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Monitoring of insect pollinators of mango (*Mangifera indica* L.) inflorescence based on citizen science

Ipin Aripin[1,4*], Topik Hidayat[2], Nuryani Y. Rustaman[3], Riandi[3]
[1]School of Postgraduates Studies of Science Education, Universitas Pendidikan Indonesia
Jl. Dr. Setiabudhi No. 229 Bandung, West Java, Indonesia. 40154
*Email: ipin_aripin@upi.edu
[2]Department of Biology Education, Faculty of Mathematics and Natural Science, Universitas Pendidikan Indonesia
Jl. Dr. Setiabudhi No. 229 Bandung, West Java, Indonesia. 40154
[3]School of Postgraduates, Universitas Pendidikan Indonesia
Jl. Dr. Setiabudhi No. 229 Bandung, West Java, Indonesia. 40154
[4]Department of Biology Education, Universitas Majalengka
Jl. KH. Abdul Halim No. 103 Majalengka, West Java, Indonesia. 45418

ABSTRACT. Mango cross-pollination can be encouraged through the presence of pollinating insects, which can be investigated and observed through citizen science activities. This study aims to monitor the presence of insect pollinators of mango (*Mangifera indica* L.) inflorescence through citizen science activities. The data generated in the study can be used as a reference to determine population trends and the biodiversity of mango insect pollinators. A citizen science approach in participatory research was used to collect and identify the data. A total of 68 volunteer participants from two universities in west Java were involved in this study. The participants had to meet the requirements to have contracted ecology courses. Smartphones and insect identification guidelines and databases at https://www.discoverlife.org/ and https://www.inaturalist.org/ were used as a tool in this research. The identified data were submitted via google form (www.bit.ly/csmangga) and the Inaturalist application for publication. It was discovered that mango inflorescence insect pollinators comprised five orders, 26 families, and 39 species. Diptera and Hymenoptera orders are insects that have the biggest role in mango pollination, and *Chrysomya* sp. is an insect species found in almost all mango cultivars.

Keywords: citizen science approach; *Chrysomya* sp.; insect pollinator biodiversity; mango cultivars; west Java

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INTRODUCTION

Mango (*Mangifera indica* L.) is one of the most popular fruit plants in Indonesia (Tasliah *et al*., 2016; Utami *et al*., 2019). This native Indian plant has spread and grown in over 111 countries (Rafique *et al*., 2016; Yadav *et al*., 2017). In West Java, the mango horticulture center is in Region III of Cirebon which covers Cirebon, Indramayu, Majalengka, and Kuningan. Their typical mango cultivars are Gedong Gincu and Indramayu (Awaliyah, 2018; Kementerian Pertanian, 2020).

Mango can self-pollinate as well as cross-pollinate. Cross-pollination requires pollinating biotic or abiotic agents such as vertebrate species, insects, wind, water, or gravity (Ramírez & Davenport, 2016; Halder *et al*., 2019). Cross-pollination of mango plants can be facilitated by insect pollinators. Pollinators are animals that differ in their morphology and behavior from other species in order to ease the pollination process (Huda *et al*., 2015). Pollination is helped by insect pollinators by transporting pollen from the anther to the stigma, where it is fertilized. Insect pollinators are critical in agriculture since they have the potential to alter crop productivity (Ferrero *et al*., 2011; Howlett *et al*., 2011; Carvalheiro *et al*., 2012).

Insects have a major role in the pollination process. It is estimated that 75-80% of flowering plants are pollinated by insects (Ollerton *et al*., 2011; Kumar *et al*., 2016; Goulson, 2019). The decline in agricultural productivity due to the low number of insect pollinator populations has become a severe

concern to scientists. The use of pesticides, pollution, intensification of agricultural land, and climate change are the leading causes of the decline in insect numbers in recent decades (Halsch *et al*., 2021; Raven & Wagner, 2021). Insects have been protected and conserved through nature reserves, habitat protection, maintaining vegetation around highways for insect habitats, reducing land use, and making narratives to build public awareness in insect conservation (Saunders *et al*., 2020; New *et al*., 2021).

