Jurnal Riset Perkebunan
P – ISSN 2723-780X E – ISSN 2828-9285
Volume. 5 No. 1 Maret 2024

KELIMPAHAN POPULASI DAN FREKUENSI KUNJUNGAN *Forcipomyia* spp. (DIPTERA: CERATOPOGONIDAE) PADA PERKEBUNAN KAKAO DI KABUPATEN LIMA PULUH KOTA, INDONESIA

POPULATION ABUNDANCE AND FREQUENCY OF VISITS Forcipomyia spp. (DIPTERA: CERATOPOGONIDAE) ON COCOA PLANTATIONS IN LIMA PULUH KOTA DISTRICT, INDONESIA

Sri Heriza[1], Yulia Dewi[1], Aswaldi Anwar[2], Zahlul Ikhsan[1*]

[1]Agroecotechnology Study Program, Faculty of Agriculture, Universitas Andalas 27573
[2]Agronomy Study Program, Faculty of Agriculture, Universitas Andalas 25166

Corresponding email: zahlulikhsan@agr.unand.ac.id

ABSTRACT

Forcipomyia spp. is a pollinator insect on cacao plants that belongs to the Ceratopogonidae Family, Diptera Order. The objectives of this research were to determine the abundance of the insect population of Forcipomyia spp. in Lima Puluh Kota District and to determine the frequency of visits of those insects to cacao flowers. This research was conducted on a small smallholder plantation in Sungai Talang Village, Lima Puluh Kota District. Then, the samples obtained were identified at the Andalas University Laboratory. This research was conducted using a survey method and purposive sampling technique. Five cacao plants were selected in each plot of land, and then three flower beds per plant were selected to bloom. Sampling was carried out by installing yellow sticky traps. The insects obtained were put into a collection bottle filled with 96% alcohol to preserve those insects, and then the abundance of Forcipomyia spp. Insects were calculated. The research results showed that the highest insect abundance was in Jorong Guguak Nunang: 1.260 individuals, then in Jorong Bukik Apik: 1.061 individuals and the lowest was in Jorong Boncah: 1.045 individuals. The highest frequency of visits was in the morning, with an average of 648 individuals/60 minutes. The insect diversity index based on the Shannon-Wienner Diversity Index in Jorong Guguak Nunang was 1,97; in Jorong Boncah, it was 2,21; in Jorong Bukik Apik was 1,88, and all of it is in the medium diversity level category.

***Keywords**: cacao, diversity, forcipomyia, pollinator, population*

INTRODUCTION

Cocoa (*Theobroma cacao* L.) is a mainstay commodity widely grown by Indonesians as a crop of economic value. Three cocoa plantation business statuses in Indonesia are state-owned plantations, privately-owned plantations, and community-owned plantations. The total area of cocoa plantations in 2021 in Indonesia is 1,497,467 ha, with a production of 728,046 tons. West Sumatra is one of the cocoa production centers in Indonesia. The area of smallholder cocoa plantations in West Sumatra in 2019-2021 is 114,746 ha, 84,969 ha, and 79,043 ha, with a total production of 53,072 tons, 43,293 tons, and 42,380 tons. The decrease in land area in 2020 also impacted decreasing production that year (Ditjenbun, 2021).

Lima Puluh Kota Regency is one of the potential areas for cocoa development in West Sumatra. In 2018, the area of cocoa plantations in Lima Puluh Kota District was 8,557 ha, producing 4,791 tons. In 2020, there was a decrease in plantation area to 6,697 ha with a production of 1,728 tons. Based on 2020 data, there was a decrease in land area followed by a decrease in production. According to the Directorate General of Cocoa (2017), one of the causes of the decline in cocoa production is the attack of cocoa fruit borer pests and the number of flowers that have not been successfully pollinated, failing fruit formation due to the failure of the fertilization process.

The decline in cocoa production shows that farmers still need to implement cultivation techniques properly, which impacts fruit production and plantation productivity. One factor affecting fruit production is the number of flowers that will develop into fruit. Cacao plants are generally cross-pollinating plants where the union of sperm and egg cells comes from different flowers. One of the causes of cross-pollination of cocoa plants is *self-incompatibility*, an event where normal pollen and pistil fail to fertilize on self-pollination (Monteiro, 2009; Branco, 2018). According to Susilo (2006) and Dani (2022), genetically, cocoa plants have the potential to pollinate themselves, which is distinguished by two variations of self-pollination: compatible self-pollinating and incompatible self-pollinating.

