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Diversity and Host Ranges of Whiteflies in Mekarsari Fruit Park, Bogor: a Comprehensive Study of 20 Whitefly Species Across 56 Fruit Plant Species

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Abstract

Mekarsari Fruit Park, situated in Bogor, boasts an extensive collection of 226 fruit species. Apart from vegetables and ornamentals, fruit plants play a significant role as hosts for whiteflies. Whitefly infestations can disrupt photosynthesis and respiration, affect the aesthetics of ornamental plants, and transmit plant diseases caused by viruses. The primary objective of this study was to assess the species diversity of whiteflies and their host ranges within Mekarsari Fruit Park. Purposive sampling was employed, followed by preparing collected samples for microscope slides and identification. A total of 20 whitefly species were collected from 56 fruit plant species spanning 20 different families. Of the 20 collected species, 16 were successfully identified, while four remained morphospecies. These whiteflies were categorized into two subfamilies: 17 species belonging to the Aleyrodinae subfamily and three species belonging to the Aleurodicinae subfamily. *Paraleyrodes minei* emerged as the most prevalent whitefly species, infesting 14 host plants across 11 families. Furthermore, the study revealed that 14 whitefly species were found exclusively on one fruit plant species, one whitefly species on two fruit plant species within the same family, and seven whitefly species on multiple fruit plant families. The Euphorbiaceae and Rubiaceae families were the most susceptible to whitefly infestation among the fruit plants.

Keywords

Fruit plant, horticulture, morphological identification, pest plant

INTRODUCTION

Whiteflies (Kutu kebul) (Hemiptera: Aleyrodidae) are significant insect pests in horticultural crops. Whiteflies belong to the order Hemiptera, suborder Sternorrhyncha, and family Aleyrodidae, divided into three subfamilies: Aleurodicinae, Aleyrodinae, and Udamoselinae. All stages of whiteflies live on the undersides of leaves to allow honeydew excretion to fall without soiling their bodies. When deposited on the upper leaf surface, the honeydew droplets provide an ideal substrate for the growth of *Capnodium* sp., which can cover the host plant's leaves, thereby blocking the sunlight needed for photosynthesis (Watson, 2007).

Some whitefly species are known to cause direct and indirect damage to plants, especially in commercial horticultural crops. Whitefly infestations can disrupt photosynthesis and respiration, affect the aesthetics of ornamental plants, and transmit plant diseases caused by viruses (Nurulaila, 2012). Direct damage is caused by the nymph and adult stages, which pierce the leaf tissue to feed on plant sap, leading to the death of leaf tissue. Indirect damage results from

honeydew excretion, which serves as a medium for the growth of sooty mold (Hoddle, 2004; Rattan, 2015). The losses incurred due to whitefly infestations can range from 20% to 100%, depending on the plant, season, and interactions with other factors (Murgianto, 2010).

Indonesia boasts a wide variety of fruit species, and one such collection of fruits can be found at Mekarsari Fruit Park. Mekarsari Fruit Park is a recreational agrotourism site dedicated to fruit trees, spanning 264 hectares and divided into several zones. Initially established as a center for preserving horticultural germplasm, it is now utilized for research, education, cultivation, and tourism (Triseptyanti, 2008). Mekarsari Fruit Park houses an extensive collection of fruit plants, encompassing 226 species from 55 fruit plant families. However, the specific whitefly species infesting fruit plants in this park have not been identified.

The family Aleyrodidae currently comprises approximately 1,200 identified species. Both adult and nymph stages possess highly specialized structures around the anus (vasiform orifice, operculum, and lingula) that play a role in honeydew excretion, preventing honeydew from soiling their bodies (Watson, 2007; Sulaymonov, 2021). According to Rahayuwati (2009), the puparium form of whiteflies can drastically change depending on the presence or absence of fine hairs or wax layers on leaf surfaces. The nymph form of whiteflies on different host plants often varies, potentially leading to misidentification. Misidentification can result in inaccurate information for further research. Information on the diversity of whiteflies infesting various plants in Indonesia is limited, making research on basic information such as the taxonomy and biology of whiteflies in horticultural plants highly necessary. This study aims to investigate the diversity and host plants of whiteflies (Hemiptera: Aleyrodidae) on various fruit plants in Mekarsari Fruit Park, Bogor Regency.