Building public awareness in insect conservation can be done through various activities such as citizen science. The citizen science approach has been widely developed in multiple countries to obtain scientific research data and build public awareness of biodiversity protection (Kobori *et al*., 2016). Gröblinger *et al*. (2019) further stated that citizen science is a collaboration between the people and scientists to research to solve a problem faced in the real world. It can act a bridge between the public and scientists in developing knowledge through the community, facilitating knowledge transfer and dissemination occurs (Urválková & Janoušková, 2019). The citizen science program has many advantages, including covering a wide area, thereby saving research costs compared to traditional field survey activities (Tulloch *et al*., 2013). Therefore, citizen science activities are widely used for monitoring ecology (Encarnação *et al*., 2021) and biodiversity, such as butterflies (Lewandowski & Oberhauser, 2017; Deguines *et al*., 2020), as well as insects (Oberhauser & Lebuhn, 2012; Williams *et al*., 2017). Numerous citizen science activities monitoring the existence of insect pollinators are conducted in European, American, and Asian countries to protect and conserve insects (Zhang *et al*., 2019; Bloom & Crowder, 2020), which is driven by the earth's declining insect population. Meanwhile, we know that insects play a critical role in pollinating flowers of a variety of plant species and serving as bioindicators of the environment's quality and biodiversity (Huda *et al.,* 2015)

This study aims to monitor the presence of insect pollinators of mango (*M. indica* L.) inflorescence through citizen science activities. This study is expected to obtain data on the distribution, type of species, and the role of insect pollinators in pollinating mango flowers to raise the community's awareness of the importance of maintaining environmental quality to prevent insect pollinator biodiversity from becoming extinct, thereby reducing human food production.

MATERIALS AND METHODS

The citizen science approach in the form of participatory research was used to collect and identify the research data. The participants involved were recruited voluntarily from the sixth-semester students who had taken general ecology courses from two universities in West Java, Indonesia. As a result, 68 students were involved as the participants. They were given directions and briefings to monitor the insect pollinators of mango inflorescence online.

Data collection. The participants carried out monitoring activities in their respective regions (Cirebon, Indramayu, Majalengka, and Kuningan). This monitoring activity was carried out from February 1 to May 1, 2021. Each participant observed at least five different mango cultivars. Smartphones and Inaturalist were the main tools for collecting and documenting the research data (Unger *et al*., 2021).

Data analysis. Data identification was carried out using insect identification guidelines, identification images, and a database at https://www.discoverlife.org/ and https://www.inaturalist.org/ (Saul-Gershenz *et al*., 2020). Data identification was carried out by the participants accompanied by the researcher as the project leader. They submitted the observational data identified through google form link (https:bit.ly/csmangga) and the Inaturalist application for publication.

RESULTS AND DISCUSSION

Insect pollinator. In this study, citizen science participants monitored insect pollinators on various mango varieties, including Harum Manis, Golek, Manalagi, Cengkir, Apel, Kelapa, Irwin, Gajah, and Gedong Gincu. Based on the identification of

the data, five orders, 26 families, and 39 species of insects were found during the observation. Table 1 is a recapitulation of insect identification results in mango (*Mangifera indica* L.) inflorescence.

Table 1. Insects pollinator found on mango inflorescences.

Order	Family	Species
Coleoptera	Cantharidae	*Discodon moissinaci* Pic
		Tylocerus pectoralis Fabricius
	Scarabaeidae	*Protaetia fusca*
	Chrysomelidae	
	Coccinellidae	*Coccinella septempunctata* L.
	Curculionidae	*Myllocerus isabellinus*
	Malachiidae	*Malachius coccineus*
Diptera	Calliphoridae	*Chrysomya megacephala*
		Chrysomya albiceps
	Diapriidae	
	Dolichopodidae	
	Drosophilidae	*Drosophila* sp.
	Ephydridae	
	Muscidae	*Musca domestica*
		Coenosia attenuata Stein
		Fannia sp.
	Sarcophagidae	*Sarcophaga* sp.
	Syrphidae	*Eristalinus arvorum*
	Tachinidae	*Drino imberbis* Wiedemann
	Tephritidae	*Bactrocera rufula*
Hemiptera	Aphididae	*Aphis glycines*
	Coreidae	*Cletus capitulatus*
Lepidoptera	Nymphalidae	*Elymnias nesaea*
		Melanitis leda
	Pieridae	*Delias belisama*
		Delias hyparete
		Catopsilia pomona
		Eurema blanda
	Papilio	*Papilio demoleus*
		Papilio memnon
	Hesperiidae	*Ancistroides nigrita maura* Snellen
Hymenoptera	Apidae	*Apis cerana*
		Trigona laeviceps
	Eulophidae	*Tetrastichus* sp.
	Formicidae	*Oecophylla smaragdina*
		Camponotus pennsylvanicus
		Solenopsis sp.
		Dolichoderus thoracicus
	Vespidae	*Ropalidia marginata*
		Polistes sagittarius de Saussure
		Vespa affinis
		Vespa analis
		Vespa tropica

Table 1 shows data on insects found visiting mango inflorescence between the first and sixth day of mango inflorescence. More insects were discovered between the second and fourth days, when the mango inflorescences were fully bloomed and reeked of nectar. After the blooms began to wither and dry up on the sixth day, insects were rarely observed. The following is documentation of citizen science participants' observations of insect pollinators in mango inflorescences.

