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SPECIES, HOST RANGE, AND IDENTIFICATION KEY OF WHITEFLIES OF BOGOR AND SURROUNDING AREA

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ABSTRACT

Species identification, host range, and identification key of whiteflies of Bogor and surrounding area. Whitefly (Hemiptera: Aleyrodidae) is a group of insects that are small, white, soft-bodied, and easily found on various agricultural crops. Whitefly is a phytophagous insect; some species are important pests in agricultural crops that can cause direct damage and can become vectors of viral diseases. The last few years the damage caused by whitefly in Indonesia has increased. Unfortunately, information about their species and host plants in Indonesia, including in Bogor, is still limited. Kalshoven, in his book entitled *Pest of Crops in Indonesia*, published in the 1980s reported that there were 9 species of whitefly in Indonesia. The information on the book should be reconfirmed. Therefore, this study was conducted to determine whitefly species and its host plants in Bogor and its surroundings. Whiteflies is identified based on the 'puparia' (the last instar of the nymph) collected from various agricultural plants, ornamental plants, weeds, and forest plants. A total of 35 species of whiteflies were collected from 74 species and 29 families of plants. The collwcted whiteflies consist of four species belong to Subfamily Aleurodicinae and 31 species of Subfamily Aleyrodinae. The most often found whitefly species were *Aleurodicus dispersus*, *A. dugesii*, and *Bemisia tabaci*. A dichotomous identification key of whiteflies was completed based on morphological character of 35 collected species. The number of whitefly species in Bogor and surrounding areas were far exceeded the number of species reported previously by Kalshoven from all regions in Indonesia.

Key words: Aleyrodicinae, Aleyrodinae, plant pests, vector of plant viruses

ABSTRAK

Spesies, kisaran inang, dan kunci identifikasi kutukebul di Bogor dan sekitarnya. Kutukebul (Hemiptera: Aleyrodidae) merupakan kelompok serangga yang berukuran kecil, berwarna putih, bertubuh lunak, dan mudah ditemukan di berbagai tanaman pertanian. Kutukebul merupakan serangga fitofag, beberapa spesies merupakan hama penting pada tanaman pertanian yang dapat menyebabkan kerusakan langsung dan dapat menjadi vektor penyakit yang disebabkan oleh virus. Beberapa tahun terakhir kerusakan yang diakibatkan oleh kutukebul pada tanaman pertanian di Indonesia mengalami peningkatan. Namun informasi mengenai spesies dan tanaman inang kutukebul di Indonesia, termasuk di Bogor, masih terbatas. Kalshoven, dalam bukunya yang berjudul *Pest of Crops in Indonesia* yang diterbitkan pada tahun 1980an melaporkan terdapat 9 spesies kutukebul di Indonesia. Informasi pada buku tersebut dirasa tidak sesuai dengan kenyataan di lapangan, untuk itu perlu dilakukan penelitian tentang jenis-jenis kutukebul dan tanaman inangnya. Penelitian ini bertujuan untuk mengetahui spesies dan tanamnan inang kutukebul di Bogor dan sekitarnya. Kutukebul diidentifikasi berdasarkan kantung 'pupa' (instar terakhir nimfa) yang dikumpulkan dari berbagai tanaman pertanian, tanaman hias, gulma, dan tumbuhan hutan. Sebanyak 35 spesies kutukebul dikoleksi dari 74 spesies dan 29 famili tanaman. Empat spesies kutukebul yang ditemukan termasuk Subfamili Aleurodicinae dan 31 spesies Subfamili Aleyrodinae. Spesies kutukebul yang paling banyak ditemukan berturut-turut adalah *Aleurodicus dispersus*, *A. dugesii*, dan *Bemisia tabaci*. Kunci identifikasi dikotomi 35 spesies kutukebul yang ditemukan di Bogor dan sekitarnya telah dibuat dan dilengkapi dengan gambar karakter morfologi. Jumlah spesies kutukebul yang ditemukan di Bogor dan sekitarnya jauh melebihi jumlah kutukebul yang dilaporkan oleh Kalshoven dari semua wilayah di Indonesia, yang berimplikasi adanya potensi ancaman hama yang lebih besar oleh kutukebul.

Kata kunci: Aleurodicinae, Aleyrodinae, hama tanaman, vektor virus tumbuhan

INTRODUCTION

Whiteflies (Hemiptera: Aleyrodidae) is a group of small, white, and soft-bodied insects. This insect is called "kutukebul" in Bahasa Indonesia because when flying in groups it looks like smoke ("kebul" in Javanese means smoke). Whiteflies is characterized by a white waxy layer that is released through special glands in the abdomen. Both nymphs and imago usually have a layer of wax with various shapes so that they can be used for identification because the appearance and pattern of wax layers differ among species (Botha *et al*., 2000).

Whitefly is an important group of pests for agricultural crops due to its direct and indirect damage. During feeding period whitefly sucks on plant fluids and injects toxins into plant tissues (Watson, 2007), causing wilting, stunting and even dead of its host plants (Botha *et al*., 2000). The nymphs may also induce physiological disorder of the host plants, such as abnormal ripening time of tomato plants and development of silver leaves on Cucurbitaceae family (Hoddle, 2004). Indirect damage caused by whitefly is related to its role as vectors for some viruses and accumulation of honeydew causing the growth of sooty molds (Francis *et al*., 2016).

Recently, whitefly has become a major pest throughout the world. Although whitefly is considered a tropical insect, many species are found throughout the world, especially in subtropical climates. *Bemisia tabaci* (Genn.) and *Trialeurodes vaporariorum* (Westwood) have been reported as major pests both in greenhouses and in the field in warm temperate regions (Martin *et al*., 2000). Nasrudin & Stocks (2014) have also reported economic losses in Indonesia due to the attack of many species of whitefly.

Kalshoven (1981) reported the diversity of whitefly in his book entitled "The Pest of Crops in Indonesia". According to him, there are at least nine species of whitefly in Indonesia. However, the number of whitefly species in Indonesia should be far exceeds this number. Based on internet searches and literature studies, we found at least 66 species of whiteflies reported from in Indonesia by some authors and this number is believed to increase as research continues on the diversity of these insects. Therefore, it is important to conduct surveys and research in order to update the status of whitefly diversity and distribution in Indonesia. According to Hodges & Evans (2005), research on the diversity of whitefly is essential in order to identify exotic and invasive whitefly, and provide appropriate recommendations for whitefly control. Furthermore, information related to the host's range is also needed as information to support the success of control measures.

The information of whitefly species diversity and its distribution in Bogor, West Java is limited. This research was initiated to study the taxonomy and distribution of whitefly in Bogor and its surrounding area.

MATERIALS AND METHODS

Research Site. Sampling and collection of samples was carried out through randomly collected whiteflies in various agricultural crops, weeds, and forest trees in Bogor, Cianjur, Sukabumi, and Garut from 2008 to 2017. The latitude and altitude of the field was recorded using a GPS (Global Positioning System). 'Puparia' of whiteflies were collected from the field and placed on tubes containing 70% of EtOH and brought to the laboratory for further samples preparation.

Whiteflies samples were subjected to slide mounting using protocol described by Martin (1987). First of all, the puparia were put into test tubes containing 80% EtOH, and heated for 10 min. The puparia were then taken out using a brush and placed into new test tubes containing 10% KOH and reheated until the puparia became transparent. Furthermore, the puparia were transferred into the cyracuse dish and the body content was removed by pressing it slowly; then it washed twice with aquadest. Next step was placing the puparia into 50% EtOH for 10 min, then soaked it in a mixture of fuchsin acid and glacial acetic acid with a ratio of 1 : 1 for 20 to 30 min. The puparia was then destained by soaking in 80% EtOH until the appropriate color was obtained. The puparia were put into carbol xylene for 1 min, absolute EtOH (100%) for 5–10 min, and clove oil for 10 min. The puparia was then placed and arranged at center of the object glass, and Canadian balsam media was dropped over the samples before placing the cover glass. The slide-mounted specimens was dried in the drying element for 3 to 4 weeks. Special treatment was given for dark pigmented puparia before staining stage. After soaking in 95% EtOH for 10 min, the puparia was stabbed at the middle of the body, then soaked in 10% KOH solution for 1 to 2 days.

