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Diversity and Abundance of Insects Pollinator of Chayote (*Sechium edule* (Jacq.) Swartz

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Abstract. *Chayote plants (Sechium edule) with monoecious characters require a pollination process. The pollination process requires pollinating agents to increase its productivity, one of which is insects. This research aimed to determine the diversity and abundance of insects pollinator on chayote plants. Observation of diversity and abundance used a scan sampling method. Pollinator insects observations were carried out in 3 time periods, morning, afternoon, and evening on male and female flowers. We measured environmental parameters such as temperature, humidity, wind speed, and light intensity. Eight species of wild insects pollinated chayote flowers, Apis cerana, Apis dorsata, Lasioglossum leucozonium, Polistes sagittarius, Phimenes flavopictus, Campsomeriella annulata, Lucilia sericata, and Musca domestica. The insect pollinators community had moderate diversity (1.23), a relatively dynamic community (0.59), and moderate dominance (0.62), with A. cerana, which had been the dominant insect pollinator with a relative abundance of 61.63%. Musca domestica and L. sericata were (0,58%) the least dominant insect pollinator with a relative abundance of 0.58%. This research concludes that the insects pollinator of chayote has a moderate level of diversity, relatively dynamic community, and average dominance.*

Keywords: *diversity, abundance, insects pollinator, chayote*

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INTRODUCTION

For most angiosperm plants with limited pollen production, pollination by animals has a crucial role in ecosystem services and helps the sexual reproduction process (Albrecht et al., 2012). Insects are the most abundant animals on earth that can be found and can adapt to almost every habitat (Borror et al., 2005). The presence of insects in a habitat provides ecosystem services in the form of assistance in the cross-pollination process that can improve the quality of fruit and seed (Barth, 1991)

About 80% of wild plants depend directly on pollination by insects for fruit and seeds formation, and 75% of agricultural plants used as a source of human food are entirely dependent on pollination by insects, especially bees. (Potts et al., 2010). Chayote (*Sechium edule* (Jacq.) Swartz□□□□) is an agricultural plant belonging to the Cucurbitaceae family, the sub-family Cucurbitoidae with the genus of Sicyoeae (Kumar, 2016). Chayote has perennial herbaceous vine stature and requires an active insect pollinator agent to help the pollination process with the character of monoecious inflorescences (Bomfim et al.,

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2016).

Borogojol Village is one of the vegetable-producing villages in the Lemahsugih Sub-district Majalengka Regency, West Java Province. Borogojol Village has ans area of 6.39 km^2 with a maximum height of 1004 meters above sea level. The distance from Borogojol Village to the capital city of Majalengka is about 61 km (Statistics of Majalengka Regency, 2020). The Borogojol Village has sunny weather with light to heavy rain. Environmental conditions vary within a specific range. Temperature conditions are around 27-30ºC with a minimum of 23.0ºC and a maximum of 36.4ºC, humidity conditions are approximately 40-95%, and wind speed conditions are about 5-31 km/hour with wind direction from northeast to the west (Kertajati Meteorological Station, 2020).

Research on the number of species and individual insects pollinator is crucial to understand the pollination of a plant (Atmowidi, 2008). Research on chayote pollinator insects has been reported previously in Indonesia, including *Amegilla cingulata*, *Apis cerana*, *Philanthus politus*, *Megachile relativa*, *Xylocopa latipes*, *Ropalidia fasciata*, *Polites fuscata*, and *Delta companiforne* at chayote plantations in Purbalingga, Central Java (Widhiono & Sudiana, 2015). However, overall, specific research on the pollination of chayote plants has never been done (A'yunin et al., 2019), especially in another chayote plantation in Majalengka, West Java. Based on this, this research aimed to determine the diversity and abundance of insects' pollinator of chayote.

MATERIALS AND METHODS

Study Area

The study was conducted at a commercial chayote garden owned by local farmers in Kampung Babakan Gintung RT 011 RW 003, Borogojol Village, Lemahsugih Sub-district, Majalengka Regency, Jawa Barat province, with the coordinates of 07°02'49.0" North Latitude and 108°11'05.7 "East longitude and an altitude of 911 meter above sea level (Fig. 1). Data collection was conducted during the rainy season, from mid-November 2020 to early April 2021. Physical environmental conditions varied widely, with temperatures around 20.3-35.1°C, humidity around 52-92%, wind speeds around 0, 0-1.7 m/s, and the light intensity around 1800-180900 lux.

