



## Insect Diversity in Siam Citrus Plantations (*Citrus nobilis* Lour.) in Sungkai, Padang City, Indonesia

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### ABSTRACT

Insect diversity in plantations is crucial for understanding the ecological roles of each species and managing pest-related issues. This study aimed to assess the diversity of insects in Siam citrus (*Citrus nobilis* Lour.) plantations in Sungkai, Padang City, Indonesia, focusing on the implications for pest management. A survey was conducted in the Siam citrus plantation, categorizing sampling sites into three groups based on the distance from the forest (20, 40, and 60 m from the forest). Insect samples were collected by spraying the plants with insecticides, hand-picking, and trapping insects on a white cloth. The results showed that the number of insect species found at the sites was 19, 18, and 12 at 20, 40, and 60 m from the forest, respectively. The species identified included *Bractocera* spp., *Toxoptera* sp., *Aphis gossypii*, *Bothrogonia* sp., *Planococcus citri*, *Sanurus* sp., *Rhynchocoris humeralis*, *Conocephalus* sp., and *Valanga nigricornis* as pests, and *Blattella* sp., *Hemithyrsochera* sp., *Coccinella transversalis*, *Nylanderia* sp., *Polyrhachis* sp., *Dolichoderus* sp., *Anoplolepis gracilipes*, *Hierodula* sp., and *Hierodula sp1* as predators, with *Lasioglossum* sp. identified as a pollinator. The species diversity at each site was categorized as medium, with diversity index values of 2.10, 2.07, and 1.95, respectively. Species evenness was categorized as high, with index values of 0.71, 0.72, and 0.78, respectively. This study provides valuable data on the pest and predator populations in citrus plantations, which can inform sustainable pest management strategies to improve crop health and productivity.

**Keywords:** Abundance, citrus, insect diversity, species evenness,

### INTRODUCTION

Citrus plants are one of the fruits that have many benefits for human health, one of which is as a source of vitamins (Putra *et al.*, 2013). Citrus plants are a horticultural commodity that is a priority to develop because they have high

economic value. Citrus plant farmers get high profits and use them as a source

of income (Pramono and Siswanto, 2007). During the *COVID-19 pandemic*, Citrus plants are a favorite fruit consumed by the public because they contain vitamin C, which is useful

in increasing the body's immunity (Amanda, 2021).

The type of citrus widely developed in Indonesia is chayote Citrus plant (*Citrus nobilis* Lour.). Siam Citrus plants are a small part of the many Citrus plant species already known and widely cultivated. Siam Citrus plants are members of tangerines that originated in Siam (Muangthai, Thailand). This plant continues to develop and spread to Indonesia (Setiawan & Trisnawati, 2003).

The area of Indonesian citrus plants in 2020 reached 61,788 ha, producing 3,246,994 tons. This Number has been unable to meet domestic needs, so Indonesia still imports Citrus plants (Agrofarm, 2022). In 2019, Indonesia received 137,585 tons of citrus imports from China, Pakistan and Australia. In addition to imports, to meet domestic needs, there must be an increase in the area of planting and an increase in productivity. All parties, including local governments, farmers, and entrepreneurs, are encouraged to increase the area of Citrus plant land and increase productivity (Hortikultura Indonesia, 2020)

West Sumatra is one of the provinces that is the center of Siam Citrus plant production. According to the Central Statistics Agency (2022), chayote lime production in West Sumatra fluctuated from 2017 to 2021. In 2017, the production of chayote Citrus plants was 102,733 tons; in 2018, it dropped to 102,463 tons; in 2019, it rose significantly to 167,668 tons. However, in 2020 it dropped again to 145,035 tons and in 2021 it decreased to 118,578 tons. Fluctuations in citrus production are caused by several factors, including improper agricultural patterns, climate, and soil conditions, especially insects that are pests on citrus plants (Hiru, 2021).