In some cases, pupal exuvia was collected from the field. Preparation of pupal exuvia specimens was similar from those of puparia specimens, except in the initial stages of slide mounting. The the pupal exuvia was soaked in 95% EtOH for 10 min, then in glacial acetic acid for 10 min. After washing the pupal exuvia with aquadest, it was soaked in carbol xylene for 1 min, then washed again with aquadest. The next stage was

the same as the method of making slide-mounted from puparia.

Morphological-based Identification and Development of Identification Keys. Observation of morphological characters was carried out using a Dyno-Eye digital microscope connected to a PC puggin in a compound microscope Olympus SZ-ST. Identification of the whiteflies using some references and identification keys, including Hodges & Evans (2005), Dooley (2006), Martin (1985), Martin (1987), Martin (1988), Martin *et al*. (2000), and Watson (2007). Photographed of whitefly specimen was taken using 12.1 Megapixel digital camera in order to captured detail morphological characters of whitefly for the purpose of developing taxonomic description.

Dichotomous identification key was developed based on morphological characters. It was first started with observation and recording of morphological characters, followed by making matrix of the morphological character and finally key development using Lucid Phoenix software (LucidCentral.org). The identification key was then tested using sample specimens.

RESULT AND DISCUSSION

Whiteflies were found in several areas in Bogor including Dramaga District, Cileungsi, Jasinga, West Bogor, Ciampea, Cigudeg, Central Bogor, and Cisarua. Environmental conditions seems to be suitable for the development of whitefly and the diversity of host plants in Bogor is quite high. Perring *et al*. (2018) indicated that host plants and temperatures play an important role in biology of whitefly. Furthermore, climate change and rising temperature can induce the development of whitefly population (Marwoto & Inayati, 2011).

The diversity of whitefly in Bogor area is quite high. A total of 35 species of whitefly were found from 74 species belong to 30 family of plants. The whiteflies species found in Bogor and its surrounding areas belong to two Subfamilies, i.e. Aleurodicinae and Aleyrodinae. Based on general morphological characters, the two subfamilies can be distinguished by the presence or absence of compound pores. Whitefly from the Subfamily Aleurodicinae has compound pore on the abdomen (Figure 1) while the Subfamily Aleyrodinae has no pore (Figure 2). Four species of Aluerodicinae and 31 species of Aleyrodinae was found in various hosts, including agricultural crops, ornamental plants, weeds, and forest trees.

1. Subfamily Aleurodicinae

Subfamily Aleurodicinae is one of the three subfamilies of whitefly that have been known so far. The distinctive characteristics of this subfamily are the existence of four compound pores which is a special structure on the whitefly that can release wax (the pore has a variety of shapes) and the tongue-shaped lingula (Figure 1). Watson (2007) described the whiteflies belonging to the Aleurodicinae subfamily as follows: there are wax-producing pores in the subdorsum, 1 pairs at the head (cephalic) and 4 to 6 pairs at the abdomen, large-sized lingula, shape like a tongue, elongated to downward adjacent to the vasiform orifice. At the lingula there are 4 hairs that are clearly visible, sometimes with 2 pairs of reduced hair. In nature, the puparia were often covered with waxy threads. Four species was successfully identified from Bogor and its surrounding area, i.e. *Aleurodicus dispersus, A. dugesii, A. destructor*, and *Paraleyrodes minei*. *A. dispersus* and *A. dugesii* are known to have broader host range compared to the other 2 species (Table 1).

The first species, *A. dispersus* is a common species of whitefly, especially in cassava plants. Both nymph and adult can be found at the same time below the leaf surface. According to some literatures, this species has many hosts range (polyphag). Gniffke (2011) states that besides in cassava plants *A. dispersus* can be found in papaya, chili, banana, hibiscus, and waringin plants in West Java. Furthermore, Nasrudin & Stocks (2014) reported the potency of *A. dispersus* in Indonesia to cause serious economic losses in chili plants. The distinctive characteristics of *A. dispersus* is the circular pattern of eggs on the leaf, so that this species is called "a spiraling whitefly". Immature stadia (first four-instar nymphs) of *A. dispersus* have an oval shaped and the body is covered by wax (Figure 6), while adult have transparent wings.

The second species, *A. dugesii* was found in Indonesia just recently (Hidayat & Watson, 2008). The immature is covered with long wax. Schoeller *et al*. (2018) explained that the wax secreted by the nymph is a defense mechanism from parasites. Like *A. dispersus*, nymph and adult of these whitefly can be found below the surface of the leaf. *A. dugesii* is known as "giant whitefly" because of its large body length. Other characteristic of *A. dugesii* is the white wax that is secreted extends downward, and the adult has a gray pattern on the front wing and is very inactive (Muniappan *et al*., 2009).

Table 1. List of whitefly species Subfamily Aleurodicinae and its host range found in Bogor and its surrounding area

No.	Species	Location	Host range
1	*Aleurodicus destructor*	Bogor	Arecaceae: coconut (*Cocos nucifera*)
2	*Aleurodicus dispersus*	Bogor, Cianjur, Sukabumi, Garut	Arecaceae: coconut (*C. nucifera*), bottle palm (*Hyophorbe lagenicaulis*), Myrtaceae: guava (*Psidium guajava*), water apple (*Syzigium samarangense*), Lamiaceae: wolfflower (*Coleus blumei*), Apocynaceae: frangipani (*Plumeria alba*), Moraceae: banyan tree (*Ficus benjamina*), Solanaceae: cayenne pepper (*Capsicum frutescens*), red chili pepper (*Capsicum annuum*), tomato (*Lycopersicon esculentum*), Caricaceae: papaya (*Carica papaya*), Euphorbiaceae: cassava (*Manihot esculenta*), wild tea (*Acalipha* spp), kastuba (*Euphorbia pulcherima*), Araceae: taro (*Colocasia esculenta*), Fabaceae: winged bean (*Psophocarpus tetragonolobus*), bean (*Phaseolus vulgaris*), butterfly flower (*Bauhinia purpurea*), bengkuang (*Pachyrhizus erosus*), Lauraceae: avocado (*Persea americana*), Malvaceae: cotton tree (*Gossypium arboretum*), hibiscus (*Hibiscus rosa*-sinensis), Musaceae: banana (*Musa paradisiaca*), Orchidaceae: anggrek tanah (*Spathoglottis plicata*), Rutaceae: orange (*Citrus sinensis*), lime (*Citrus amblycarpa*)
3	*Aleurodicus dugesii*	Bogor, Cianjur, Sukabumi, Garut	Lamiaceae: Wolfflower (*C. blumei*), Apocynaceae: frangipani (*Plumeria alba*), Annonaceae: sugar apple (*Annona squamosa*), Arecaceae: coconut (*C. nucifera*), yellow palm (*Dypsis lutescens*), Asteraceae: dahlia (*Dahlia pinnata*), Begoniaceae: Begonia (*Begonia grandis*, *Begonia* sp.), Cannaceae: kana (*Canna indica*), Cucurbitaceae: chayote (*Sechium edule*), Euphorbiaceae: ekor kucing (*Acalypha hispida*, *Acalypha wilkesiana*), Lauraceae: avocado (*Persea americana*), Malvaceae: hibiscus (*Hibiscus rosa-sinensis*), Moraceae: murbei (*Morus alba*), jackfruit (*Artocarpus heterophyllus*), Musaceae: ornamental banana (*Heliconia colisiana*), banana (*M. paradisiaca*), Myrtaceae: dewandaru (*Eugenia uniflora*), Caricaceae: papaya (*C. papaya*), Fabaceae: bengkuang (*P. erosus*), butterfly flower (*B. purpurea*), Rutaceae: orange (*C. sinensis*), Solanaceae: cayenne pepper (*C. frutescens*).
4	*Paraleyrodes minei*	Bogor, Cianjur, Sukabumi	Arecaceae: coconut (*C. nucifera*), palm oil (*Elaeis guineensis*), palem putri (*Veitchia marilii*), palem ekor ikan (*Caryota urens*), palem phoenix (*Phoenix roebelenii*), Lauraceae: Avocado (*Persea americana*), Myrtaceae: water apple (*S. samarangense*), Rutaceae: lime (*Citrus aurantifolia*), pamelo (*Citrus maxima*)

A. dugesii is known as a polyphagous whitefly with a very broad host range including ornamental plants such as hibiscus, lotus, begonias, orchids; fruit crops such as avocados, oranges, bananas, guava, soursop; vegetables crops from the families Solanaceae, Brassicaceae, Cucurbitaceae; and also various types of weeds (Setiawati *et al*., 2016). During our survey in Bogor, *A. dugesii* was found in Lamiaceae, Apocynaceae, Annonaceae, Asteraceae, Arecaceae, Begoniaceae, Myrtaceae, Apocynaceae, Moraceae, Solanaceae, Caricaceae, Euphorbiaceae, Fabaceae, Lauraceae, Malvaceae, Musaceae, Rutaceae, Cannaceae, and Cucurbitaceae (Table 1).