METHODS

The research was conducted from April to August 2016 at Mekarsari Fruit Park, Bogor Regency. Whitefly and their host plant observations were conducted in five areas or fruit cultivation blocks within Block A, Block B, Block C, Block D, and Block E. Whitefly observations were made six times between April and June 2016. Sampling was conducted on 20 plant families, with 478 trees from 56 fruit plant species. Whitefly samples were collected by cutting leaves from plants affected by whitefly infestations and selecting four branches per tree for observation. Each branch was taken from the top 30 cm of the tree, where whitefly colonies were present. Whiteflies in various stages (eggs, nymphs, pupae, and pupal cases) were placed in transparent plastic bags. The collected whiteflies were preserved for slide preparation following Watson's procedure (2007). Permanent whitefly slide preparations were made to allow long-term storage. Morphological images of whitefly preparations were captured using a digital camera connected to a compound microscope and a Leica M205C microscope.

Morphological observation and whitefly identification were done in the Insect Biosystematics Laboratory, Department of Plant Protection, Faculty of Agriculture, Bogor Agricultural University—the identification was conducted under a stereo microscope at 400x magnification. Whitefly identification was based on reference books such as "An Identification Guide to Common Whitefly Pest Species of the World (Homoptera: Aleyrodidae)" by Martin (1987), "Identification of Whiteflies (Hemiptera: Aleyrodidae)" by Watson (2007), and the thesis "Species Diversity and Identification Key of Whiteflies (Hemiptera: Aleyrodidae) on Agricultural Plants in West Java" by Nurulalia (2012).

RESULTS AND DISCUSSION

Of the 56 fruit plant species sampled (representing 20 fruit plant families), only 26 were infested by whiteflies. A total of 20 whitefly species were collected, with 16 species successfully identified up to the genus level, while four species remained at the morphospecies level. Among these whiteflies, 17 species were categorized under the subfamily Aleyrodinae, while three were classified under the subfamily Aleurodicinae.

The most commonly encountered whitefly from the Aleyrodinae subfamily in the field was *Dialeuropora decempuncta*, which infested five plant species from four fruit plant families, namely, buns and Menteng (*Euphorbiaceae*), avocado (*Lauraceae*), gay (*Leguminosae*), and banana (*Musaceae*). On the other hand, from the Aleurodicinae subfamily, *Paraleyrodes minei* was the predominant whitefly species, infesting 14 plant species from 11 fruit plant families, including guava (*Myrtaceae*), avocado and Engkala (*Lauraceae*), chokun orange (*Rutaceae*), kecapi (*Meliaceae*), buni (*Euphorbiaceae*), gayam (*Leguminosae*), soursop and custard apple (*Annonaceae*), rukem (*Flacourtiaceae*), sapodilla

(*Sapotaceae*), rambutan (*Sapindaceae*), and mulberry and jackfruit (*Moraceae*) (Table 1). This distribution can be attributed to the physical leaf surface characteristics, particularly the presence of trichomes.

Table 1. Diversity of Whitefly Species Found at Various Locations During Six Observations from April To June 2016