Pollinator insects are insects that play a role in the process of pollinating plants. Plant pollination is the transfer of pollen from male to female sex cells in flowers. Nugroho (2013) states that pollinating insects on cocoa plants can help cross-pollination, increasing fruit and seed yields. Amirullah *et al.* (2018) state that insects assist ±80% of crops in pollination. Pollination in cocoa flowers is assisted by pollinator insects. One of the pollinator insects is *Forcipomyia* spp., which belongs to the order Diptera, and almost 80% of cocoa flowers are assisted by these insects.

Limited knowledge of farmers about correct cocoa cultivation techniques and farmers' lack of knowledge about pollinating insects or pollinators on cocoa plants impact the lack of pollinating insects. Farmers only know the presence of insect pests on cocoa plants, but not all types of insects act as insect pests; some of these insects act as pollinating insects, even as natural enemies.

The lack of farmers' knowledge of pollinator insects impacts the number of pollinating insects in cocoa plantations because most of these insects are killed during pest eradication. The wrong thing that should be done by farmers is to carry out total sanitation on cocoa plantations by weeding grass, trimming cocoa branches, and removing fallen cocoa leaves from the field. Some farmers even do weeding using synthetic herbicides for more practical results. However, farmers need to realize that this also results in environmental conditions that are no longer suitable for the growth and development of pollinating insects.

This condition will have an impact on increasing the production of cocoa plants, where a large number of flowers in one tree does not guarantee that the cocoa plant will be able to become a fruit that will later increase cocoa production. It is hoped that the insect community pollinating cocoa plants can help pollinate cocoa flowers. This underlies the need for this research, with the aim of 1) Determining the abundance of *Forcipomyia* spp. Insect populations in smallholder cocoa plantations in Nagari Sungai Talang, Guguak District, Lima Puluh Kota District; 2) To determine the frequency of visits *of Forcipomyia* spp. Insects in smallholder cocoa plantations in Nagari Sungai Talang, Guguak District, Lima Puluh Kota District.

MATERIALS AND METHODS

Research Materials

The material used in this study is flowering cocoa that has been aged for more than three years. The cocoa in the study came from smallholder plantations with a planting distance of 3 m x 3 m, and 96% alcohol was used to preserve insect samples.

Research Equipment

The equipment used in this study was *a yellow sticky trap*, raffia rope, collection bottle, small brush, tweezers, camera, label paper, stationery, *and binocular microscope*.

Location Determination

Determination of the location of research by survey method. The technique used in sampling is *purposive sampling*. The research location is determined based on the results of field surveys by directly observing land conditions based on research needs. The research locations that have been determined are 10-year-old cocoa plants in Jorong Guguak Nunang, 10-year-old cocoa plants in Jorong Bukik Apik, and 5-year-old cocoa plants in Jorong Boncah in Nagari Sungai Talang, Guguak District, Lima Puluh Kota District.

Determination of Plant and Flower Samples

Sample plants were randomly determined at the study site based on diagonal lines. From the total number of plants at the study site, 10% were selected, so five cocoa plants were obtained at each location. In the predetermined samples, three flower pads were selected at each location, so the total sample in this study was 45 sample points. The chosen flower pads are flower pads that will fully bloom on the stem. Set traps and observations are made of the frequency of insect visits on the predetermined flower pads.

Insect sampling

Sampling of insect abundance was carried out using a *yellow sticky trap* with a size of 10 x 10 cm. This trap is tied to the cocoa stem precisely under the bearing of the cocoa flower that will bloom. *Yellow Sticky Trap* The working principle is very simple. Insects love yellow, so when insects see that color, they will come to it.

In this trap, there is immediate glue that can trap insects. Insect retrieval is carried out by direct collection method where insects trapped in the *yellow sticky trap* are taken directly using tweezers and then transferred into collection bottles filled with 96% alcohol liquid, which is used to preserve insect samples. Abundance sampling is carried out four times in one month with a period of once a week.