As a component of biodiversity, insects have an important role in the food web, namely as herbivores, carnivores, and detritivores (Hadi & Aminah, 2012; Ikhsan, 2022; Hidrayani, 2024). Herbivorous insects greatly affect plant cultivation activities because the presence of herbivorous insects in crops can cause a decrease in the quality and quantity of crop

yields (Suheriyanto, 2008). Insect biodiversity affects the quantity and quality of agricultural products produced. Natural ecosystems generally have population stability between pests and natural enemies so that the existence of insect pests is no longer detrimental (Widiarta *et al.*, 2000).

Research on insect diversity in chayote citrus plants has been conducted by Maesyaroh *et al* (2018) in Citrus plant fields in Karang Sari Village, Garut Regency with a medium diversity index and a low dominance index. The insects found are nine orders that act as insects, pests and natural enemies. Insects that act as pests are dominated by the order Diptera and as natural enemies are dominated by the order Odonata. Pora (2013) researched insect diversity in inorganic and semi-organic Citrus plant plantations in Bumiaji District, Batu City, found four orders, 11 families, and 221 individuals in inorganic Citrus plant plantations. Semi-organic Citrus plant plantations were found in 4 orders, 13 families, and 328 individuals. The value of the diversity index in inorganic and semi-organic citrus plantations is included in the medium category. Bangun (2018) also researched insect diversity in citrus plants in Juma Raja village, Karo Regency. The study results showed that the number of insects obtained at the location of each sampling differed because it was influenced by environmental factors, namely the impact of volcanic ash from Mount Sinabung. The Number and type of insects caught on land unaffected by volcanic ash was greater than that of Citrus plant land affected by volcanic ash. The insect diversity index values in both lands are in the same category, namely the medium category.

Padang City has not yet become an area with the largest S production level advantage. However, there is an opportunity in this regard with the government's efforts to develop tourism with the concept of agrotourism in Padang City, one of which is in Sungkai. This is not only improving the economic wheels of residents but also increasing the promotion of citrus plants in the area. Based on the initial survey, farmers in Sungkai have started to develop citrus plantations which, until now, there are around

600 Citrus plant stalks on a land area of about 1.5 ha. Citrus plant land is directly adjacent to secondary forests. Citrus plants grow well and produce large, quality fruit. Farmers have harvested 2 times with production of 400 and 600 kg respectively. However, recently, there has been a pest attack that causes citrus fruits to harden and the grains to dry and fall, which causes a decrease in citrus production so that the fruit that can be harvested is only about 50% of the previous harvest. To overcome the occurrence of losses, managing pests on citrus plants is necessary. As basic knowledge, it is necessary to study the diversity of insect species in citrus plants and know the role of each.

This study aims to assess the diversity and population of insect species in Siam citrus plantations and evaluate their role as pests, predators, or pollinators in Sungkai, Padang City, Indonesia. This information can be used as a basis for pest control of the Siam citrus plant (*C. nobilis* L.) in Sungkai.

## METHODS

The research was conducted from December 2021 to February 2022 on Siam Citrus plant land owned by farmers in Sungkai, Lambung Bukit Village, Pauh District, Padang City, followed by the Insect Bioecology Laboratory, Department of Pests and Plant Diseases, Faculty of Agriculture, Andalas University, Padang.

The tools used are a 15-liter *back sprayer*, a binocular microscope, a film bottle, a magnifying glass, label paper, tweezers, stationery, a small brush, and a documentation tool. The ingredients used in this study are 70% alcohol and insecticides.

The research was conducted using a survey method. Citrus plantations are grouped into three positions based on the distance of the plants from the edge of the forest, namely 20, 40, and 60 m from the edge of the forest. Planting is limited by forests on only three sides: West, East, and North. In each planting position, 10 sample plants were taken from three sides.

## Preliminary Survey

Before the research, a preliminary survey was carried out in the form of a review of the research location and interviews and discussions with farmers who cultivated whose land would be used for sampling. Location reviews, interviews, and discussions with farmers were carried out to obtain information about the condition of Siam Citrus plant land and how to cultivate Siam Citrus plant plants. Data were collected using a questionnaire.

