



Notes on the Citrus Rust Mite, *Phyllocoptura oleivora* (Ashmead), as a Major Pest of Citrus in Indonesia

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ABSTRACT

Most citrus farmers in Indonesia believed that rust on citrus fruits resulted from insect attacks. This research aims to determine the cause of rust on citrus fruit and its damage intensity. The study was carried out in commercial citrus plantations in three provinces, on *Citrus sinensis* and *C. reticulata* plantations in East Java, *C. reticulata* and *C. suhuensis* in West Kalimantan and *C. suhuensis* in North Sumatra. An additional observation was also conducted to collect mite specimens on citrus plantations in Malang, East Java. Scanning Electron Microscope (SEM) and light microscope were used to observe and identify each collected sample. Results showed that the cause of rust-colored citrus fruit in three provinces is the citrus rust mite, *Phyllocoptura oleivora* (Ashmead). It belongs to the family Eriophyidae with two pairs of legs with regular segmentation, five-rayed featherclaws, and a net pattern on prodorsum. The specific damage produced by this mite is rust-colored symptoms. Damage intensity of citrus rust mite in tree provinces averaging 32.6%, ranging from 30 to 40%, and ca. the mite attacks 90% of citrus fruits. Predaceous mites, predaceous insects, and entomo-acaropathogenic fungi are found on plantations.

INTRODUCTION

In early 2016, world citrus production reached 124,246.0 thousand tons. The two biggest citrus production countries, China and Brazil, contributed 32,705.9 and 16,555.1 thousand tons, respectively (FAO, 2017). In 2019, citrus production in Indonesia was around 2.77 million tons. From 2015 to 2019, citrus production was estimated to increase at 3.64% per year (Pusat Data dan Sistem Informasi Pertanian, 2015). Citrus production was significantly increased over the last six years due to the agricultural intensification and the expansion of citrus plantations across Indonesia. A massive 8,000% expanded the citrus production in West Kalimantan. In contrast, in the other prominent citrus producing regions, including North Sumatra (Medan), East Java (Malang), and South Sumatra, it was expanded by about 500%, 900%, and 5,000%, respectively. In South Sulawesi, the fruit production

was only slightly increased, 100% (Morey, 2007).

Various types of pests, vertebrates, and invertebrates attack citrus plantations in different parts of the world and cause severe economic losses. In this regard, arthropods are the most injurious biological stressors, mainly phytophagous insects and mites (Vacante, 2010). Mites belong to the class Arachnida, and to date, more than 50,000 species have been identified (Gerson & Weintraub, 2011). Several species of mites are pests of citrus, especially those belonging to the families Tetranychidae, Tenuipalpidae, Tarsonemidae, and Eriophyidae. Most of them are generalist herbivores, except for the members of the Eriophyidae (Gerson, 2003). Superfamily Eriophyoidea (Acari: Prostigmata) is one of the taxa with high diversity. All eriophyid mites are phytophagous, and are generally specialists with a limited host range. In infested plants, they cause a wide variety of

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symptoms; hence, they are often referred to as blister, bud, gall, or rust mites. In Greece, more than a hundred species of eriophyoids have been found associated with crops in various orchards (Kapaxidi, 2013). Some species that often cause yield losses in citrus plantations are *Aceria sheldoni* (Ewing) (citrus bud mite), *Aculops pelekassi* (Keifer) (pink citrus rust mite) and *Phyllocoptruta oleivora* (Ashmead) (citrus rust mite) (Al-Azzazy & Alhewairini, 2020; Kapaxidi, 2013; Tsuchida & Masui, 2020). In California, the mite shows a southern coastal distribution from Santa Barbara to San Diego counties (Keifer, 1952). The citrus rust mite, *P. oleivora* (Eriophyoidea: Eriophyidae: Phyllocoptinae: Phyllocoptini), is an injurious pest of various *Citrus* spp. that has a global distribution, causing considerable losses in citrus orchards worldwide (Xue, Song, & Hong, 2010).

In 2003, the authors' first survey in citrus plantations in Bogor, West Java, showed that the pest that caused rust in citrus fruit is a mite. Various mites are known that attack citrus fruit. Each variety has different rust-colored symptoms, and the symptoms have a particular pattern. However, most of the citrus farmers in Indonesia do not know the cause of rust on citrus fruit. They were very much concerned about the cause of russet fruit. Some growers believed it resulted from adverse soil conditions, others, it was of insect (thrips). It is essential to know the cause of rust-colored on citrus fruit and its damage intensity, especially in the citrus production center in Indonesia. The research evaluated the cause and abundance of rust mites in citrus orchards as a first step toward developing citrus mite control programs.