Measure visit frequency by examining how many pollinator insects visit flowering cacao plants. Observations were made by setting *yellow sticky trap* traps, and observations were made three times a day for ten days with periods, namely morning (07.00-08.00 WIB), day (11.00-12.00 WIB), and afternoon (16.00-17.00 WIB). When observations were calculated, how many insects visited cocoa flowers within 1 hour?

Data Analysis

Identification is carried out using a microscope by looking at the morphological characteristics of insects and referring to the critical book of insect determination, namely Borror (2005), to determine insect species based on their morphology.

Formula:

$H = -\sum (Pi.Ln.pi)$

$pi = n/N$

Odum (1996) stated the criteria for the value of the Shannon-Winner diversity index as follows:

If the value of $H' < 1$, then diversity is categorized as low

If the value of 1 > H' > three, then diversity is categorized as medium

If the value of H' > three, then diversity is categorized as high

RESULTS AND DISCUSSION

Pollinating insects *Forcipomyia* spp.

The body of *the insect Forcipomyia* spp. is divided into three parts: the head, thorax, and abdomen. On the head of the insect, there is a pair of antennae, compound eyes, and a mouth with a sucking type because *Forcipomyia* spp. Belongs to the order Diptera. Thoracic *Forcipomyia* spp. has a size of 0.16 mm and a length of 1.00 mm, which can collect a lot of cocoa pollen. The effectiveness of pollination by insects is influenced by the size of the insect's body (< 1 mm – 3 mm) because this is related to touching the thoracic part that enters the inside of the staminodes and then attaches pollen to the stigma. The insect *Forcipomyia* spp. Visits cocoa flowers and collects pollen using the dorsal part equipped with hairs.

Forcipomyia spp. Insects are visitors to cocoa plants, but not all insects that visit flowers will help pollinate flowers; only *Forcipomyia* spp. Insects play the most role in the pollination process. This is based on the insect's hairy body shape, broad thorax, and more frequent behavior of visiting flowers, as well as movements that enter the staminodes and touch the pistil. The morphology of the insect *Forcipomyia* spp. can be seen in Figure 1.

Abundance of Insect Populations *Forcipomyia* spp.

Based on the results of the study, the abundance of *Forcipomyia* spp. Insects found in cocoa plantations amounted to 3,366 individuals. Where the highest number was found in Jorong Guguak Nunang, which was 1,260 individuals, then in Jorong Bukik Apik, which was 1,061 individuals, while in Jorong Boncah, the total number of insects collected amounted to 1,045 individuals (Table 1).

Table 1 shows that there are differences in the abundance of *Forcipomyia* spp. Insects at each site. Based on its abundance, the highest is in Jorong Guguak Nunang because cultivation techniques are not done well by farmers in Jorong Guguak Nunang, such as not pruning and cleaning the remaining cocoa skin. Garden conditions also affect the abundance of insects. According to Yuliana (2015), the number of insects visiting untreated cocoa plants is more than the well-maintained cocoa plantations, as happened in Jorong Guguak Nunang, which is rarely sanitized by farmers, which affects the abundance of insects. In Jorong Guguak Nunang, the abundance of insects amounts to 1,260 individuals; this number is more than in other garden locations. Unkempt garden conditions create humid environmental conditions that insects like.

The cultivation technique in Jorong Bukik Apik has been done well but in an irregular period. Unlike what happened to Jorong Boncah, farmers routinely carry out maintenance on cocoa plantations, such as pruning and clearing land from the remaining cocoa skins. This is one thing that affects the abundance of insects in each location. According to Zakariyya (2016), the abundance of insects visiting cocoa can be influenced by various factors, such as climate and weather, which will affect population development and the spread of a species.