## Determination of Sample Crops

After the planting position is determined based on the distance of the plants from the edge of the forest, which is 20, 40, and 60 m, then sample plants are determined. In each position, 10 sample plants were taken on three sides. Four plants were taken each on the West and East sides, and 2 sample plants were taken on the North side.

## Sample Insect Collection

Insect sampling on chayote citrus plants is carried out by spraying the sample plants with insecticides that have the active ingredient *monokrotofos* with the dosage as recommended. Spraying is done by surrounding the plant until it is flat. Insects not falling off the plant after spraying are taken by hand.

To facilitate the collection of insects, before the plants are sprayed, a white cloth is placed as wide as the plant canopy to accommodate the insects that fall after being sprayed. The insects in the white cloth are then collected and put into collection bottles for identification. Sampling activities by spraying insecticides were carried out 3 times on different sample plants with a time interval of 14 days. Each sample plant that has been sprayed is marked with a label.

Insects obtained from the field were then taken to the laboratory to be observed based on morphological characteristics and identified according to their type using insect identification manuals such as the Insect Determination Key book, Introduction to Insect Lessons Borror (1992), and the Bugguide.net identification site (Iowa State University Department of Entomology).

## Observation

### 1. Conditions of Siam Citrus Cultivation

Observations were made by directly observing the condition of the citrus plantation area and interviewing the land management farmers. Observations were made on all aspects of garden management (type, origin of seedlings, plant age, protective trees, fertilization, sanitation, and OPT control).

### 2. Types, populations, and role of insects in chayote citrus plants

Insect identification in chayote lime plants was carried out at the Laboratory of Insect Bioecology, Faculty of Agriculture, Andalas University using a microscope and magnifying glass concerning the book Borror *et al* (1992) and bugguide.net based on morphological characteristics.

After the insects are identified, the population of each type of insect is calculated. The calculation is carried out using data that will be processed to obtain the value of the insect diversity index at the research location of the Sungkai Siam citrus plantation, Lambung Bukit Village, Pauh District, Padang City.

### 3. Diversity index (H') and species equality (E')

Insect species diversity is measured using the Shannon-Wiener diversity index (Krebs, 2000). The data is calculated using Microsoft Excel. The Shannon-Wiener diversity index is as follows:

$$H' = -\sum P_i (\log e. P_i) \quad P_i = n_i/N$$

Information:

H' = Shannon-Wiener diversity index

P<sub>i</sub> = Proportion of individual species to i in the community

N<sub>i</sub> = Abundance of individual species to i

N = Total Number of individuals

**Table 2.** Shannon-Wiener species diversity benchmark value

Value	Information
H' < 1	Low diversity
1 < H' < 3	Moderate diversity

The value of the interspecies equality index to assess the stability or stability of insect species in a community is used using the formula:

$$E' = H' / \ln(S)$$

Information:

E' = Species equality index

H' = Shannon Index

S = Number of types found

ln = Logaritma natural

According to Odum (1996), the species equality index criteria are as follows.

**Table 2.** Species equality benchmark value (E')

Value	Information
E < 0.3	Low evenness
0.3 < E < 0.6	Moderate evenness
E > 0.6	High evenness

## RESULTS AND DISCUSSION

### 1. Citrus Planting Conditions

Farmers' citrus plantations in Sungkai are at an altitude of ±250 meters above sea level. The type of Citrus plants planted are Siam Gunuang Omeh Citrus plants obtained from Gunuang Omeh Fifty Cities Regency and the Padang City Agriculture Office. The lifespan of citrus plants is around 3.5 years. The planting distance used by farmers is 4m x 5m and 5m x 5m. The difference in planting distance occurs because it adjusts to flat and sloping land conditions (without terraces). The Siam Citrus plant land is directly adjacent to secondary forests (natural habitats) and rivers.