MATERIALS AND METHODS

The study was carried out on the commercial citrus plantations in East Java, North Sumatra, and West Kalimantan provinces in 2015. East Java is included in the wet tropical climate with an average annual rainfall of 1,900 mm, with as many as 100 rainy days during the rainy season. Based on recent data, the highest temperature in East Java in October and November (35.5°C) and the lowest in August (19.8°C) with a relative humidity of 39-97%, highest air in August amounted to 1012.0 millibars, and rainfall occurs in February. The topography of East Java can be divided into the high, medium, and lowlands. Plateau is an area with a height of 100 meters above sea level. The climate in North Sumatra, including tropical climate influenced

by Passat and Monsson winds. Average relative humidity of 78-91%, rainfall 800-4,000 mm per year, and 43% of solar radiation. West Kalimantan is located right on the equator (latitude 0°) based on its geographical location. It is one of the tropical regions with relatively high temperatures and is accompanied by high humidity.

The three provinces were the center of citrus plantation in Indonesia. Most farmers grow *Citrus sinensis*, *C. reticulata*, and *C. suhuensis* varieties in almost all citrus plantation areas. Observations were conducted on *C. sinensis* and *C. reticulata* plantations in East Java, *C. reticulata* and *C. suhuensis* in West Kalimantan, and *C. suhuensis* in North Sumatra. Citrus plants in this study aged 5-7 years with a spacing of 4 x 4 m. The average dose and type of fertilizer applied to plant citrus trees were the same, Urea 200, SP36 200, ZK 60 g/tree/application, and manure was 40 kg/tree/application. Fertilizer application was made 2-3 times a year.

On each plantation, 10% citrus plants or ca. 60 plants were selected as samples. A number of all sample plants were ca. 300. For each sample plant, five fruits were determined randomly, and its placed 0.5 to 1.5 m from ground level. The fruit surface was divided into four imaginary quadrants, both two quadrants on the upper and lower side citrus fruit surface to count the damage intensity. Each quadrant was measured damage intensity, how many percent of rust symptoms covered citrus fruit skin surface. Percentage average of rust symptom of four quadrants was damage intensity on a sample fruit, and percentage average of five fruit samples was the percentage average of a sample plant. On the same plant sample of each species, citrus rust attack symptoms, color types, and counted number of attack fruit of rust were observed. Observation of pest-caused rust was conducted on every fruit sample using loupe 16x magnification. Other arthropods, especially natural enemies on the fruit samples, were collected to be identified in the laboratory. Using a fine brush, all arthropods were placed in the collecting bottle containing 70% alcohol. Determining of arthropod was taken by a binocular microscope. The slide was prepared using Hoyer's liquid to identify phytophagous and predaceous mites. Observation of damage intensity, attack symptoms on each variety, and mite pest were conducted every week for six months.

An additional observation was also conducted from 2016 to 2017 to collect specimens

of mites on citrus plantations in Malang, East Java. Scanning Electron Microscope (SEM) and binocular microscope were used to identify each collected specimen. Pictures of mites were taken by SEM and binocular microscope in Biology Laboratory, State University of Malang and Laboratory of Plant Pest, Department of Plant Pests and Diseases, Faculty of Agriculture, Universitas Brawijaya, Malang. All collected data were analyzed by descriptive analysis. All pictures related to symptoms and body parts of mites were described briefly.

RESULTS AND DISCUSSION

Based on the identification, the cause of rust on citrus fruit in three provinces is citrus rust mite. It belongs to the family of Eriophyidae. Eriophyid mites are small in size with ca. 200 μm the body length of adults and have two legs (Fig. 1). The mobility of

adults is lower than insects or more giant arthropods. There is standard segmentation on two couples of adult legs and five-rayed feather claws (Fig. 2). There is a specific net pattern on the prodorsum of adults (Fig. 3), and it is mainly found on the adult of citrus rust mite, *Phyllocoptruta oleivora*. The adult is an elongated, wedge-shaped body and ca. 0.13 mm long. Keifer, Baker, Kono, Delfinado, & Styer (1982) mentioned that the standard segmentation of legs is with five-rayed feather claws on citrus rust mites. The broad trough on the dorsal side of its opisthosoma is net patterned (Keifer, Baker, Kono, Delfinado, & Styer, 1982). In detail, Vacante (2010) described that the citrus rust mite adults have very short setae ca. 40 μm in length. The basal genital cover flap is granular, has a median longitudinal line, and has 14-16 ribs apically on the genital cover flap.