Apart from environmental factors and cultivation techniques carried out by farmers, food factors are also very influential on the abundance of insects visiting cocoa. Erniwati and Kahono (2011) stated that the abundance of cocoa plant flowers will impact the abundance of insects. In general, insects from the Order Diptera are insects sucking sweet liquids where the source of protein is found in pollen so. The order Diptera has flabellum, which is used to accommodate pollen, which,

when carried, will fall into other flowers to allow pollination. Atmowidi *et al*. (2007) said that the source of food for visitor insects is blooming flowers (anthesis) containing sugar (nectar) and pollen. Jumar (2000) and Vandeweyer (2021) stated that insects use food to survive and thrive, so the quality and suitability of food have an impact on insect populations, and Ikhsan (2022) said that the diversity of plant species will form a more complex structure so that the habitat of an area can provide various resources such as alternative hosts, food sources, other plant habitats, as shelter and food availability for survival and specific insect diversity.

Another factor that affects insect abundance is the age of plants; in Jorong Guguak Nunang and Jorong Bukik Apik, cocoa plants observed are more than ten years old, while in Jorong Boncah, the age of plants observed is five years. The number of cocoa plant flowers in Jorong Boncah is still tiny compared to other research locations. Susanto (1994) also explained that factors that affect the success of pollination are plant age, flower conditions, pollinating insect behavior, the amount of pollen attached to insects, and insect body size. This is in line with this study, which found that the age of old cocoa plants increases the number of insects in abundance. The younger 5-year-old cocoa plants in Jorong Bukik Apik have a lower population abundance than those in Jorong Guguak Nunang and Jorong Boncah. This shows that there is a mutually beneficial interaction between plants and pollinator insects or pollinating insects, where more and more insect plant flowers get nectar as a source of food and pollen attached to the body of insects so that it can help pollinate other cocoa flowers (Rusfidra, 2006; Crowley, 2021).

Frequency of Visits of Insects *Forcipomyia* spp.

The frequency of visits by *Forcipomyia* spp. Insects visiting cocoa flowers in the morning, afternoon, and evening periods at the three study sites can be seen from the data presented in Table 2.

The frequency of insect visits varied with each observation; the highest number of visits was in the morning period (07.00 WIB-08.00 WIB) in 10 days of observation in Jorong Bukik Apik, which was 656 months / 60 minutes, and the lowest frequency of visits during the day (11.00 WIB-12.00 WIB) in 10 days of observation in Jorong Boncah which was 308 moths / 60 minutes. This is related to the process of anthesis in cocoa flowers, where many food sources are available so that many insects visit in the morning; the more flowers bloom, the more insects will visit. The lowest frequency of visits is during the day, with the number of individuals 308 months / 60 minutes; another thing conveyed by Nugroho (2013) states that *Forcipomyia* spp. Insects settle more in one flower in the afternoon. In addition, insects move more in the morning until noon.

The frequency of visits was observed to see how often insects visited the flowers. This is related to the pollination of cocoa flowers, where the more often insects visit the flowers, the more pollen will be carried by insects. Likewise, what happens to *Forcipomyia* spp. Insects are pollinating insects that actively move in the morning, while during the day, the activity of these insects will decrease. This is in line with the results of the study, which showed that the highest visit of *Forcipomyia* spp. in the morning was 656 months / 60 minutes; later in the afternoon, it was 589 months / 60 minutes, while during the day, it was 401 months / 60 minutes.

In addition to the above factors, the morphology of the insect *Forcipomyia* spp. Affects the amount of pollen to be carried.

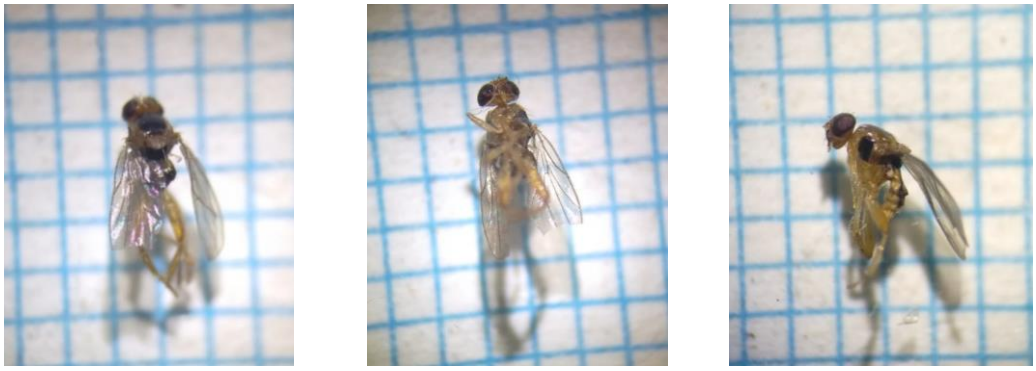
Forcipomyia spp. Insects are included in the flies, and their body characteristics are filled with fine hairs on the thorax, abdomen, and legs, allowing them to carry more pollen (Young, 1986; Pal, 2023).