Pant families	**Host plants**	**Whitefly species**	**Average per branch (individual)**
Anacardiaceae	Manggo *(Mangifera indica)*	*Dialeuropora* sp.	2.04
	Gandaria *(Bouea marchophylla)*	*Dialeuropora* sp.	4.88
Annonaceae	Custard apple *(Annona reticulata)*	*P. minei*	2.36
	Sugar apple *(Annona squamosa)*	*D. decempuncta* *P. minei*	3.15*
Euphorbiaceae	Buni *(Antidesma bunius)*	*A. antidesmae* *P. minei*	100.62*
	Menteng *(Baccaurea javanica)*	*A. antidesmae*	4.87
	Otaheite Gooseberry *(Phylanthus acidus)*	*Aleurotrachelus* sp. 1 *Aleurotrachelus* sp. 2	2.39*
Flacourtiaceae	Rukam *(Flacourtia rukam)*	Aleyrodinae sp. 1 *P. minei*	9.01*
Lauraceae	Avocado *(Persea americana)*	*D. kirkaldyi* *D. decempuncta* Aleyrodinae sp. 2 *P. minei*	6.28*
	Engkala *(Litsea garciae)*	*P. minei*	13.30
Leguminoceae	Gayam *(Eugenia uniflora)*	*D. decempuncta* *P. minei*	1.57*
Meliaceae	Kecapi *(Sandoricum koetjape)*	*P. minei* *D. decempuncta* *Aleuroclava* sp.	0.73*
Moraceae	Black mulberry *(Morus nigra)*	*Dialeurodes* sp. *P. minei*	0.86*
	Jackfruits *(Arthocarpus heterophyllus)*	*P. minei* *A. aucubae*	1.78*
Musaceae	Banana (*Musa x paradisiaca*)	*D. decempuncta*	0.14
Myrtaceae	Guava *(Psidium guajava)*	*A. psidii* *A. dispersus* *P. minei*	5.13*
	Rose apple *(Syzygium jambos)*	*A. lushanensis*	0.96
Rubiaceae	Coffee *(Coffea arabica)*	*Cockerelliella* sp.2	0.13
	Noni *(Morinda citrifolia)*	Aleyrodinae sp. 3 *D. kirkaldyi*	93.81*
Rutaceae	Pomelo *(Citrus Grandis)*	*A. dugesii* *A. jasmini*	1.72*
	Chokun orange *(Citrus sp.)*	*P. minei* Aleyrodinae sp. 3	1.64*
Sapindaceae	Rambutan *(Nephelium lappaceum)*	*P. minei* Aleyrodinae sp. 1	0.26*
Sapotacea	Abiu *(Pouteria caimito)*	*A. antidesmae*	0.39
	Caqui *(Manilkara kauki)*	*P. minei* *A. antidesmae*	4.20*
	Sapodilla *(Achras zapota)*	Aleyrodinae sp. 4	0.42

*Note: * indicates a combination of species from each host plant.*

Whiteflies were frequently found on rough or hairy leaf surfaces, which serve as a defense and protection against rain. Additionally, whitefly eggs located beneath the leaf surface can avoid the influence of wind. Whiteflies were only found in small numbers on smooth leaf surfaces and were more scattered (solitary), such as on guava, rose apple, coffee, and abiu leaves, which have smooth leaf surfaces. According to Schoonhoven et al. (1998), whitefly nymphs are likelier to cluster on plants with hairy or trichome-covered leaves than those with smooth leaf surfaces. Nymphs were also more frequently found on the lower leaf surfaces of plants than on the upper leaf surfaces or buds.

The highest species diversity of whiteflies was found in Block D among the five observation blocks, with ten species. This is because the diversity of host plants in that location is more significant than in the other blocks. There are 28 plant families in Block D, while Blocks A, B, C, and E have less than 15 plant families. In total, 14 fruit plant families were observed to be infested by whiteflies. According to Karami (2012), the more comprehensive the range of hosts for whiteflies, the more abundant they tend to be in the field. According to Muniappan et al. (2009) and Hidayat et al. (2019), some whiteflies are invasive insects (Hemiptera: Sternorrhyncha) in Southeast Asia and West Africa, such as *A. dugesii*, the giant whitefly. This species prefers woody plants, fruit-bearing plants, and Hibiscus sp. Whiteflies in California and Hawaii have been successfully controlled using parasitoids such as *Idioporus affinis* LaSalle & Polaszek (Hymenoptera: Pteromalidae), *Encarsiella noyesii* Hayat (Hymenoptera: Aphelinidae), and *Entedononecremnus krauteri* Zolnerowich & Rose (Hymenoptera: Eulophidae).