**Table 3.** Description of citrus growing conditions in Sungkai

Citrus Planting Conditions	Information
Height of the place	±250 mdll
Temperature	25-290C
Varieties	Siam Citrus plant Gunung Omeh
Plant Age	3.5 years
Planting Distance	4m x 5m and 5m x 5m
Fertilization	1 x 6 months
Planting system	Monoculture
Land Sanitation	Fallen fruit is rarely cleaned, and there is still a lack of clearing of land from weeds.
Crop Pruning	Pruning citrus plants is still not done



**Figure 1.** Condition of citrus cultivation of the Sungkai. a. Land condition at a distance of 20 m from the forest b. Land condition at a distance of 40 m from the forest. c. Land condition at a distance of 60 m from the forest. d. Citrus fruits

Farmers have not cultivated optimally. Fertilization and maintenance are not carried out intensively. Maintenance such as pruning, weeding, and sanitation are rarely performed. In weed control, in addition to using lawnmowers, farmers also use herbicides. A description of the conditions of citrus cultivation in Sungkai is presented in Table 3.

Citrus plants are planted on flat, sloping land without terraces. Citrus farmers have not done good cultivation because the land is overgrown with weeds and left alone. The pruning of plants that are still not done so that many branches bear heavy fruit are too heavy to duck to the ground, and land clearing from fallen fruits has not been routinely carried out. Based on observations in the field and interviews, farmers' knowledge of pests that attack citrus plants is still lacking, so farmers have not controlled pests that attack citrus plants.

## 2. Types, populations, and roles of insects in chayote citrus plants

The insects found in citrus plants in Sungkai consisted of 7 orders, 13 families, and 1758 individual insects in 3 observations made every 14 days. The Number of orders, families, insect types, Number of individuals, and the role of insects in citrus plants in Sungkai can be seen in Table 4.

Based on Table 4, the number of insect individuals found on citrus plants in Sungkai, Lambung Bukit Village, Pauh District, Padang City was the highest at the location of insect sampling in citrus plants with a distance of 20 m from the edge of the forest, which was 1040 individuals, while the least Number of individuals were in the sample plants with a distance of 60 m from the edge of the forest as many as 222 individuals. The Number of species found in the sample plants at a distance of 20, 40 and 60 m

from the edge of the forest was 19, 18 and 12 species respectively. The predominant insect in the siam lime plant is an insect of the order Hemiptera. Among the insect species found, which act as pests amounted to 9 species, as predators as nine species and pollinating insects as many as one species. Insects of the order Mantodea and Orthoptera are insects commonly found in cultivated plants and weeds.

Based on the data on figure 2, it can be seen that in each observation, the highest Abundance of insect individuals was found in the sample plants with a distance of 20 m from the edge of the forest. The Abundance of insect individuals is the least found in the sample plants at a distance of 60 m from the forest. The data shows that insect species dominate each sample plant at a distance of 20 m, 40 m, and 60 m from the forest's edge. Insect observation data on siam lime plants in Sungkai, Lambung Bukit Village, Pauh District, Padang City.