Data Colection

For this study, ten individual chayote plants were selected, with 2-3 female flowers, in a 5×5 m square plot. Each plot was chosen randomly, and the distance between the study plots was about 1-2 m. The age of the chayote garden was six months after the seed planting period. We used the scan sampling method to observe the diversity and abundance of insects pollinator (Martin & Bateson, 1986). We observed in 3 time periods, morning (07.00-09.00 AM), afternoon (12.00-02.00 PM), and evening (03.00-05.00 PM). We observed when the weather was sunny (cloud cover ≤ 50%) (Klein et al., 2003), cloudy, or rainy. At the beginning of the observation, we measured environmental factors such as temperature and humidity with a thermohygrometer, wind speed with an anemometer, and light intensity with a lux meter.

The collection and preservation of insects pollinator used the dry method (Borror et al., 2005). The identification process used species image references and determination keys from various sources of books and scientific journals, such as Danforth (1999), Lien & Carpenter (2002), Borror et al. (2005), Saito et al. (2005), Whitworth (2006), Carvalho & Mello-Patiu (2008), Kim (2009), Engel

(2012), Engel et al. (2018), Nugroho et al. (2020), and Trianto & Purwanto (2020).

Data Analysis

Insect pollinator community was analyzed based on Shannon-Wiener diversity index (H'), Pielou evenness index (J'), Berger-Parker dominance index (D) (Wheater et al., 2011), and relative abundance (KR) (Bisui et al., 2020). The Spearman rank correlation test analyzed the correlation between insects' pollinator abundance and environmental factors. The statistical analysis was conducted by PAST 4.06b (Hammer et al., 2001).

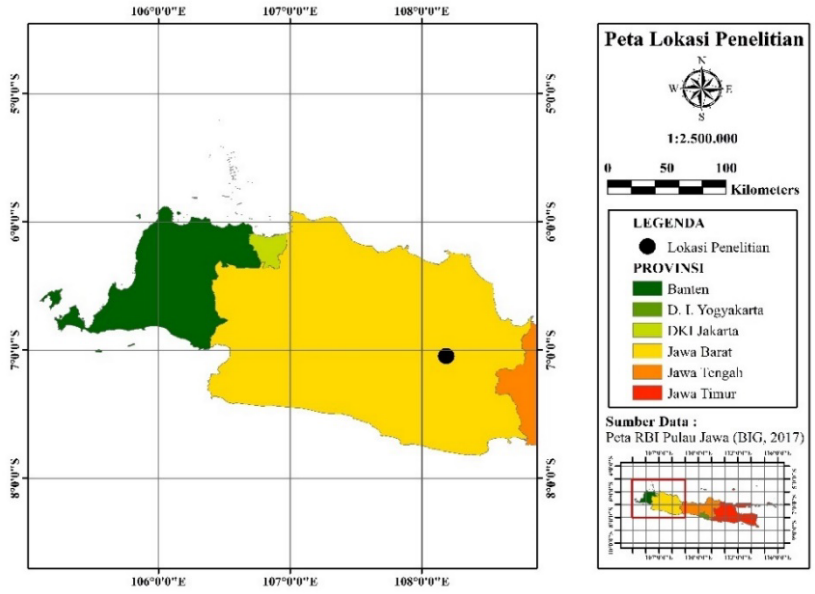

Figure 1. Research site (Geospatial Information Agency, 2017)

RESULTS AND DISCUSSION

In this study, a total number of 172 insect pollinators was collected and identified into 8 species (6 families and 2 orders) (Table 1). The Apidae family was the most abundant among all insect pollinators, with 120 individuals of two species. The Apidae family is a communal insect and has perennial colonies (Borror et al., 2005). Also Apidae family is primarily diurnal species in foraging activity (Baum et al., 2011). They had general characteristics in foraging behavior, which means they had wide-ranging feed preferences (Cui & Corlett, 2016). On the other hand, the lowest diversity and abundance were recorded in the families Muscidae and Calliphoridae, consisting of one species and one individual. Muscidae and Calliphoridae families are mostly scavenger flies (Borror et al., 2005). They had special characteristics in foraging behavior. The Muscidae family specializes in plants that smell like feces, while the Calliphoridae family specializes in plants that smell like carrion. The chosen plants are only those that can be a place to lay eggs (Raguso, 2020).