The third species, *A. destructor* has a unique morphological characters i.e. white thick-wax at median dorsal and a thinner wax at margin of its body that looks like a lump. *A. destructor* is known as "coconut whitefly", because it commonly attacks coconut plants. The fourth, *P. minei* was discovered very recently in Indonesia (Nurulalia, 2012). *P. minei* has yellow to transparent pupa and 6 pairs of compound pores with 2 pairs sizes reduced at the anterior part (Figure 5).

2. Subfamily Aleyrodinae

There were 31 species of Aleyrodinae were identified in Bogor and its surrounding areas (Table 2). Some species of Aleyrodinae has a distinctive shaped of puparium. *Aleuroclava aucubae* has pear shaped (Figure 23); the pupa of Genera *Aleurocanthus* has a lot of spines such as in *Aleurocanthus citriperdus* (Fig 11); puparium of *Minutaleyrodes minuta* has a flower-like shaped (Figure 31).

Adult (imago) of Aleyrodinae was very difficult to find, generally only premature (pupa or puparium) are found below the leaf surface. In this subfamily, it is common to find mixed populations, i.e. more than one species on the leaves of the host plant. For example, a mixed population of *Aleuroclava psidii*, *Dialeurodes kirkaldyi*, *Asialeyrodes* sp., *Dialeuropora decempuncta* can be found in rambutan leaves. Mixed populations were also found in citrus plants, namely *Aleurocanthus citriperdus* with *Paraleyrodes minei* or *Paraleyrodes minei* with *Aleurocanthus dispersus*.

One species of Aleyrodinae that is commonly found and known as a pest is *Bemisia tabaci*. *B. tabaci* is a very important pest because it also becomes a vector of viral diseases. According to Hasyim *et al.* (2016) *B. tabaci* is commonly found in eggplant plants showing yellow symptoms in several areas in West Java (Bogor and Bandung), Central Java (Pati and Blora), and the Special Region of Yogyakarta (Bantul). Furthermore, *B. tabaci* was reported to cause a decrease in the quality and production of tomato plants and at the same transmitted *Tomato yellow leaf curl virus* (TYLCV) (Fang *et al*., 2013). In Bogor, *B. tabaci* was found on

Table 2. Whitefly species of the Subfamily Aleyrodinae and its host range found in Bogor and its surrounding area

No.	Species	Location	Host range
1	*Aleuroclava psidii*	Bogor	Myrtaceae: guava (*P. guajava*), water apple (*S. samarangense*), Sapindaceae: rambutan (*Nephellium lappaceum*).
2	*Aleuroclava jasmini*	Bogor	Myrtaceae: bay-leaf (*Syzygium polyanthum*), Oleaceae: jasmine (*Jasminum sambac*), Sapindaceae: rambutan (*Nephellium lappaceum*)
3	*Aleuroclava canangae*	Bogor	Arecaceae: salak (*Salacca zalacca*), Myrtaceae: guava (*P. guajava*)
4	*Aleuroclava aucubae*	Bogor, Sukabumi	Myrtaceae: Rose apple (*Syzigium malaccense*)
5	*Aleurocanthus woglumi*	Bogor	Arecaceae: coconut (*C. nucifera*), palm oil (*E. guineensis*), palem putri (*V. marilii*), areca nut (*Areca catechu*), palem phoenix (*P. roebelenii*), Rutaceae: orange (*Citrus sinensis*)
6	*Aleurocanthus spiniferus*	Bogor, Cianjur	Arecaceae: coconut (*C. nucifera*), palm oil (*E. guineensis*), areca nut (*A. catechu*), Moraceae: jackfruit (*Artocarpus heterophyllus*), banyan tree (*F. benjamina*), Myrtaceae: guava (*P. guajava*), Rutaceae: orange (*Citrus sinensis*)

Table 2. Continued

No.	Species	Location	Host range
7	*Aleurocanthus cocois*	Bogor	Arecaceae: coconut (*C. nucifera*), palem putri (*V. marilii*)
8	*Aleurocanthus citriperdus*	Bogor, Cianjur	Rutaceae: Lime (*Citrus aurantifolia*), pamelo (*Citrus maxima*)
9	*Aleurotrachelus atratus*	Bogor	Arecaceae: palm oil (*E. guineensis*), palem putri (*V. marilii*), yellow palm (*D. lutescens*), palem manila (*Adonidia merrillii*), squirrel palm (*Wodyetia bifurcate*), japanese palm (*Ptychosperma macarthurii*)
10	*Aleurotrachelus annonae*	Bogor	Arecaceae: Areca nut (*A. catechu*), coconut (*C. nucifera*), yellow palm (*D. lutescens*)
11	*Aleurotrachelus caerulescens*	Bogor	Aracaceae: Coconut (*Cocos nucifera*)
12	*Aleurotrachelus tracheifer*	Bogor	Fabaceae: winged bean (*Psophocarpus tetragonolobus*)
13	*Cockeriella psidii*	Bogor, Sukabumi	Myrtaceae: Guava (*P. guajava*), bay-leaf (*S. polyanthum*)
14	*Cockeriella quaintacei*	Bogor	Arecaceae: Red palm (*Cyrtostachys renda*)
15	*Cockeriella meghaleyensis*	Bogor	Arecaceae: Coconut (*Cocos nucifera*), palm oil (*E. guineensis*), yellow palm (*Dypsis lutescens*)
16	*Dialeurolobus* sp.	Bogor	Malvaceae: Hibiscus (*Hibiscus rosa-sinensis*), Fabaceae: dadap bong (*Erythrina microcarpa*)
17	*Dialeurodes kirkaldyi*	Bogor	Oleaceae: Jasmine (*Jasminum sambac*), Rubiaceae: morinda fruit (*Morinda citrifolia*), Convolvulaceae: *Ipomoea triloba*
18	*Bemisia tabaci*	Bogor, Cianjur, Garut	Cucurbitaceae: Cucumber (*Cucumis sativus*), pumpkin (*Cucurbita spp.*), Euphorbiaceae: cassava (*Manihot esculenta*), Fabaceae: long beans (*Vigna unguiculata*), kedelai (*Glycine max*), winged bean (*Psophocarpus tetragonolobus*), dadap bong (*E. microcarpa*), peanuts (*Arhachis hypogea* L), bean (*P. vulgaris*), Solanaceae: eggplant (*Solanum melongena*), red chili pepper (*C. annuum*), cayenne pepper (*C. frutescens*), tomato (*Lycopersicon esculentum*), Malvaceae: hibiscus (Hibiscus rosa-sinensis), Graminae: *Setaria palmivora*, Musaceae: banana (*M. paradisiaca*), Araceae: taro (*C. esculenta*)
19	*Asialeyrodes* sp.	Bogor	Magnoliaceae: Green cempaka (*Michelia cliampaca*), Myrtaceae: water apple (*S. samarangense*)
20	*Aleurothrixus antidesmae*	Bogor	Gnetaceae: Melinjo (*Gnetum gnemon*), Lauraceae: avocado (*Persea americana*), Rubiaceae: asoka flower (*Ixora coccinea*), Sapindaceae: rambutan (*N. lappaceum*), Annonaceae: kenanga (*Canangium odoratum*)
21	*Aleurotuberculatus neolitseae*	Bogor	Myristicaceae: Nutmeg (*Myristica fragrans*), Moraceae: jackfruit (*Artocarpus heterophyllus*)