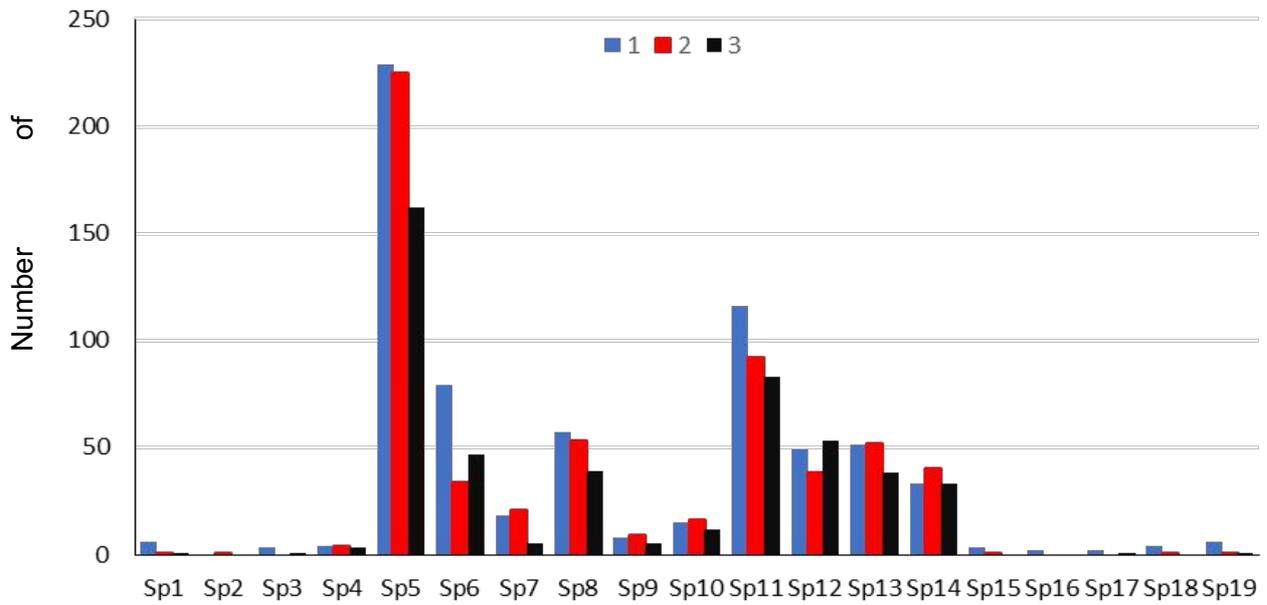
## 3. Diversity index (H') and species equality (E)

The values of the diversity index (H') and the equality of insect species (E) in the siam citrus plant in Sungkai, Lambung Bukit Village, Pauh District, Padang City are shown in Table 5.

Table 5 shows that the highest value of species diversity index (H') is found in plants with a distance of 20 m from the forest, and the lowest is found in siam lime plants with a distance of 60 m from the forest. Meanwhile, the highest value of the species equality index (E') is found in Siam citrus plants with a distance of 60 m, and the lowest is found in Siam citrus plants with a distance of 20 m. The value of H' at each distance has the same category, namely the medium category. The value of E' for each distance also has the same category, which is the high category.

**Table 4.** Number of orders, families, insect types, Number of individuals and the role of insects in citrus plants in Sungkai

Order	Family	Species	Number of individuals found in the sample plant			Role
			Distance 20 m	Distance 40 m	Distance 60 m	
Blattodea	Ectobiidae	<i>Blattella</i> sp.	4	2	2	Predator
	Ectobiidae	<i>Hemithyrsochera</i> sp.	1	0	0	Predator
Coleoptera	Coccinellidae	<i>Coccinella transversalis</i>	3	1	0	Predator
Diptera	Tephritidae	<i>Bractocera</i> spp.	7	3	1	Brothers
Hemiptera	Aphididae	<i>Toxoptera</i> sp.	305	241	70	Brothers
	Aphididae	<i>Aphis gossypii</i>	148	12	0	Brothers
	Cicadidae	<i>Bothrogonia</i> sp.	22	14	8	Brothers
	Pseudococcidae	<i>Planococcus citri</i>	83	41	25	Brothers
	Florida	<i>Sanurus</i> spp.	20	2	0	Brothers
Hymenoptera	Pentatomidae	<i>Rhynchocoris humeralis</i>	29	11	3	Brothers
	Formicidae	<i>Nylanderia</i> sp.	192	62	37	Predator
	Formicidae	<i>Polyrhachis</i> sp.	92	26	22	Predator
	Formicidae	<i>Dolichoderus</i> sp.	78	36	27	Predator
	Formicidae	<i>Anoplolepis gracilipes</i>	44	38	24	Predator
Mantodea	Halictidae	<i>Lasioglossum</i> sp.	2	1	1	Pollinator
	Mantidae	<i>Hierodula</i> sp	1	1	0	Predator
	Mantidae	<i>Hierodula</i> sp1	2	1	0	Predator
Orthoptera	Acrididae	<i>Conocephalus</i> sp.	4	1	0	Brothers
	Tettigoniidae	<i>Valanga nigricornis</i>	3	3	2	Brothers
Total			1040	496	222	