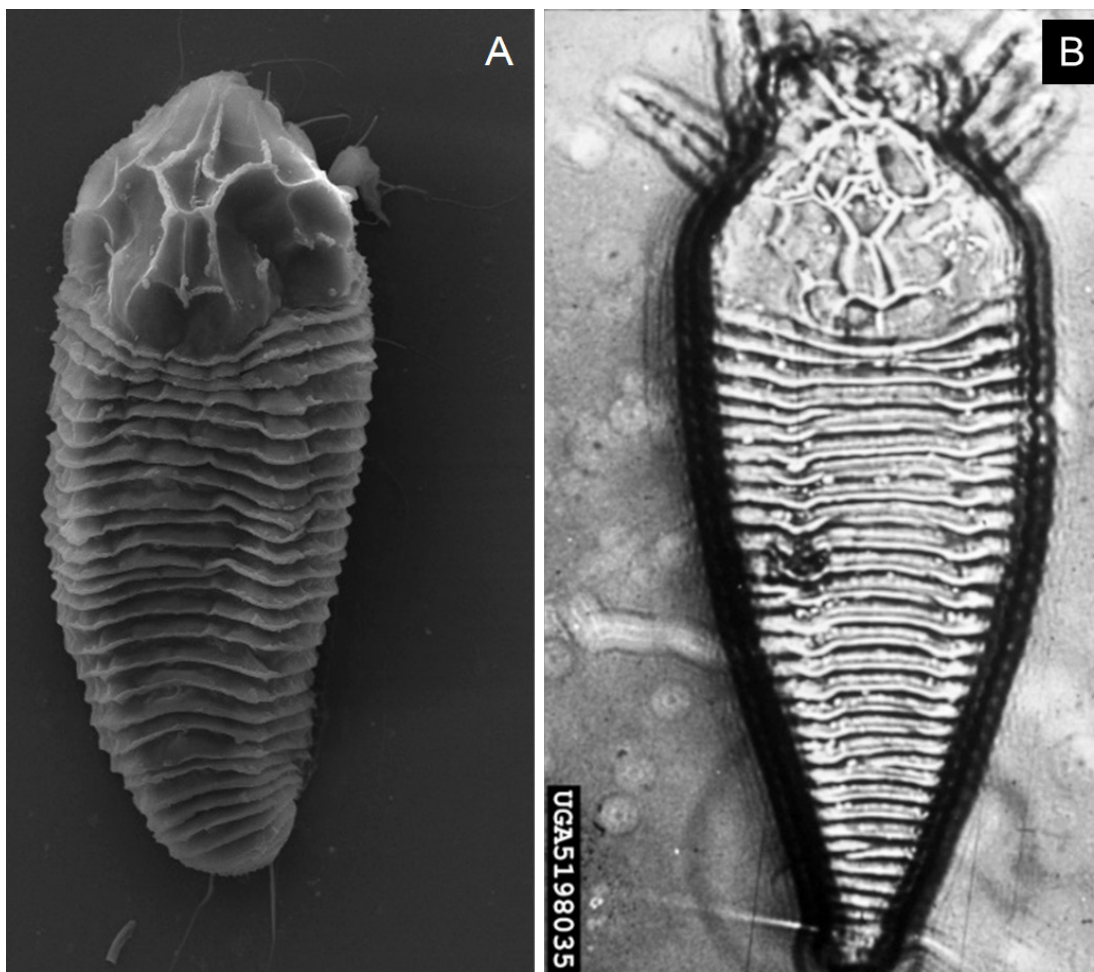


Fig. 1. Dorsal view of citrus rust mite adult based on Scanning Electron Microscope (SEM) (A); and based on an image of Florida Division of Plant Industry (2007) (B).