Whiteflies are polyphagous insects that can attack more than one family of host plants. Some polyphagous whitefly species include *P. minei*, *D. decempuncta*, *A. antidesmae*, *D. kirkaldyi*, Aleyrodinae sp. 1, and Aleyrodinae sp. 3. There are also whitefly species that attack two types of host plants within the same family, such as the species *Dialeuropora* sp. and those that are most commonly found on a single host plant, including species *A. maesae*, *Cockerelliella* sp., *A. psidii*, *A. dispersus*, *A. dugesii*, *Dialeurodes* sp., *A. aucubae*, *Aleuroclava* sp., *Aleurotrachelus* sp. 1, *Aleurotrachelus* sp. 2, *A. jasmini*, Aleyrodinae sp. 2, and Aleyrodinae sp. 4 (Table 1).

The symptoms of whitefly infestation are most visible in the buni plant (Euphorbiaceae), followed by the noni plant (Rubiaceae). Based on the data in Table 1, these two plants are the most heavily infested by whiteflies. The morinda plant exhibits symptoms of leaf deformation, transitioning from a standard shape to wrinkled leaves due to whitefly infestation. In contrast, the buni plant shows a leaf surface covered in honeydew (Figure 1). This is because noni and buni plants are recognized for their dense foliage, which leads to increased humidity levels.

Moreover, when examining the leaf structure, both of these plants possess a notable abundance of leaf hairs, and this specific leaf structure appeals to whitefly. Quantitatively assessing the damage to the plants is challenging, even though these insects feed on the plant's source of nutrients. The impact of piercing-sucking mouthpart insects can be detected by comparing infested and non-infested plants. While feeding on plant fluids, these insects can produce a substance similar to saliva-containing enzymes that can cause necrosis in plant tissues (Gullan & Cranston, 2000; Tan et al., 2016).

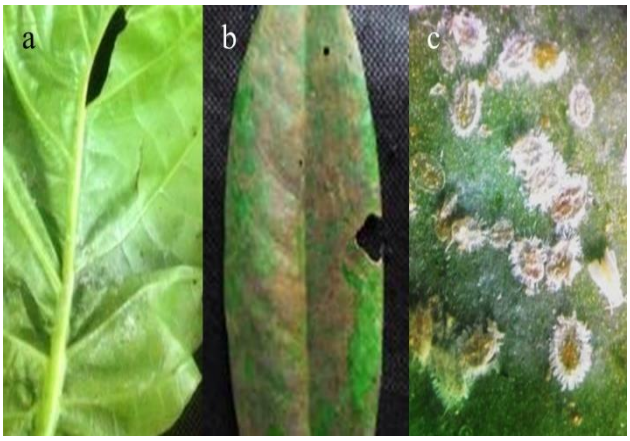

Figure 1. Symptoms of wrinkling due to whitefly infestation on morinda plant leaves (a); honeydew on buni plant leaves (b); whitefly pupa colonies on buni plant leaves (c).

Whitefly Species Found in Mekarsari Fruit Park

Subfamily Aleurodicinae

Characteristics of this subfamily include the presence of four or six pairs of pores on the subdorsal region and one pair of compound pores on the head (cephalic). These pores have a distinctive crown-like or splinal shape and serve to produce wax. Another unique feature in this subfamily is the vasiform orifice, which has an elongated, tongue-shaped lingula and two pairs of hairs at the tip of the lingula (Figure 2).

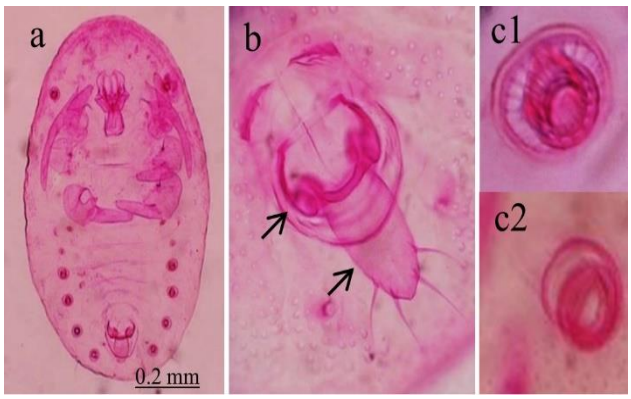

Figure 2. Whitefly exuvia (a), Vasiform orifice hole and lingula of the Aleurodicinae subfamily (b), Compound subdorsal pores (c1; c2).