Visitor Insect Diversity Index

The research diversity index results in Guguak District show that insect and cocoa visitors can be seen in Table 3. The highest diversity index value is found in cocoa plantations in Jorong Boncah, which is 2.21, while in Jorong Guguak Nunang, it is 1.97. The lowest diversity index in Jorong Bukik Apik is 1.88. This shows that the level of insect diversity of visitors to cocoa plantations in Nagari Sungai Talang, Guguak District, Regency 50 cities are included in the medium or medium category because the value of H' = 1 > H' > 3 (Odum, 1996). The medium category is caused by community activities in maintaining agricultural land that does not pay attention to environmental aspects, such as excessive pesticide use, which impacts the number of insects visiting cocoa plantations.

Based on the diversity index research results in Nagari Sungai Talang, Guguak District, 50 City Regency, two orders were found, namely the Diptera and Hymenoptera orders. The number of more dominant species comes from the order Hymenoptera, which acts as a visitor insect, then for the most significant number of individual species, *Forcipomyia* spp. This can be seen from the abundance of numbers. However, according to Nayak (2020), three orders of insects act as pollinating agents, namely Homoptera, Hymenoptera, and Diptera. The diversity index can express the relationship of species abundance within a community. Species diversity consists of 2 components, namely the number of species in the community, which is often called species richness and species similarity. The similarity shows the abundance of species, the number of individuals, and the ground cover. Species diversity is a trait of a community that shows the level of diversity of the types of organisms in it.

The value of the diversity index in Jorong Boncah is the value of H', ranging from 2, which shows a moderate level of diversity (Odum, 1996). This is related to the abundance of food resources. At the location of Jorong Boncah, many food sources are found, such as flowers that will bloom or are blooming for pollinator insects or visitor insects. Insect diversity is related to the amount of pollen used as a source of protein and nectar as a source of sugar for its life. In the study, two orders dominated cocoa plantations, namely the Diptera and Hymenoptera orders, which also act as parasitoid insects that can regulate the population of herbivorous insects and control pests on cocoa plants.



a b c

Figure 1. Insects *Forcipomyia* spp. a. dorsal, b. ventral, c. lateral

Table 1. The abundance of insects *Forcipomyia* spp.

Location	Week				∑ Individuals
	I	II	III	IV	
Jorong Guguak Nunang	289	364	285	322	1.260
Jorong Bukik Apik	225	278	275	283	1.061
Jorong Boncah	270	203	271	301	1.045

Table 2. Frequency of visits to *Forcipomyia* spp. on cocoa flowers

Location	Time (WIB)			∑ Visits
	07.00-08.00	07.00-08.00	07.00-08.00	
Jorong Guguak Nunang	644	401	578	1.623
Jorong Bukik Apik	656	316	589	1.561
Jorong Boncah	644	308	555	1.507

Table 3. Diversity index of visitor insect.

Location	Diversity index (H')
Jorong Boncah	2,21
Jorong Guguak Nunang	1,97
Jorong Bukik Apik	1,88

CONCLUSION

1. The highest abundance of *Forcipomyia* spp. insects are found in Jorong Guguak Nunang, and the lowest is in Jorong Boncah; this is related to environmental conditions and cultivation techniques carried out by farmers in each location of cocoa plantation land.
2. The frequency of visits is highest in the morning, decreases during the day, and then increases again in the afternoon.
3. The insect diversity index of visitors' cocoa flowers in Nagari Sungai Talang is at a moderate level of diversity.

ACKNOWLEDGMENTS

Acknowledgments are conveyed to all parties who have helped research in the field and the laboratory.