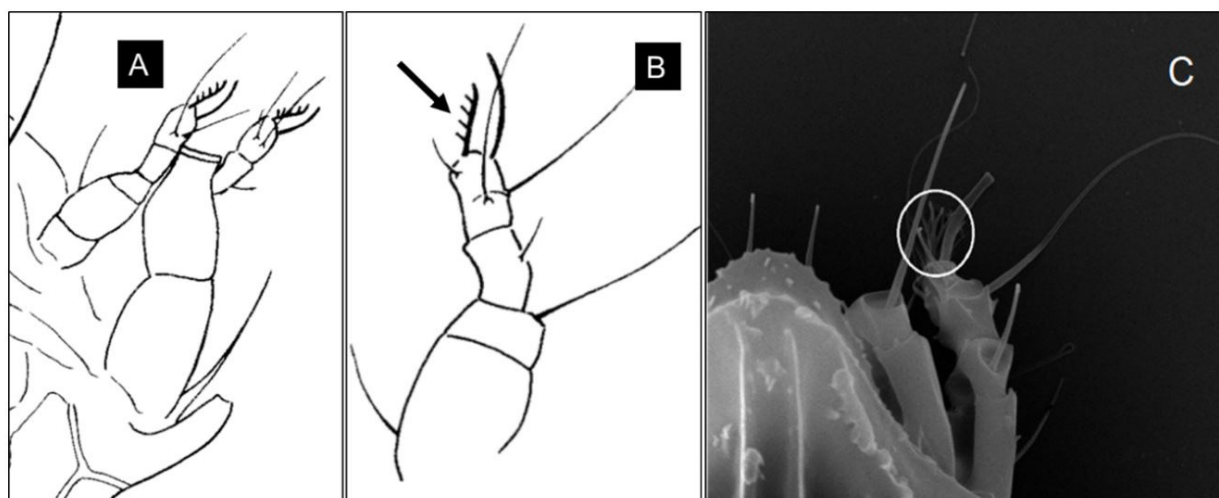


Fig. 2. Citrus rust mite adult: legs with the normal segmentations (Manson, 1984) (A); Empodial feather claws are five-rayed (Manson, 1984) (B); and five-rayed feather claws based on SEM (C).

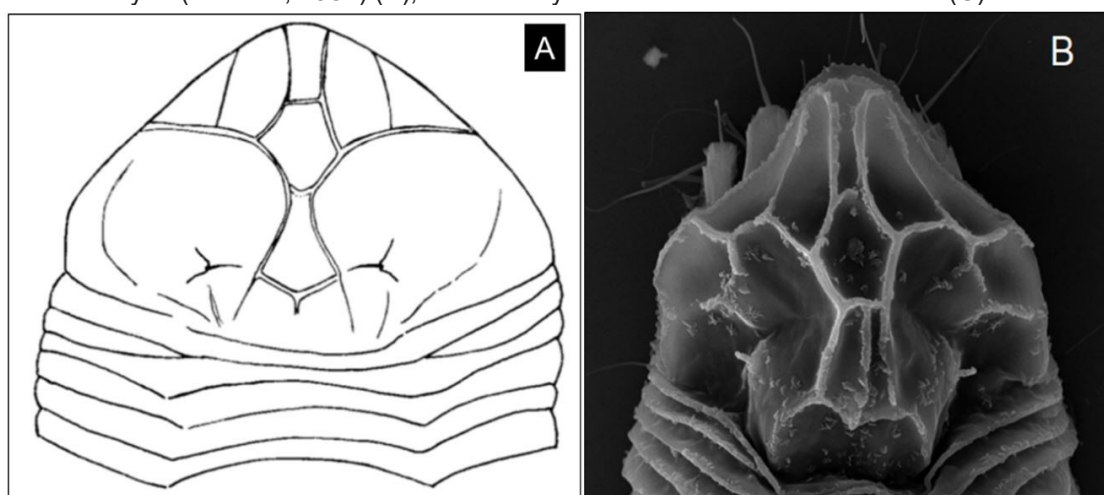


Fig. 3. Prodorsum of citrus rust mite adult with net pattern based on Manson (1984) (A) and SEM (B).

Based on field observation, citrus rust mite is tiny and difficult to see. However only yellowish body color can be used to estimate their body under the leave of citrus. The adult body color is described in Fig. 4. It was mentioned by Kelly, Miles, Conner, Sikora, & Majumdar (2016) that adult citrus rust mite is light yellow and difficult to see on the field. In the temperate zone, mites overwinter under bud scales as fertilized adult females and emerge at bud break in spring (Davis, 2011). In the growing season, males and females are easily found. The continuous reproduction of mites in the growing season can produce completed generations and overlapping generations every two or three weeks (Davis, 2011).