The Shannon-Wiener diversity index (H') was 1.23 (moderate level of diversity). The Pielou evenness index (J') was 0.59 (relatively dynamic community), and finally, the Berger-Parker dominance index (D) was 0.62 (average dominance) (Table 2). This moderate diversity was due to wild flowering plants around the chayote plant. Wild flowering plants in the plantation area provide an alternative food source (Purwantiningsih et al.,

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2012) and shelter for insects pollinator against predators or extreme weather (Aminah et al., 2020). Wild flowering herbaceous plants in the chayote garden area were *Acmella paniculata*, *Ageratum houstonianum*, *Commelina benghalensis*, *Crassocephalum crepidiodes*, *Mimosa pudica*, *Mirabilis jalapa*, *Nasturtium montanum*, and *Wedelia biflora*.

Table 1. Species and total individual of chayote pollinator insects

Ordo	Family	Genus	Species	Total Individual
Hymenoptera	Apidae	*Apis*	*Apis cerana*	106
			Apis dorsata	14
	Halictidae	*Lasioglossum*	*Lasioglossum leucozonium*	3
	Vespidae	*Polistes*	*Polistes sagittarius*	28
		Phimenes	*Phimenes flavopictus*	4
	Scoliidae	*Campsomeriella*	*Campsomeriella annulata*	15
Diptera	Muscidae	*Musca*	*Musca domestica*	1
	Calliphoridae	*Lucilia*	*Lucilia sericata*	1
2 Ordo	6 Families	7 Genera	8 Species	172 Individuals

Table 2. Parameter index of chayote pollinator insects diversity

Index Type	Value
Shannon-Wiener diversity (H')	1.23
Pielou evenness (J')	0.59
Berger-Parker dominance (D)	0.62

For relatively dynamic communities, average dominance was due to dominant pollinators in the community. According to Hidayat et al. (2016), high dominance index value also affects the evenness index value. The higher the dominance index value, the simpler the community structure. Widhiono & Sudiana (2015) reported that chayote plantations in Purbalingga, Central Java had moderate diversity of insects pollinator, relatively dynamic communities, and average dominance. According to Siregar et al. (2014), there are seven interacting influencing factors for insect species diversity in the community. Those factors are community age, environmental and flora community heterogeneity, competition to exploit natural resources, predation, climate stability, flora community productivity, and natural resources.

The relative abundance of chayote insect pollinator species from the highest to the lowest is *A. cerana* (61,63%), *P. sagittarius* (16,28%), *C. annulata* (8,72%), *A. dorsata* (8,14%), *P. flavopictus* (2,33%), *L. leuconozium* (1,74%), and *M. domestica* with *L. sericata* (0,58%) (Fig. 2). *Apis cerana* species became the most abundant insect pollinator due to the eusocial type of bee. *A. cerana* is a diurnal bee (Cui & Corlett, 2016) that has a life span of about 3 weeks (Koetz, 2013). These bees have colonies that allow many individual workers to forage for food (Widhiono & Sudiana, 2015). In addition, these bees like bright-colored flower characters, such as the yellow color of chayote flowers and moderate flower scent, and tend to be sweet. At

the same time, *M. domestica* and *L. sericata* species were the slightest insect pollinator. *Musca domestica* has a life span of about 2-3 weeks (Iqbal et al., 2014) and *L. sericata* has about 2-4 weeks (Kurnia et al., 2018). *Musca domestica* and *L. sericata* species like white, cream, or greenish-yellow flowers and strong flower scents like rotten flesh or feces (Willmer, 2011). The amount of flower availability (Lestari et al., 2014), environmental factors (E. H. Siregar et al., 2016), and climate change (Pudasaini et al., 2015) influenced the abundance of pollinating insects.