BIBLIOGRAPHY

Amirullah, Sitti W, Desi A. (2018). Keanekaragaman Serangga Polinator Di Perkebunan Kakao (*Theobroma cacao* L.) Desa Puudongi Kecamatan Kolono Kabupaten Konawe Selatan Sulawesi Tenggara. Biowallacea. 5 (1): 735–749.

Atmowidi T, Buchori D, Manuworoto S, Suryobroto B, & Hidayat P. (2007). Diversity of Pollinators Insects in Relation to Seed Set of Mustard (Brassica rapa L: Cruciferae). Hayati Journal of Biosciences. 14 (4): 155-161.

Borror DTC & Johnson N. (2005). Borror and Delong's Introduction to the Study of Insects 7th Edition. Brooks/Cole, Belmont, C.A.: U.S.A.

Branco, S., Silva, D., Lopes, U., & Corrêa, R. (2018). Characterization of the sexual self and cross-compatibility in genotypes of cacao. American Journal of Plant Sciences, 09(09), 1794-1806.

Crowley, L., Sadler, J., Pritchard, J., & Hayward, S. (2021). Elevated CO2 impacts on plant-pollinator interactions: a systematic review and free air carbon enrichment field study. insects, 12(6), 512.

Dani, D. and Rokhmah, D. (2022). A review of the role of pollination on the yield of cocoa plants. Kultivasi, 21(3).

Direktorat Jenderal Perkebunan. (2017). Statistik Perkebunan Indonesia 2015-2017. Jakarta.

Direktorat Jenderal Perkebunan. (2021). Statistik Perkebunan Indonesia 2017-2021. Jakarta.

Erniwati & Kahono S. (2011). Keragaman Serangga Pengunjung Bunga pada Lima Jenis Tanaman Buah di Jawa Timur: Pusat Penelitian Biologi. Bogor.

Ikhsan, Z. (2022). Diversity of Hymenoptera parasitoid species in rice cultivation and their correlation with environmental factors in tidal swamp land. *Biodiversitas Journal of Biological Diversity*, *23*(5).

Monteiro RD, Gorup FL, Takamiya SA & Barbosa BD. (2009). The growing importance of materials that prevent microbial adhesion: antimicrobial effect of medical devices containing silver.

Nayak, P., Behera, P., Behera, D., & Das, S. (2020). Surveying, record keeping and identifying the various insect pollinators visiting mango inflorescence under coastal odisha conditions. International Journal of Chemical Studies, 8(3), 1157-1162.

Nugroho A. (2013). Diversitas Serangga Pengunjung, Aktivitas Kunjungan Lalat *Forcipomyia* sp dan Pembentukan Buah Kakao (*Theobroma cacao* L.). Departemen Biologi Fakultas MIPA IPB: Bogor.

Odum EP. (1996). Dasar Dasar Ekologi. Edisi ketiga. Yogyakarta: Gadjah Mada University press.

Pal, G., Brahma, S., & Hazra, N. (2023). One new species and new records of three species of the genus *Forcipomyia meigen*, 1818 (diptera, ceratopogonidae) from west bengal, India. Evolutionary Systematics, 7(1), 83–89.

Rusfidra. (2006). Peranan Lebah Madu sebagai Serangga Penyerbuk untuk meningkatkan Produksi Tanaman dan Pendapatan Petani. Makalah Disampaikan pada Konferensi Nasional Konservasi Serangga. IPB (Institute Pertanian Bogor).

Susanto FX. (1994). Tanaman Kakao Budidaya dan Pengolahan Hasil: Kanisius. Yogyakarta.

Susilo AW. (2006). Kemampuan Menyerbuk Sendiri Beberapa Klon Kakao (*Theobroma cacao* L.). Pelita Perkebunan 2006. 22(3) 159–167.

Vandeweyer, D., Smet, J., Looveren, N., & Campenhout, L. (2021). Biological contaminants in insects as food and

feed. Journal of insects as food and Feed, 7(5), 807-822.

Young AM. (1986). Cocoa Pollination: Cocoa Growers Bulletin. (37) 5–23.

Zakariyya, F., Sulistyowati, E., & Rahayu, D. (2016). abundance of pollinator insect (*Forcipomyia* spp.) of cocoa under some shade trees. Pelita Perkebunan (a Coffee and cocoa Research Journal), 32(2), 91–100.