Table 2. Continued

No.	Species	Location	Host range
22	*Aleuroputeus perseae*	Bogor	Bignoniaceae: Kecrutan (*Spathodea campanulata*)
23	*Dialeuropora decempuncta*	Bogor, Cianjur, Garut	Anacardiaceae: Manggo (*Mangifera indica*), Lauraceae: avocado (*Persea americana*), Moraceae: jackfruit (*Artocarpus heterophyllus*), Myrtaceae: guava (*P. guajava*), Sapindaceae: rambutan (*N. lappaceum*), Musaceae: banana (*M. paradisiaca*)
24	*Lipaleyrodes* sp.	Bogor	Euphorbiaceae: Meniran (*Phyllanthus niruri*), katuk (*Sauropus androgynus*)
25	*Minutaleyrodes minuta*	Bogor	Myrtaceae: Rose apple (*S. malaccense*), Rubiaceae: asoka flower (*Ixora coccinea*), Verbenaceae: hardwood tree (*Tectona grandis*)
26	*Orchamoplatis mammaeferus*	Bogor	Euphorbiaceae: Croton (*Codiaeum variegatum*)
27	*Parabemisia* sp.	Bogor	Moraceae: Jackfruit (*Artocarpus heterophyllus*)
28	*Setaleyrodes* sp.	Bogor	Rubiaceae: morinda fruit (*M. citrifolia*)
29	*Trialeurodes vaporariorum*	Bogor, Cianjur, Garut	Fabaceae: Long beans (*Vigna unguiculata sesquivedali*), Solanaceae: eggplant (*Solanum melongena*), tomato (*Lycopersicon esculentum*), Musaceae: banana (*Musa paradisiaca*)
30	*Aleurolobus marlatti*	Bogor	Arecaceae: palem phoenix (*P. robelenii*), palm oil (*E. guineensis*), yellow palm (*D. lutescens*), Musaceae: Banana (*Musa paradisiaca*)
31	*Rusostigma* sp.	Bogor, Cianjur, Sukabumi	Anacardiaceae: Manggo (*Mangifera indica*), Myrtaceae: water apple (*S. samarangense*), rose apple (*S. malaccense*), bay-leaf (*S. polyanthum*), Rubiaceae: morinda fruit (*M. citrifolia*)

Identification key of collected whiteflies in Bogor and its surrounding area

1a Puparium with 4 to 6 pairs abdominal compound pores in subdorsal, large-sized lingula shaped like tongue and 1-2 pairs of setae at the tip (Figure 1), nymph and pupa secreted white wax that covered the surface of body …… **Subfamili Aleurodicinae (2)**

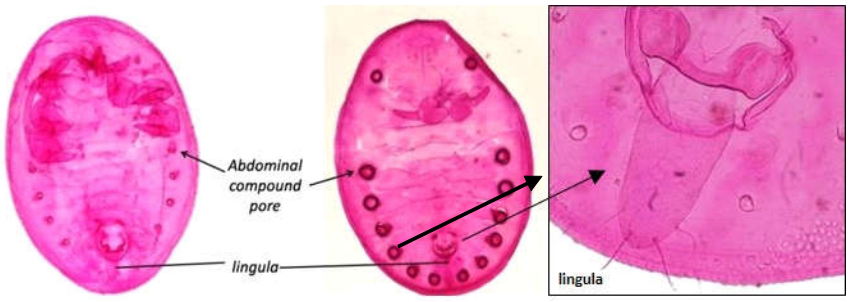

Figure 1

1b Puparium without abdominal compound pores in subdorsal and 5 pairs pores simple (if any) (Figure 2), various shape and size of lingula, color of pupa has variation, nymph and pupa does not secreted or slightly wax on the surface of body..... **Subfamili Aleyrodinae (5)**

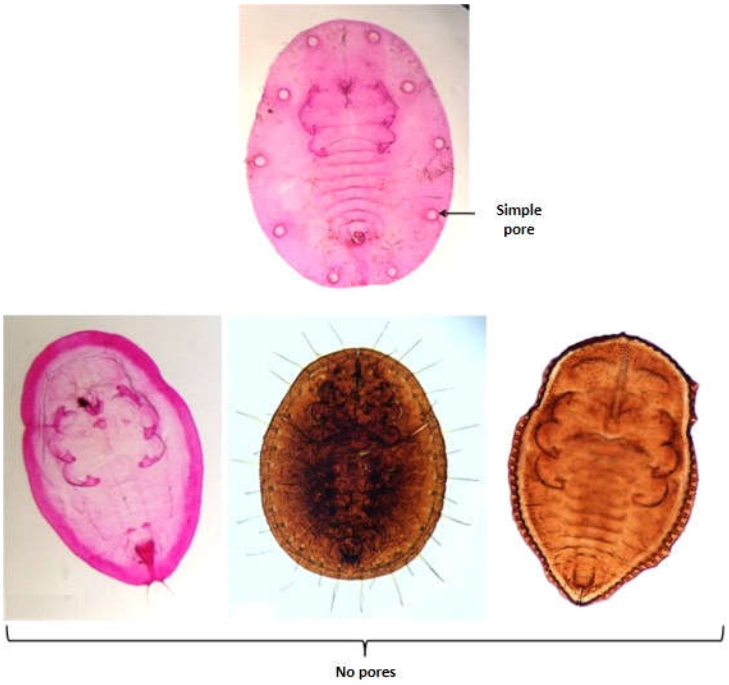

Figure 2

2a With 6 pairs abdominal compound pores that size are same and big, one setae at lingula (Figure 3), commonly found on coconut trees …… ***Aleuroctarthrus destructor***

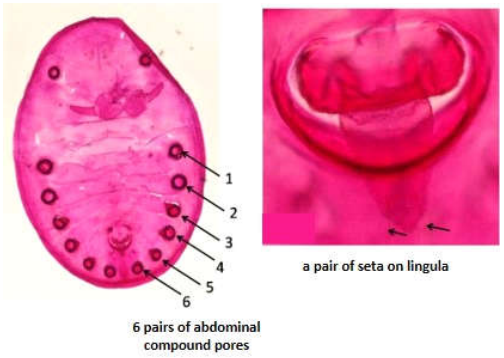

Figure 3

2b With 4 to 6 pairs abdominal compound pores that have same size. Two pairs setae at the tip of lingula (Figure 4) **3**

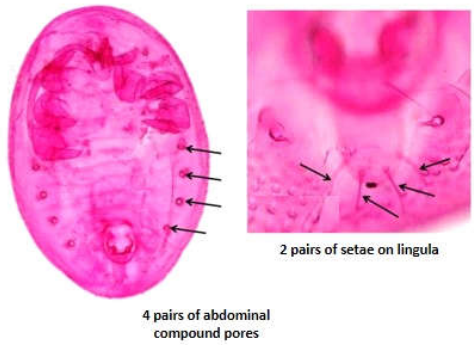

Figure 4

3a 6 pairs abdominal compound pores present with splines shaped on the median area , 2 pairs abdominal compound pores at anterior that the size reduced, discal pore among abdominal compound pores segment VIII and vasiform orifice (Figure 5), female adult secreted wax like a nest shaped ..... ***Paraleyrodes minei***

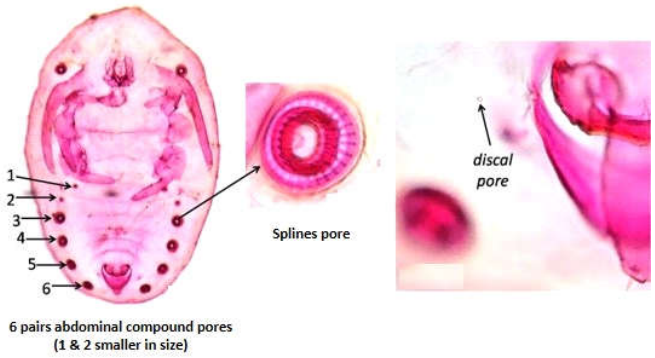

Figure 5

3b 4-6 pairs abdominal compound pores, lots of small pores in subdorsal, very wide host range (polyphagous) **4**