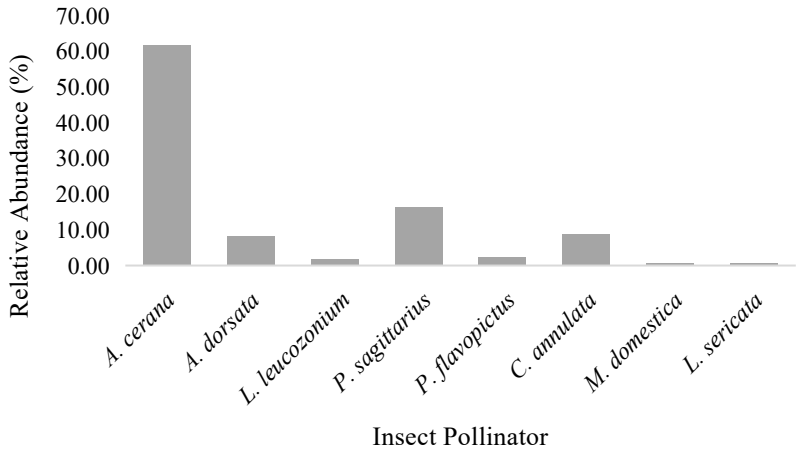

Figure 2 The relative abundance of each insect pollinator species of chayote

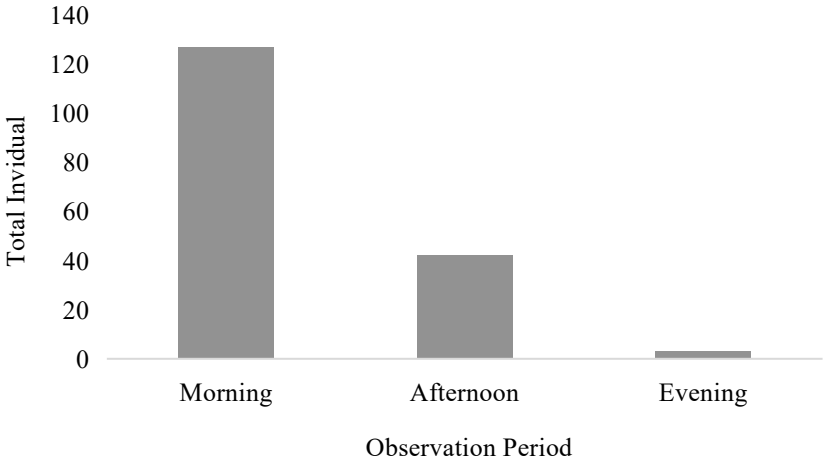

Figure 3 Number of individual insect pollinators based on the observation period

The total individual insect pollinator of chayote based on the observation period from the highest to the lowest is morning (127 individuals), afternoon (42 individuals), and evening (3 individuals) (Fig. 3). The morning was the highest visit time due to the availability of high nectar volume. The volume of chayote flower nectar increased from 08.00 AM to 01.00 PM (A'yunin et al., 2019). It allowed many visits by insects pollinator to the flowers by nectar volume and sugar concentrations that tended to be high in the morning (Men-

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sah & Kudom, 2011). Meanwhile, the evening was the lowest visit time because the flowers on the Cucurbitaceae family began to close in the evening (Layek et al., 2021).

Table 3. Spearman Rank correlation test results on the total individual pollinating insects with environmental factors

Insect Pollinator Species	Environmental Factors							
	Temperature		Wind Speed		Humidity		Light Intensity	
	r	P	r	P	r	P	r	P
A. cerana	0.13	0.42	-0.25	0.14	-0.18	0.28	0.41	0.01*
A. dorsata	0.38	0.02*	-0.15	0.36	-0.45	0.005*	0.53	0.0007*
L. leuconozium	0.32	0.05	-0.11	0.48	-0.35	0.03*	0.19	0.25
P. sagittarius	0.41	0.01*	-0.10	0.54	-0.37	0.02*	0.46	0.004*
P. flavopictus	0.10	0.53	-0.16	0.33	-0.17	0.32	0.04	0.80
C. annulata	0.27	0.10	-0.19	0.24	-0.49	0.001*	0.35	0.03*
L. sericata	-0.21	0.21	-0.20	0.22	0.02	0.88	-0.05	0.74
M. domestica	0.20	0.23	-0.20	0.22	-0.20	0.23	0.18	0.27

Temperature and light intensity positively correlated, while wind speed and humidity negatively correlated with a total insect pollinator (Table 3). However, only humidity and light intensity had a significant effect. At optimal light intensity, pollinating insects will start foraging for food and stop when light intensity is low (Widhiono, 2015). Humidity plays a role in the balance of temperature and water content in the bodies of insects pollinator for flight activities in search of food (Willmer, 2011). In addition, humidity and temperature can determine the concentration of sugar content in nectar in flowers (Putra et al., 2017). Hasan et al. (2017) reported that air temperature, wind speed, humidity, and light intensity influenced the visiting activity of cucumber insects' pollinators.

CONCLUSION

This research concludes that the insects' pollinator of chayote has a moderate level of diversity. relatively dynamic community, and average dominance. *Apis cerana* is the most abundant insect pollinator of chayote. Environmental factors can affect the total insect pollinator that visits chayote flowers. However, there is a recommendation for further research to observe the foraging behavior of insects' pollinator of chayote and their pollination effectiveness.

AUTHOR CONTRIBUTION

M.D.A. design the research, collecting data, data analysis and wrote the manuscript, A.D.P. supervised data collection and revised the manuscript, R.E.P. provided funding, design the research, supervised data collect and analysis, wrote and revised the manuscript.

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CONFLICT OF INTEREST

There is no conflict of interest during the research work.

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