Three whitefly species belonging to the Aleurodicinae subfamily were found. *P. minei* was discovered on 11 plant species, including guava, avocado, chokun orange, kecapi, buni, gayam, soursop, rukem, sapodilla, Engkala, and jackfruit leaves. *A. dispersus* was found on avocado and guava leaves. *A. dugesii* was identified on pomelo leaves. These three whitefly species exhibit different body lengths and widths, as seen in Figure 3. According to Murgianto (2010), *A. dispersus* was found to attack 111 plant species from 53 different plant families in the Dramaga, Bogor area, and surrounding areas of West Java. In addition, *A. dugesii* has been observed attacking 40 species from 27 different plant families, with a particular preference for plants in the Solanaceae family. This species is predominantly found in highland regions, such as Cipanas, and has emerged as a significant pest for avocado plants.

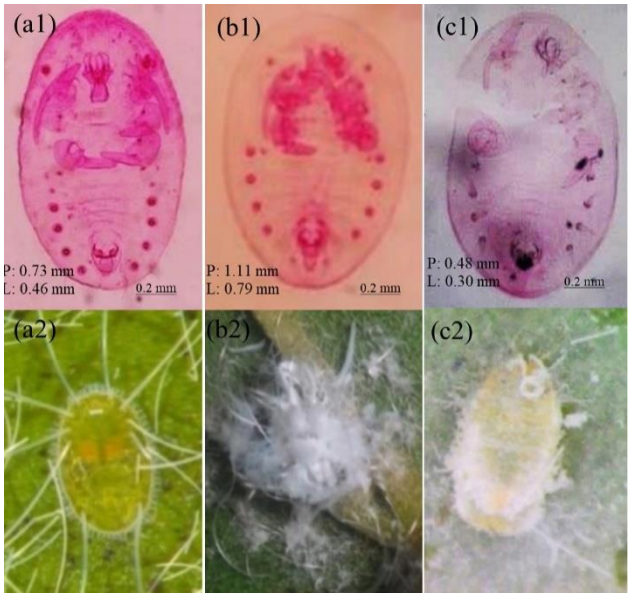

Figure 3. Microscope slides of *P. minei* (a1); *A. dispersus* (b1), *A. dugesii* (c1), pupa *P. minei* (a2); *A. dispersus* (b2); *A. dugesii* (c2)

Subfamily Aleyrodinae

The distinctive feature of this subfamily typically includes the absence of pores in the subdorsal or cephalic regions, but some species within this subfamily possess five pairs of superficial pores. The lingula is usually tiny and not tongue-shaped, often varying in form. Whitefly species from the Aleyrodinae subfamily tend to produce little wax. Furthermore, the c (Watson, 2007) (Figure 4). According to Watson (2007), the Aleyrodinae subfamily had a higher species diversity than the Aleurodicinae subfamily. Furthermore, the distribution of this subfamily is also quite widespread. This is because the Aleyrodinae subfamily has smaller body sizes than the Aleurodicinae, which enables the species from the Aleyrodinae subfamily to be more active in flight and more easily carried by the wind when moving to new locations.