4a 4 pairs abdominal compound pores at segment III-VI that have same size (Figure 6), pattern of wax like a tail at posterior……..…….... ***Aleurodicus dispersus***

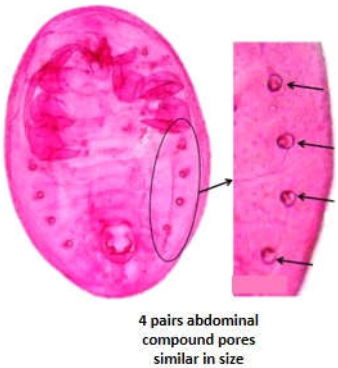

Figure 6

4b With 6 pairs abdominal compound pores on segment III-VIII, abdominal compound pores segment III-VI have same size, while segment VII and VIII reduced (Figure 7), many of wax and elongated like a beard ..... ***Aleurodicus dugesii***

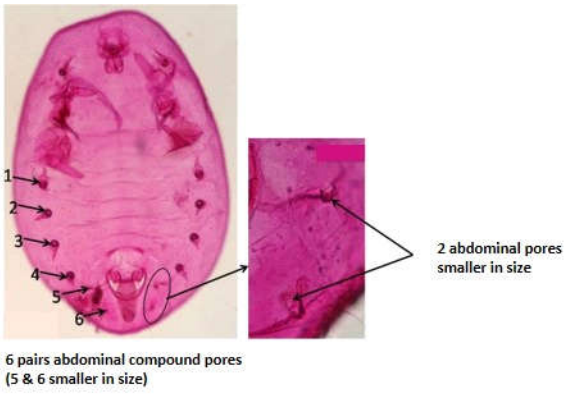

Figure 7

5a Spines with acute pointed at subdorsal, pupal usually dark (Figure 8) or pale until slightly blackness.....**6**

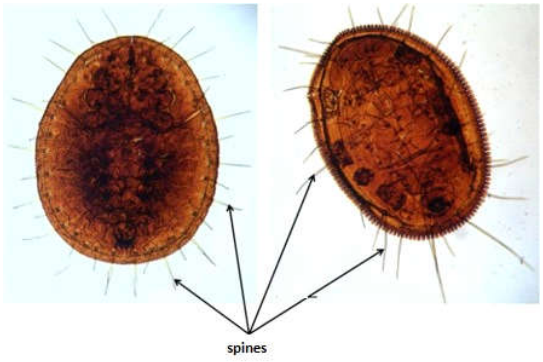

Figure 8

5b Spines at subdorsal absent, pupal color pale or dark.....**9**

6a 11 pairs spines at subdorsal…….…….....…….....…….....…….....…….. **7**

6b More than 11 pairs of spines at subdorsal…….....…….....…….....…….....…. 8

7a 11 pairs acute spines at subdorsal that have same size (Figure 9), found on citrus leaves, guava, and jack fruit…….....…… ***Aleurocanthus spiniferus***

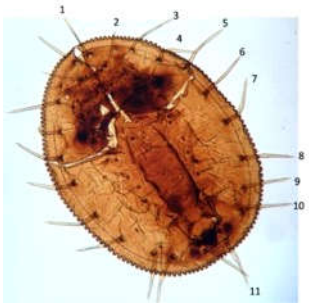

Figure 9

7b 11 pairs acute spines at subdorsal, one pairs at posterior has longer size than others and like a tail (Figure 10), commonly found on citrus leaves…..…. ***Aleurocanthus woglumi***

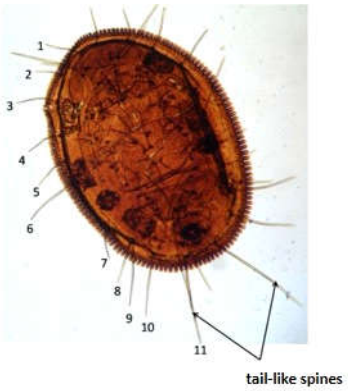

Figure 10

8a 16 pairs acute spines at subdorsal that have same size (Figure 11), commonly found on citrus leaves..... ***Aleurocanthus citriperdus***

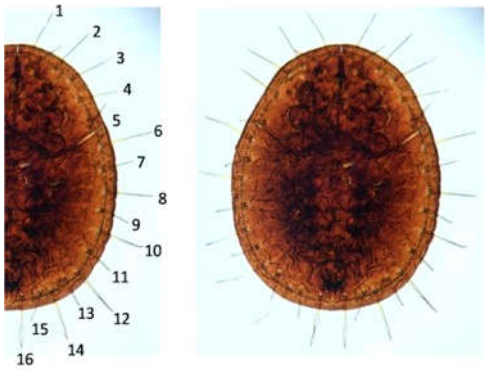

Figure 11

8b 30 to 36 pairs acute spines at subdorsal (Figure 12) ……..... ***Aleurocanthus cocois***

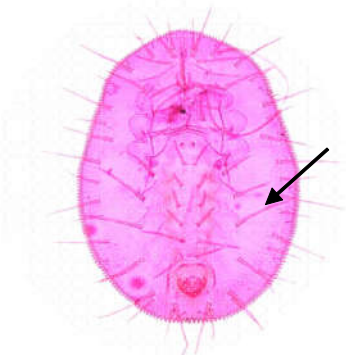

Figure 12

9a Rachis (indentation pattern) at subdorsal abdomen (Figure 13), pupa color pale or dark..... **10**

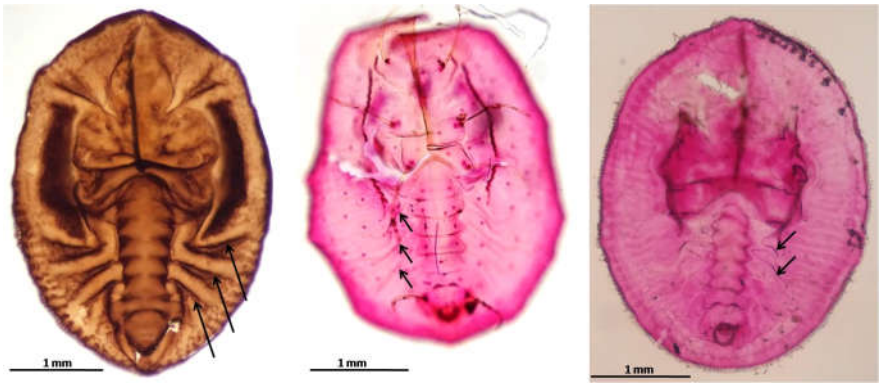

Figure 13

9b Rachis at dorsal abdomen absent……..…….…...……..…….. **14**

10a Longitudinal stripe at subdorsal elongated from cephalothorax to anterior abdomen (Figure 14) **11**

Figure 14

10b Dark puparium, rachis pattern at abdomen, the eyespot like comma shaped with brighter color at anterior subdorsal present, margin dentate (like 3 teeth pattern) at posterior, triangular vasiform orifice (Figure 15) …..……..…… ***Aleurolobus marlatti***

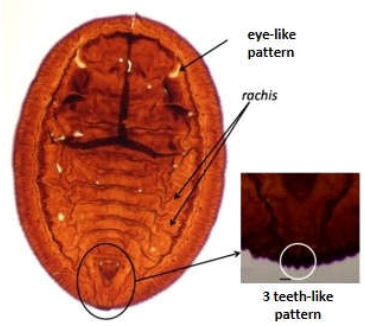

Figure 15

11a Process of thickening or pigmenting at subdorsal pupa present..... **12**

11b Without thickening and pigmenting process at subdorsal pupa…….....…….**13**

12a Process of thickening or pigmenting at molting suture present (Figure 16) ……..…..***Aleurotrachelus caerulescens***

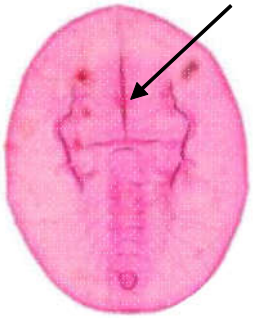

Figure 16

12b *Rhachis* at subdorsal very thick (Figure 17)..... ***Aleurotrachelus tracheifer***