Information:

- 1: Observation 1
  - 2 : Observation 2
  - 3 : Observations 3
- Sp1 : *Blattella* sp.
  - Sp2: *Hemithyrsocera* sp.
  - Sp3: *Coccinella transversalis*
  - Sp4: *Bractocera* spp.
  - Sp5: *Toxoptera* sp.
  - Sp6: *Aphis gossypii*
  - Sp7: *Bothrogonia* sp.
  - Sp8: *Planococcus citri*
  - Sp9: *Sanurus* spp.
  - Sp10: *Rhynchocoris humeralis*
  - Sp11: *Nylanderia* sp.
  - Sp12: *Polyrhachis* sp.
  - Sp13: *Dolichoderus* sp.
  - Sp14: *A. Gracilipes*
  - Sp15: *Lasioglossum* sp
  - Sp16: *Hierodula* sp.
  - Sp17: *Hierodula* sp1
  - Sp18: *Conocephalus* sp.
  - Sp19: *Valanga nigricornis*

**Figure 2.** The Abundance of insect individuals in 10 sample plants at three observations

**Table 5.** Diversity index (H") and species evenness (E) of insects at the research site based on the distance of plants to forests (natural habitat) in Sungkai

Parameter	Sample plant position		
	20 m from the edge of the forest	Distance 40 m from the edge of the forest	Distance 60 m from the edge of the forest
Insect abundance	1040	496	222
Number of Species found	19	18	12
Species Diversity Index (H')	2,10*	2,07*	1,95*
Species Equality Index (E')	0,71**	0,72*	0,78*

Description : \* = medium category, \*\* = high category



The abundance of insects found at the study site based on the distance of plants from the forest, which is at a distance of 20, 40, and 60 m, respectively, is 1040, 496, and 222 individuals. The total number of individuals found is 1758 individuals belonging to 13 families, namely, Ectobiidae, Tephritidae, Coccinellidae, Aphididae, Cicadidae, Pseudococcidae, Flatidae, Pentatomidae, Formicidae, Halictidae, Mantidae, Acrididae, and Tettigoniidae. The difference in the Number of insect abundance at each distance of plants from the forest is caused by weather factors and the condition of citrus cropland adjacent to the natural habitat (forest). According to Ricco *et al.* (2019), the abundance of individuals and the richness of insect species obtained at each sampling location have different values; weather conditions can cause these differences during sampling, as well as the characteristics of the location and conditions around the land. At the first observation, the individual abundance of each species was the highest (Figure 2). According to research conducted by Maesyaroh (2018), the increase in the Number of insect populations in the last observation was caused by environmental factors, namely the condition of the land becoming humid due to rain. According to Wardani (2017), high humidity is a condition that organisms need to carry out physiological processes in the body. The metabolic process of insects will be fast, and development will be much shorter.

The Abundance of individuals and species richness in citrus plants is decreasing as the distance of citrus plants from natural habitats (forests) increases. On the other hand, individual abundance and species richness increase as the distance of citrus plants to natural habitats (forests) closer. The relationship between insect species wealth and the distance of plants to natural habitats is explained by MacArthur & Wilson (1967) in the theory of archipelago biogeography, which states that the wider the size of an island, the higher the species richness in it. The large size of the island makes the diversity of its habitat high, so the chances of *suitable niches* are also higher. The farther an

island is from the mainland, the fewer species there are.

On the other hand, the closer an island is to the mainland, the more species there are on the island. The island's distance is an obstacle for certain species to move to the island. Only species with high *dispersal* capabilities can move to the island. The availability of alternative hosts also affects the Abundance of individuals and the richness of species found, in the vicinity of citrus plants closer to the forest some weeds are hosts for insects. In addition, in natural habitats, various plants are alternative insect hosts. According to Susilawati (2017), natural habitats are the main source of insects' resources, both in the form of main hosts and alternative hosts, as well as shelters and breeding.

