the families Scelionidae 340, Braconidae 337, and Diapriidae 180 individuals (Figure 2). The Number of parasitoid Hymenoptera morphospecies found in agricultural ecosystems is the families Ichneumonidae 36, Braconidae 34, and Scelionidae 25. In primary forest ecosystems, the highest number of morphospecies were found, namely Braconidae 47, Ichneumonidae 34, and Scelionidae 26 morphospecies (Figure 3).

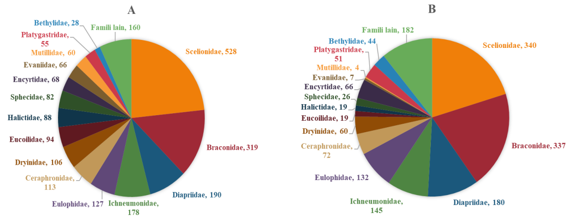

Figure 2. Number of parasitoid Hymenoptera individuals in ecosystems: (A) Agriculture and (B) Primary Forest

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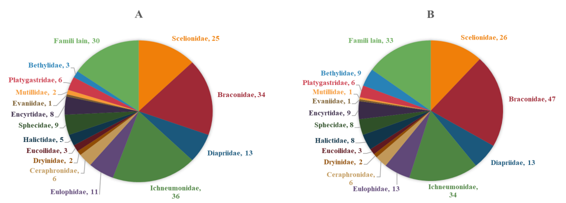

Figure 3. Number of parasitoid Hymenoptera morphospecies in ecosystems: (A) Agriculture and (B) Primary forests

Number of morphospecies found per sampling

The Number of morphospecies found from eight times sampling using malaise traps and twice using yellow tray traps in each ecosystem saw an increase in morphospecies found in each sampling. The first sampling in agricultural ecosystems found 149 morphospecies, and the eighth sampling found 213. The first sampling in primary forest ecosystems found 169 morphospecies, and the eighth sampling found 288 (Figure 4).

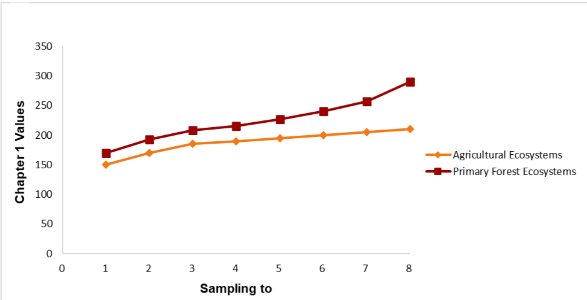

Figure 4. Accumulated Number of morphospecies found at the study site

Number of morphospecies, abundance, evenness index, and diversity index of parasitoid Hymenoptera in agricultural ecosystems and primary forests

From the comparison of agricultural ecosystems and primary forests, the Number of parasitoid Hymenoptera morphospecies in primary forest ecosystems is more than in agricultural ecosystems. However, agricultural ecosystems have more individual abundance than primary forests. The evenness index of parasitoid Hymenoptera species in primary forest ecosystems is higher than that of agricultural ecosystems. The highest parasitoid Hymenoptera diversity index is also found in primary forest ecosystems. These two ecosystems are included in the high evenness category with an equitable index value in primary forest ecosystems of 0.905, while agricultural ecosystems have a value of 0.887. The diversity index of parasitoid Hymenoptera in both ecosystems belongs to the high category. The diversity index in primary forest ecosystems is 4,879, and agricultural ecosystems are 4,675.

Table 5. Number of morphospecies, abundance, evenness index, and diversity index of parasitoid Hymenoptera in agricultural ecosystems and primary forests

Parameters	Agriculture	Primary Forest
Morphospecies	194	219
Individual Abundance	2.262	1.684
Evenness Index	0,887	0,905
Diversity Index	4,675	4,879

Index of species similarity of parasitoid Hymenoptera in agricultural ecosystems and primary forests

The level of morphospecies similarity of Hymenoptera parasitoid in both ecosystems, namely agriculture and primary forest, is high, with a value of 0.607 (Table 6).