Figure 4. Microscope slide of the whitefly (a); *Vasiform orifice* (b1), a lingula inside it and one pair of setae at the tip of the abdomen (b2); Shape of superficial pores (c1; c2)

Whitefly species belonging to the Aleyrodinae subfamily were found in a total of 17 species, including *D. kirkaldyi* on morinda and avocado plants; *D. decempuncta* on soursop, avocado, gayam, kecapi, and banana plants; *A. psidii* on guava plants; *Aleurotrachelus* sp. 1 *and Aleurotrachelus* sp. 2 on ceremai plants; *A. lushanensis* on rose apple plants; *Cockerelliella* sp. on coffee plants; *Dialeurodes* sp. on mulberry plants; *Dialeuropora* sp. on mango and gandaria plants; *A. antidesmae* on buni, menteng, abiu, and sapodilla plants; *A. aucubae* on jackfruit plants; *Aleuroclava* sp. on kecapi plants; Aleyrodinae sp. 1 on rukem and rambutan plants; *A. jasmini* on pomelo plants; Aleyrodinae sp. 2 on avocado plants; Aleyrodinae sp. 3 on morinda and chokun orange plants; Aleyrodinae sp. 4 on sapodilla plants. These whitefly species exhibit varying body lengths and widths (Figure 5).

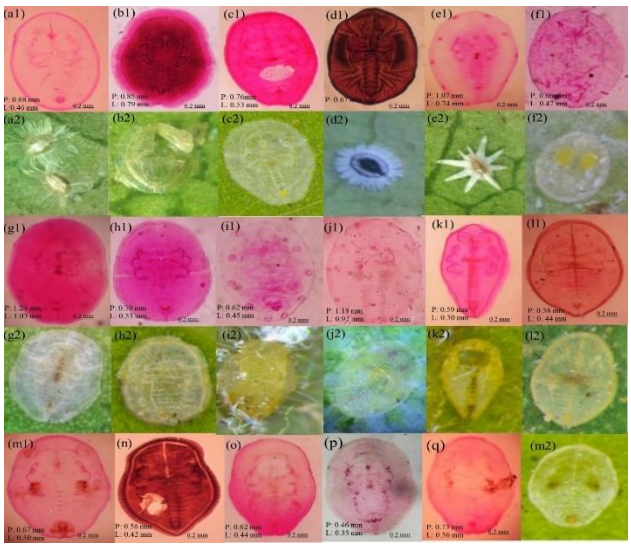

Figure 5. Micrscope slides of *A. antidesmae* (a1); *A. lushanensis* (b1); *Cockerelliella* sp. (c1); *Aleurotrachelus* sp. 1 (d1); Aleyrodinae sp. 4 (e1); *Aleurotrachelus* sp. 2 (f1); *D. kirkaldyi* (g1); *Dialeurodes* sp. (h1); *D. decempuncta* (i2); *Dialeuropora* sp. (j1); *A. psidii* (k1); *Aleuroclava* sp. (l1); *A. jasmini* (m1); *A. aucubae* (n); Aleyrodinae sp. 1 (o); Aleyrodinae sp. 2 (p); Aleyrodinae sp. 3 (q); pupa *A. antidesmae* (a2); eksuvia *A. lushanensis* (b2); pupa *Cockerelliella* sp. (c2); *Aleurotrachelus* sp. 1 (d2); Aleyrodinae sp. 4 (e2); *Aleurotrachelus* sp. 2 (f2); *D. kirkaldyi* (g2); *Dialeurodes* sp. (h2); *D. decempuncta* (i2); *Dialeuropora* sp. (j2); *A. psidii* (k2); *Aleuroclava* sp. (l2); *A. jasmini* (m2); *A. aucubae* (n).

CONCLUSIONS

Mekarsari Fruit Park boasts a diverse population of whiteflies, totaling 20 species in all. Out of these, 17 species were successfully identified, while five remained morphospecies without specific classification. Most whitefly species, precisely 17, were affiliated with the Aleyrodinae subfamily, while the Aleurodicinae subfamily comprised the remaining three. *Paraleyrodes minei* emerged as the predominant whitefly species infesting fruit plants. What is interesting is that seven whitefly species exhibited the ability to infest multiple host plant families, one species preferred two different plants within a single family, and 14 other species were found exclusively on a single type of fruit plant. Notably, the families Euphorbiaceae and Rubiaceae were the most significantly affected by whitefly infestations. This rich diversity and host range of whiteflies within the park underscores the need for further research and management efforts to protect fruit plants in the Euphorbiaceae and Rubiaceae families.

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