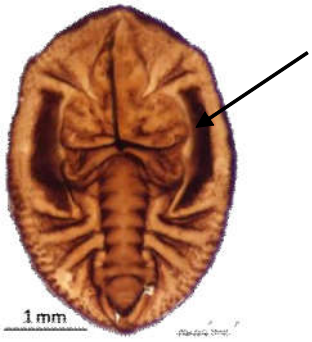

Figure 17

13a 3 pairs spines at the margin of dorsal (Figure 18)……..……***Aleurotrachelus annonae***

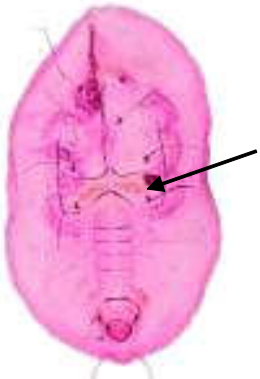

Figure 18

13b Spines at the margin of dorsal absent, irregular margin..... ***Aleurotrachelus atratus***

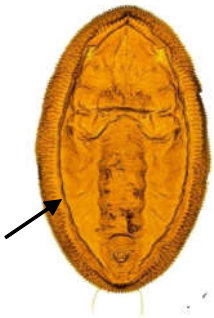

Figure 19

14a 5 pairs pores at subdorsal (Figure 20), 12 pairs sub marginal setae and one pairs lanceolate cephal thorax (if visible), pupa secreted shine blue wax ..... ***Dialeuropora decempuncta***

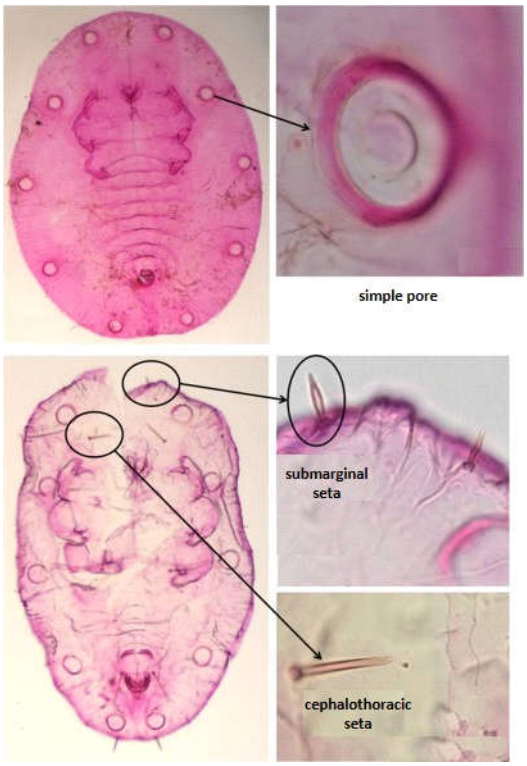

Figure 20

14b Do not have the characteristics as mentioned above ……..…….....……**15**

15a Dentate sub marginal row, some species with papillae at subdorsal (Figure 21) .....……**16**

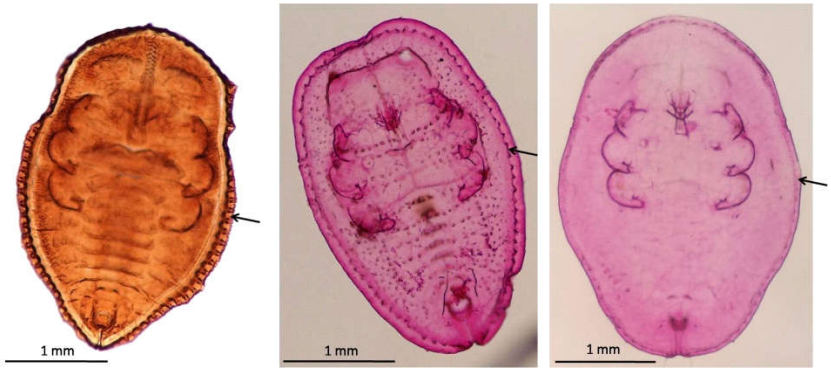

Figure 21

15b Do not have the characteristics as mentioned above …….....……... **20**

16a One pairs of round shape tubercles at metathorax (Figure 22), pupa color pale…..... **17**

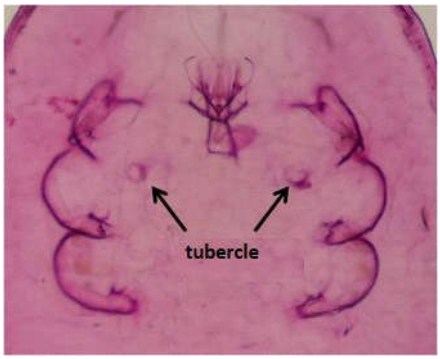

Figure 22

16b Tubercle at mesothorax absent, pupa color dark or pale…….....…….**18**

17a Papillae at subdorsal area absent, dentate sub margin (Figure 23) ……..…….....……..…. ***Aleuroclava aucubae***

Figure 23

17b Papillae at subdorsal area, the color of sub margin area more transparent that others part of pupa, dentate sub margin and margin of pupa…….....….***Aleurotuberculatus neolitseae***

18a "T"shaped at cephalothorax, tubercles along median abdomen (Figure 24), yellow to transparent pupa with pigmentation at cephalothorax, median abdomen, and vasiform orifice ..... ***Aleuroclava psidii***

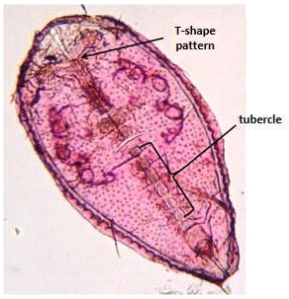

Figure 24

18b Without "T"shaped at cephalothorax, one pairs of setae at cephalothorax and 3rd legs (if any), papillae rows at subdorsal **19**

19a Setae at cephalothorax and 3rd legs usually consist of one segment (if any) (Figure 25), widen shaped at median (from mesothorax to abdomen segment 5), cephalothoracic fold not clear, usually found on jasmine..... ***Aleuroclava jasmini***

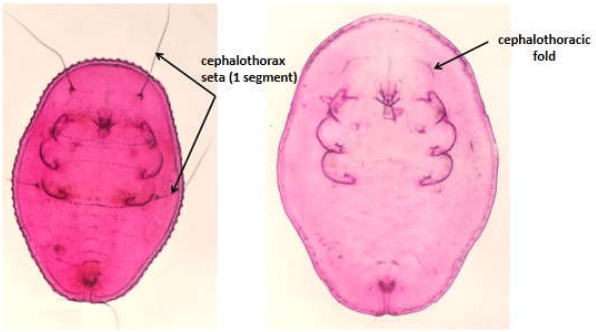

Figure 25

19b Setae at cephalothorax and 3rd legs (if any) usually consist of two segment, body oval, cephalothoracic fold clear (Figure 26), usually found on guava….....***Aleuroclava canangae***

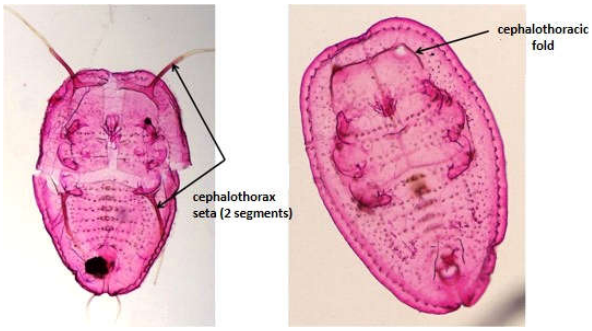

Figure 26

20a Oval to round shaped pupa, fold that separate sub margin area with dorsal disc present, longitudinal and transversal molting suture allied with cephalothoracic suture, concentric with margin and easy to molted when the adult emerged from pupa (Figure 27) …….....….***Cockerelliella* (21)**