Insects found in siam citrus plants in Sungkai have different roles; some insects act as pests for plants so that they cause damage and economic losses. Insects beneficial to plants, acting as pollinators or pollinators that help the pollination process of flowers and acting as natural enemies of pests, are usually used as biological control in cultivated plants. According to Nurmaisah and Purwati (2021), insects have a role in obtaining food, some insects act as insect pests, predators, parasitoids and pollinating insects.

Based on the data in Table 4, insects that act as pests in chayote citrus plants are insects from the families Tephritidae, Aphididae, Cicadidae, Pseudococcidae, Flatidae, Pentatomidae, Acrididae, and Tettigoniidae. Meanwhile, insects that act as natural enemies are insects from the families Ectobiidae, Coccinellidae, Formicidae, and Mantidae. The Halictidae family acts as pollinating insects. Insects of the Tephritidae and Pentatomidae families are pests that cause direct damage and cause loss of production, these insects attack citrus fruits causing citrus fruits to fall. The Pentatomidae family is an insect that has a long stilet to suck the nutritional liquid of citrus fruits so that citrus fruits harden and the grains are not juicy (dry).

Species of the aphididae family have the most Abundance of individuals, this happens because citrus plants are still growing. A few days before observation and during sampling, some of the sampled plants experienced new bud growth where nymph and imago phase aphids generally sucked the leaves on the lower surface, flower buds, and shoots of plants. The appearance of new shoots on citrus plants, the availability of food for aphids is abundant, causing an increase in aphid populations. Sudarwadi *et al.* (2012) also state that the increase in the Number of aphids occurs because new shoots that are food sources continue to develop into young leaves that are large in Number, so the reproductive process is also high.

Insect pollinating citrus plants were found to be one species due to some citrus plants not having yet appeared and Citrus plant fields not having flowering plants. According to Faheem *et al.* (2004), pollinating insects are insects that come to the flower to help the pollination process because of the attraction of flowers, such as the shape of the flower, the color of the flower, pollen, nectar, and aroma. In addition, the distance between citrus plantation land and forests as a natural habitat for insects causes pollinating insects to be rare. The presence of pollinating insect nests, such as bees, around the location can also be one factor that affects the Abundance of pollinating insects at an observation location. According to Khairiah *et al.* (2012), insects generally fly not too far from their nests when foraging and pollinating insects tend to visit the type of flowering plants closest to their nests.

The value of the species diversity index (H') at the research site was differentiated based on distance from the forest, namely at a distance, 20, 40 and 60 m respectively, namely 2, 10; 2,07; and 1.95, in the medium category. The species diversity index (H') value difference is influenced by the number of species found. Insects found one species is dominant, namely a species in the family Aphididae (Table 4). Diversity is high when the Number of species is increasing and the distribution of species is evenly distributed and no species population becomes dominant.

On the other hand, if a community is less diverse, then there are one or two species whose population becomes dominant (Hasyim, 2009). The species equality index (E') value at the research site was differentiated based on distance from the forest, namely at 20, 40, and 60 m, respectively of 0.71, 0.72, and 0.78, with the high category (Table 5). The Type Equality Index (E') value has the same category in each sampling plot. The species equality index is a mathematical description that assesses the stability of insect species in an area and community.

## CONCLUSIONS

This study identified 1758 individual insects from 19 species and 13 families in Siam citrus plantations in Sungkai, Padang City. Key pests included *Bractocera spp.*, *Toxoptera sp.*, and *Aphis gossypii*, while predators such as *Blattella sp.* and *C. transversalis* were also observed, along with *Lasioglossum sp.* as a pollinator. Insect diversity indices were medium (H'), and species evenness was high (E'), indicating a balanced insect community.

The findings suggest promoting insect diversity through habitat protection can reduce pest pressure and improve citrus crop sustainability. By fostering natural pest control via predators and pollinators, farmers can reduce chemical pesticide use. Future research should focus on the interactions between pests and natural enemies and explore how habitat management and farming practices influence insect populations for more effective and sustainable pest management strategies.

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