Table 6. Species similarity index in agricultural ecosystems and primary forests

Ecosystem	Agriculture	Primary Forest
Agriculture		
Primary Forest	0,607	

Discussion

Based on samples collected in agricultural ecosystems and primary forests in Lubuk Kilangan District, Padang City, parasitoid and non-parasitoid Hymenoptera were found. Of the 36 parasitoids Hymenoptera families found, the families Ichneumonidae and Braconidae are the families that have the most morphospecies. At the same time, the most significant number of individuals come from the families Scelionidae and Braconidae. Goulet and Huber (1993) say the families Ichneumonidae and Braconidae are distributed worldwide and can live in various habitats ranging from tropical, humid, and dry. The results of this study are similar to those reported by Perdana (2010) and Ikhsan et al., (2020) in that the families Ichneumonidae and Braconidae are the families that dominate the forest ecosystem. In monoculture and polyculture vegetable ecosystems, the abundance of the families Ichneumonidae and Braconidae is relatively high (Hamid & Yunisman, 2007). Yaherwandi *et al.* (2006) also state that Braconidae, Ichneumonidae, and Scelionidae dominate agricultural ecosystems. Most family species act as parasitoids of rice pest insects of the order Hemiptera, such as leafhoppers, and order Lepidoptera, such as stem borers. In Syafitri's research (2017) found in the rice stem borer host (*Scirpophaga* sp.) (Lepidoptera) found several species of parasitoids, including Telenomus rowani (Scelionidae) and *Telenomus dignus (Scelionidae).*

From each ecosystem, a different number of individuals is obtained. The Number of individuals in agricultural ecosystems is more significant than in primary forest ecosystems. This happens because the abundance of plants and plants that act as food sources affects the Number of parasitoid host individuals. If the host is abundant, the parasitoids are also abundant. Sperber *et al.* (2004) reported that parasitoid Hymenoptera's interest in inhabiting an ecosystem is influenced by microhabitat factors, food availability, and availability of parasitoid hosts that associate with plant types in an ecosystem.

The Number of morphospecies found in both ecosystems increases with each sampling. The increase in the Number of morphospecies in each sampling is more in primary forest ecosystems than in agricultural ecosystems. This happens because vegetation in agricultural ecosystems is relatively homogeneous, so adding new morphospecies is not too much with each sampling. Conversely, the vegetation of primary forest ecosystems is more complex, resulting in an increase in the Number of parasitoid Hymenoptera morphospecies obtained. This is supported by research conducted by Febrita *et al.* (2008), which states that vegetation composition factors influence the abundance of insects in an ecosystem.

The diversity index of Hymenoptera parasitoids obtained in primary forest and agricultural ecosystems is classified as high diversity because the index obtained is >3.5. Primary forest ecosystems' diversity index is higher than agricultural ecosystems. This comparison occurs because the Number of morphospecies obtained from primary forest ecosystems is more than agricultural ecosystems, while for individual abundance, there are more agricultural ecosystems than primary forests. The species evenness index of both ecosystems is classified as high evenness. This can be seen from the benchmark value of the Krebs (2000) evenness index obtained, which is > 0.6. Primary forest ecosystems are more evenly distributed than agricultural ecosystems. However, the value of evenness is similar, meaning no species dominates the two ecosystems. Magurran (1988) said that if the evenness index is close to 0, it means that only a few species dominate the community; if the value is close to 1, then all species are at the same level of evenness.

The parasitoid Hymenoptera species similarity index obtained a value of 0.607, included in the high similarity index category. This category shows that the species in primary forest ecosystems are almost the same as in agricultural ecosystems. Environmental conditions such as habitat diversity and landscape structure significantly affect the value of diversity, equity, and similarity of species of an ecosystem (Ikhsan, 2022; Maulina et al., 2018). Fauzan (2018), in his research, said environmental factors such as landscapes that are not much different are causing the evenness and similarity of the same species. These agricultural ecosystems are close to forest ecosystems. The location of agricultural ecosystems surrounded by forest ecosystems allows parasitoids from forest ecosystems to move into agricultural ecosystems.

CONCLUSIONS

Agricultural ecosystem and primary forest in Lubuk kilangan sub-district Padang city 36 families, 258 morphospecies, and 3,946 individuals of Hymenoptera parasitoids. The Hymenoptera parasitoid family has some dominant individuals and morphospecies: Braconidae, Ichneumonidae, and Scelionidae. The diversity index of both ecosystems is high, with a value of 4,879 for primary forest ecosystems and 4,675 for agricultural ecosystems. The evenness index of both ecosystems is classified as high, with a value of 0.905 for primary forest ecosystems and 0.887 for agricultural ecosystems. The species similarity index of both ecosystems is classified as high, with a value of 0.607. It is necessary to conduct further research on identifying parasitoid Hymenoptera up to the species level.

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