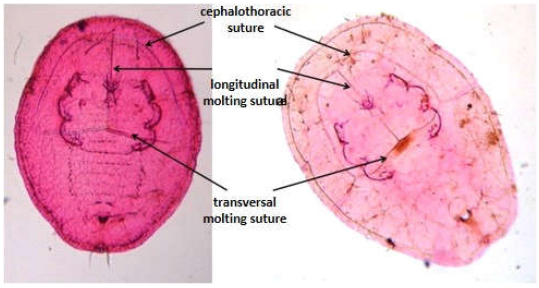

Figure 27

20b Fold that separate sub margin area with dorsal disc absent…….....……**23**

21a Oval pupa, papillae at subdorsal, sub marginal suture clear..... **22**

21b Pupa covered with granules, sub marginal suture absent (Figure 28) ……..…….....……..***Cockeriella quaintacei***

Figure 28

22a Papillae rows at subdorsal present, cephalothoracic suture with transversal moulting suture are separated (Figure 29) ..... ***Cockerelliella psidii***

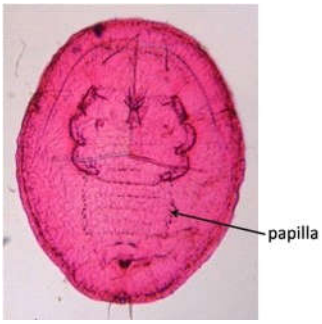

Figure 29

22b Papillae arranged at abdomen, cephalothoracic suture with transversal moulting suture are separated (Figure 30) ……..……..…….. ***Cockerelliella meghaleyensis***

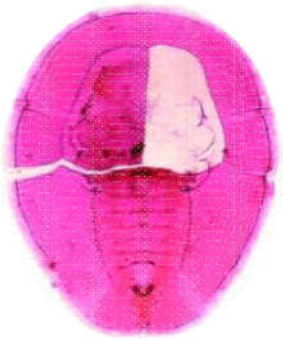

Figure 30

23a Small-round shaped pupa….……..…… **24**

23b Medium to large-oval shaped pupa..... **25**

24a Widen area of pupa present (from metathoracic to abdomen segment 2) (Figure 31) ..... ***Minutaleyrodes minuta***

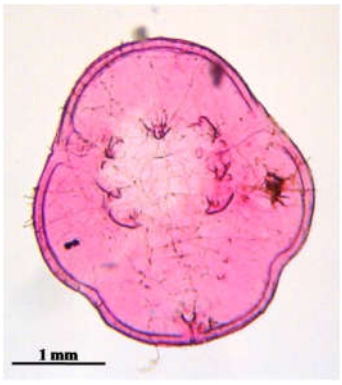

Figure 31

24b Round-shaped pupa (relative), fold at the margin of pupa present (Figure 32) ……..……*Asialeyrodes* **sp.**

Figure 32

25a Dentate margin, 1 to 2 pairs setae at abdomen…….…….. **26**

25b Setae at abdomen absent ..…….....……..……...… **27**

26a Dentate margin, 2 pairs setae at median anterior abdomen (Figure 33) ……..... *Asiothrixus antidesmae*

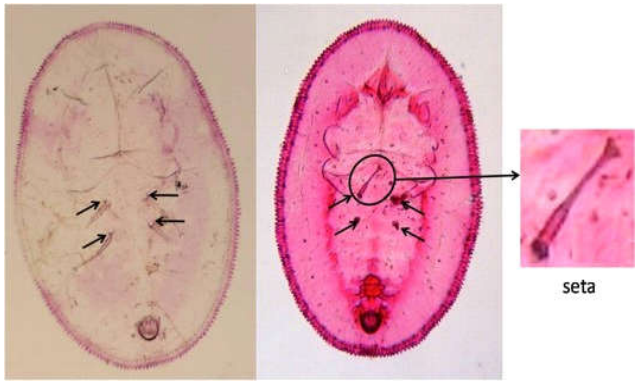

Figure 33

26b Trachea pores like comb-shaped, one row tooth-shaped of glands present, one pairs setae at abdomen segment 1 (Figure 34) ……..……. ***Orchamoplatus mammaeferus***

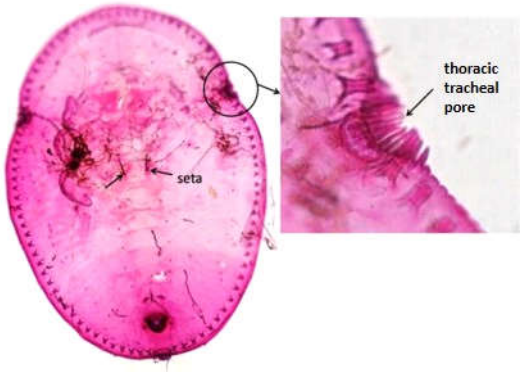

Figure 34

27a Granules at subdorsal disc present, reticulation at tracheal cleft and at caudal furrow area present, large-round-shaped pupa (Figure 35)……..…… ***Rusostigma* sp.**

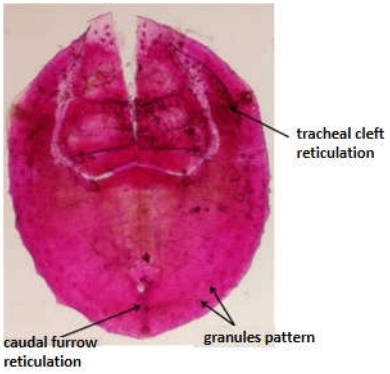

Figure 35

27b Do not have the characteristics as mentioned above …….....……..……**28**

28a Papillae rows at sub marginal present (Figure 36), papillae that found on the leaf which have lot of cuticula bigger than papillae at sub margin, the short setae found at each base of mid and back legs.....***Trialeurodes vaporariorum***

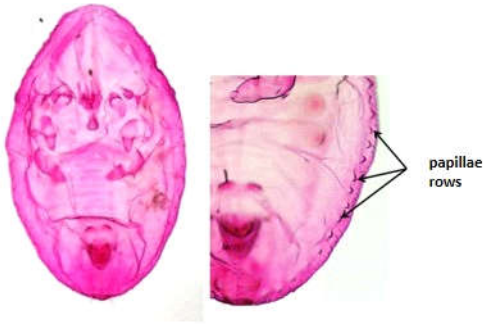

Figure 36

28b Papillae rows at sub margin absent, do not have the characteristics as mentioned above..... **29**

29a Oval pupa, vasiform orifice longer than caudal furrow ...……..….**30**

29b Do not have the characteristics as mentioned above..... **31**

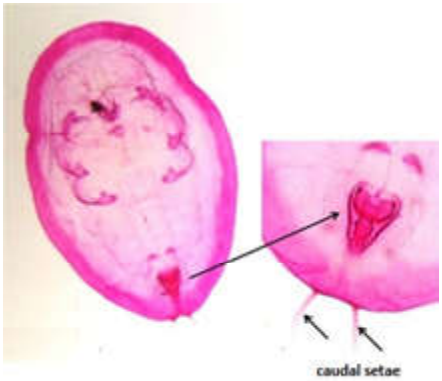

Figure 37

30b Without setae cauda and trachea pores, vasiform orifice like half-moon shaped, smooth margin (Figure 38)…….....…….***Parabemisia* sp.**

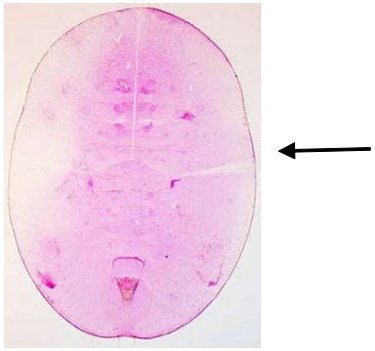

Figure 38

31a Brown to black of median line at puparium (from mouth until abdomen segment-1, setae abdomen segment 8 at the widest area of vasiform orifice) (Figure 39)..... ***Dialeurodes kirkaldyi***

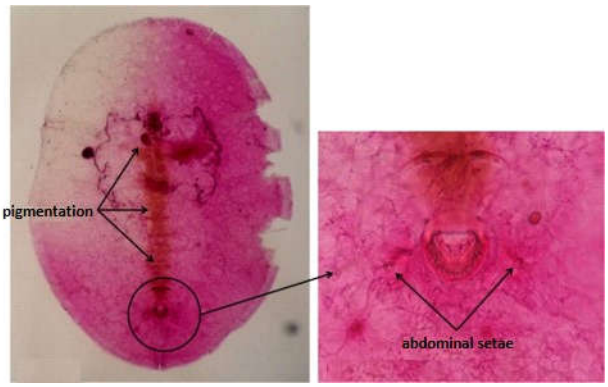

Figure 39

31b Do not have the characteristics as mentioned above..... **32**

32a Oval pupa, one pairs tubercles on median thoracic area ..…….....…..…..……...**33**