Fig. 1. Insect pollinators found in study area: a. Diptera order; b. Lepidoptera order; c. Hymenoptera order.

Fig. 1 shows insects that play a role in mango inflorescence. Based on the research conducted by the citizen scientists, the Diptera and Hymenoptera orders were the most frequently encountered insects. *Chrysomya megacephala* was the most common insect species in all mango species observed. Insect pollinators visit mango flowers is mainly during the day, especially in the Lepidoptera order. It is the right time to look for food (Peggie, 2014).

The role of pollinators in mango inflorescence. Mango (*M. indica* L.) is a fruit commodity with a high economic value. Mango tree productivity is influenced by various factors, especially climate (Triani & Ariffin, 2019). Besides climate, insect pollinators also have an essential role in mango tree productivity, especially in pollination (Reddy *et al*., 2015; Yadav *et al*., 2017). One way to increase mango productivity is by optimizing the role of ecosystem services in pollination by certain insects (Huda *et al*., 2015). West Java's climate is tropical, with average temperatures of 23.8°C and humidity levels of 74-77% in 2019-2020 (Badan Pusat Statistik Provinsi Jawa Barat, 2021). According to Li *et al*. (2019), *Apis cerana* workers become intolerant to temperatures at 55°C, while Islam *et al*. (2015) discovered that the largest peak of the *Vespa tropica* population occurred at an average temperature of 22.86-35.14°C and a relative humidity of 58.93-88.71%. These findings corroborated our studies. Temperature and humidity in West Java are thought to favor insect pollinator adaptation.

Mango flowers attract a wide variety of insect species, particularly those belonging to the Diptera and Hymenoptera orders. *Chrysomya megacephala*, commonly referred to as green bottle flies, is the most frequently encountered insect species during mango pollination (Reddy *et al*., 2015; Annoh *et al*., 2017). Additionally, insect pollinators have a significant influence in determining the quality and quantity of mango produced. Mangoes that have been pollinated by insects are greater in size than those that have not been pollinated (Saeed *et al*., 2016). Certain mango cultivars are incapable of self-pollination and thus require pollinators to produce the greatest amount of fruit. Mango flowers that are pollinated by pollinators such as *Eristalinus* sp., *Chrysomya* sp., *Stomorhina* sp., *Sarcophaga* sp., and *Camponotus* sp. produce more fruit than those that are self-pollinated or pollinated naturally (Huda *et al*., 2015; Latif *et al*., 2019).

Apart from providing ecosystem services through pollination, insect pollinators also create derivative goods such as honey produced by the Apidae family, implying that insect pollinators indirectly contribute to the production of nutrients critical for human health (Ellis *et al*., 2015). The declining insect population as a result of human activities, agricultural intensification, and climate change (Halsch *et al*., 2021; Raven & Wagner, 2021) must be of concern to humans since it has the potential to diminish food supply, especially the productivity of fruit crops like mangoes.

Along with developing species literacy, mango inflorescence monitoring activities can heighten participants' awareness and concern. Monitoring of mango inflorescence insect pollinators has been conducted in a number of countries, including Australia, Pakistan, and Ghana, for the purpose of conducting research and conserving insects (Rafique *et al*., 2016; Annoh *et al*., 2017). Monitoring insect pollinators in mango inflorescences as part of a

citizen science program can help enhance awareness and knowledge about the protection and conservation of insect biodiversity (Ellwood *et al*., 2017; McKinley *et al*., 2017). Monitoring insect pollinators can help determine the trends and distribution of insects, which can be utilized to build community knowledge and conservation efforts. Citizen science initiatives such as insect pollinator monitoring can be recommended to the community in order to raise their knowledge, awareness, and participation in insect conservation activities.

CONCLUSION

The results of citizen science-based monitoring of mango inflorescence insect pollinators could identify five orders, 26 families, and 39 species. Diptera and Hymenoptera orders are insects that have the biggest role in mango pollination and *Chrysomya* sp. is an insect species found in almost all mango cultivars.

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