32b Tubercle at median abdomen area present, tubercles at thorax are not set (if any) **34**

33a Tubercle very clear, sub marginal furrow present, slightly dentate margin (Figure 40) ……..…… ***Dialeurolobus* sp.**

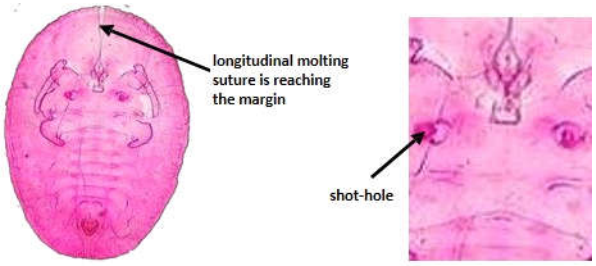

Figure 40

33b Tubercle not clear, layer of wax at sub margin area present, dentate sub margin (Figure 41)……..…….....…….…..*Lipaleyrodes* **sp.**

Figure 41

34a Tubercle at abdomen segment 1 to3 and fold of thorac to abdomen segment 8 at submedian present, without setae (Figure 42) .....*Aleuroputeus perseae*

Figure 42

34b Tubercles on median area at all segment of thorax and abdomen present, setae only found at anterior and posterior of puparia (Figure 43) ……..…….....…….***Setaleyrodes* sp.**

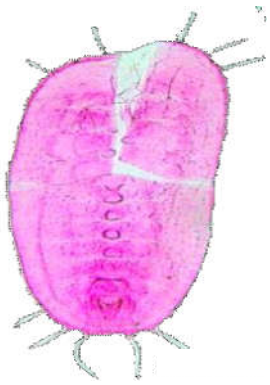

Figure 43

Cucurbitaceae, Euphorbiaceae, Fabaceae, Solanaceae, Malvaceae, Musaceae, dan Araceae (Table 2). Morphology characteristics of *B. tabaci* include triangular *vasiform orifice* of the puparium and the presence of setae cauda at posterior (Figure 37).

CONCLUSION

Whitefly species found in Bogor region belongs to the subfamily Aleurodicinae (4 species) and subfamily Aleyrodinae (31 species). The most common species are *Aleurodicus dispersus*, *A. dugesii* and *Bemisia tabaci*. A dicotomous identification key of 35 whitefly species has been successfully constructed based on morphological characters. The number of whitefly species found in Bogor and surrounding areas outnumbered the species previously reported by Kalshoven in all regions of Indonesia. This fact may have implications on the greater threat of pests in cultivated plants.

AKCNOWLEDGMENTS

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REFERENCES

Botha J, Hardie D, & Power G. 2000. *Spiraling Whitefly* Aleurodicus dispersus*: Exotic Threat to Western Australia*. Fact Sheet.

Dooley J. 2006. *Key to Commonly Intercepted Whitefly Pest*. http://keys.lucidcentral.org/keys/v3/whitefly/Old INTODUCTION%20TO%20THE%20ALEYRODIDAE.htm. Accessed on 20th July 2017.

Fang Y, Jiao X, Xie W, Wang S, Wu Q, Shi X, Chen G, Su Q, Yang X, Pan H, & Zhang Y. 2013. Tomato yellow leaf curl virus alters the host preferences of its vector *Bemisia tabaci*. *Sci. Rep*. 3: 2876.

Francis AW, Stocks I, Smith TR, Boughton AJ, Mannion CM, & Osborne LS. 2016. Host plants and natural enemies of rugose spiraling whitefly (Hemiptera: Aleyrodidae) in Florida. *Fla. Entomol*. 99(1): 150–153.

Gniffke PA. 2011. Integrated Disease Management (IDM) for anthracnose, Phytophthora blight and whitefly-transmitted geminivirus in chilli pepper in Indonesia. Final Report No. FR2011-22, Australian Centre for International Agricultural Research (ACIAR). Canberra, Australia.

Hasyim A, Setiawati W, & L Liferdi. 2016. Kutu kebul *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae) penyebar penyakit virus mosaik kuning pada tanaman terung. *Iptek Hortikultura.* 12: 50–54.

Hidayat P & Watson GW. 2008. Recognition of giant whitefy, *Aleurodicus dugesii* cockerell (Hemiptera: Aleyrodidae), a potential pest newly introduced to Indonesia. Poster. *Seminar Nasional V, Perhimpunan Entomologi Indonesia, Cabang Bogor.* LIPI Cibinong, Bogor. March 18–19, 2008.

Hoddle MS. 2004. The biology and management of silverleaf whitefly, *Bemisia argentifolii* Bellows and Perring (Homoptera: Aleyrodidae) on greenhouse grown ornamentals. http://www.biocontrol.ucr.edu/bemisia.html#biology. Accessed on 17th May 2018.

Hodges GS & Evans GA. 2005. An identification guide to whiteflies (Hemiptera: Aleyrodidae) of the southeastern united states. *Fla. Entomol.* 88(4): 518–534.

Kalshoven LGE. 1981. *The Pests of Crops in Indonesia*. Jakarta: Ichtiar Baru-van Hoeven.

Martin JH. 1985. The whitefly of New Guinea (Homoptera: Aleyrodidae). *Bull. Br. Mus. Nat. Hist.* (*Ent.*) 50(3): 303–351.

Martin JH. 1987. An identification guide to common whitefly pest species of the world (Homoptera: Aleyrodidae). *Trop. Pest Manage*. 33(4): 298–322.

Martin JH. 1988. Whitefly of Northern Sulawesi, including new species from clove and avocado (Homoptera: Aleyrodidae). *Indo-Malayan Zool*. 5: 57–85.

Martin JH, Mifsud D, & Rapisarda C. 2000. The whiteflies (Hemiptera: Aleyrodidae) of Europe and the Mediterranean Basin. *Bull. Entomol. Res.* 90(5): 407–448.

Marwoto & Inayati A. 2011. Kutu kebul: hama kedelai yang pengendaliannya kurang mendapat perhatian. *Iptek Tanaman Pangan.* 6(1): 87–98.

Muniappan R, Shepard BM, Watson GW, Carner GR, Rauf A, Sartiami D, Hidayat P, Afun JVK, Goergen G, & Rahman AKMZ. 2009. New records of invasive insects (Hemiptera: Sternorrhyncha) in Southeast Asia and West Africa. *J. Agric. Urban Entomol*. 26(4): 167–174.

Nasrudin A & Stocks IC. 2014. First report of economic injury due to the spiraling whitefly (Hemiptera: Aleyrodidae) on pepper in Indonesia. *Fla. Entomol*. 97(3): 1255–1259.

Nurulalia L. 2012. Keanekaragaman spesies dan kunci identifikasi kutukebul (Hemiptera: Aleyrodidae) pada tanaman pertanian di Jawa Barat. *Tesis*. Institut Pertanian Bogor. Bogor.

Perring TM, Stansly PA, Liu TX, Smith HA, & Andreason SA. 2018. Whiteflies: biology, ecology, and management. In: Wakil W, Brust GE, & Perring TM (Eds). *Sustainable Management of Arthropod Pests of Tomato*. pp. 73–110. Academic Press.

Schoeller EN, Yassin M, & Redak RA. 2018. Host-produced wax affects the searching behavior and efficacy of parasitoids of the giant whitefly *Aleurodicus dugesii* (Hemiptera: Aleyrodidae). *Biol. Control.* 121: 74–79.

Setiawati W, Hasyim A, & Hudayya A. 2016. Waspadai invasi kutu kebul raksasa (giant whitefly) *Aleurodicus dugesii* Cockerell (Homoptera: Aleyrodidae) pada tanaman sayuran. *Iptek Hortikultura*. 12: 40–45.

Watson GW. 2007. Identification of whiteflies (Hemiptera: Aleyrodidae*). APEC Re-entry Workshop on Whiteflies and Mealybugs in Malaysia.* 16th to 26th April 2007.