Manson (1984) reported that in New Zealand, *P. oleivora* is found on lemons, oranges, mandarins, and grapefruit. Since 1879, it has been known in Florida (Keifer, 1952). Initially, all new flush leaves were infested by mites within a few days, and the first leave will be the most rapid population increase. Before this mite is detected on fruit, it will be well-established on the new flush (Mccoy, 1979).

Fig. 5 describes the several symptoms produced by citrus rust mite on three citrus species, namely *C. reticulata*, *C. suhuensis* and *C. sinensis*. The specific symptom produced by this mite is rust-colored symptoms. This symptom can be found in all plantations in the three observed provinces. Severe damage will have resulted when the mite

attacks young fruits. This attack causes a decrease in fruit size. Finally, the attacked fruit becomes smaller in diameter, and sometimes the skin of some fruits has few cracks. Attack symptom on infested fruit is different compared to another species. Keifer, Baker, Kono, Delfinado, & Styer (1982) reported that in California, citrus rust mite is a severe pest on a lemon that feeds and ruptures the epidermal cells of the rind. The infested fruits become silverish or show russet effects. In addition,

the rind becomes thicker than regular fruit, and the affected fruit is smaller. Another symptom of citrus rust mite infestations on lemons and grapefruits is the appearance of “sharkskin”, which is when the outer layer of the rind can be peeled off. The feeding activity of the mites on leaves and twigs will produce bronzing. Kalaisekar, Naidu, & Rao (2000) concluded that damaged fruits contributed to several aspects such as less fruit weight, fruit size, juice volume, and titratable acidity.



Fig. 4. Adult citrus rust mite captured by light microscope at 400x magnification.



Fig. 5. Injuries caused by citrus rust mite on fruit skin of *C. reticulata* (A), *C. suhuensis* (B), and *C. sinensis* (C).

Damage intensity of citrus rust mite in three provinces averaging 32.6%, ranging from 30% to 40% (Fig. 6A), and ca. 90% of citrus fruits were attacked by the mites (Fig. 6B). It means that 32.6% of the fruit skin on three citrus species in all provinces was covered by rust-colored symptoms. The reduction also occurs on three citrus species.

In Venezuela, specifically in the north-western regions, *P. oleivora* is one ubiquitous species that attack *Citrus latifolia*. Under favorable conditions, the mite populations can increase rapidly ca. 24 mites per fruit (Quiros-Gonzalez, 2000). The imperfect fruit surface resulting from extensive mite feeding can lower the quality of the affected fruits. The mite infestation also reduces the size of fruit and causes fruit drop. Furthermore, damage and fruit drop have also resulted from the duration of feeding. In summer or fall, the color of the injured surface on fruit became “bronzing”. In the spring, “sharkskin” will be produced by citrus rust mite (Futch, Childers, & McCoy, 2017).

Based on Table 1, there are three groups of natural enemies for citrus rust mite on plantations in three provinces, i.e., predaceous mites, predaceous

insects and entomo-acaropathogenic fungi. Predaceous mites (Phytoseiidae, *Amblyseius* sp.), predaceous insects (Chrysopidae), and entomo-acaropathogenic fungi (*Hirsutella* sp.). Phytoseiid is found on all orchards in most citrus plants, although their population level is low. *Amblyseius* sp. is an essential predator in citrus plantations. In citrus plantations, a study has reported around 29 species of predaceous mites from nine families that inhabit citrus plants (Fadamiro, Xiao, Nesbitt, & Childers, 2009). Phytoseiidae (18 species) and Stigmaeidae (1 species) are the most commonly found taxa among those families. The various pest-debilitating mechanisms used by Acarine biocontrol Agents are found (Gerson, 2014). A Hyphomycetous fungus, *Hirsutella thompsonii*, infects *P. oleivora* for the first report in May 1972, in Texas (Lower Rio Grande Valley) (Villalon & Dean, 1974). Other phytoseiid mites that are the main natural enemies of *P. oleivora* in fields are *Amblyseius swirskii* and *Iphiseius degenerans*. During winter and spring, they could significantly decrease the population of the citrus rust mite (Palevsky, Argov, David, & Gerson, 2003).

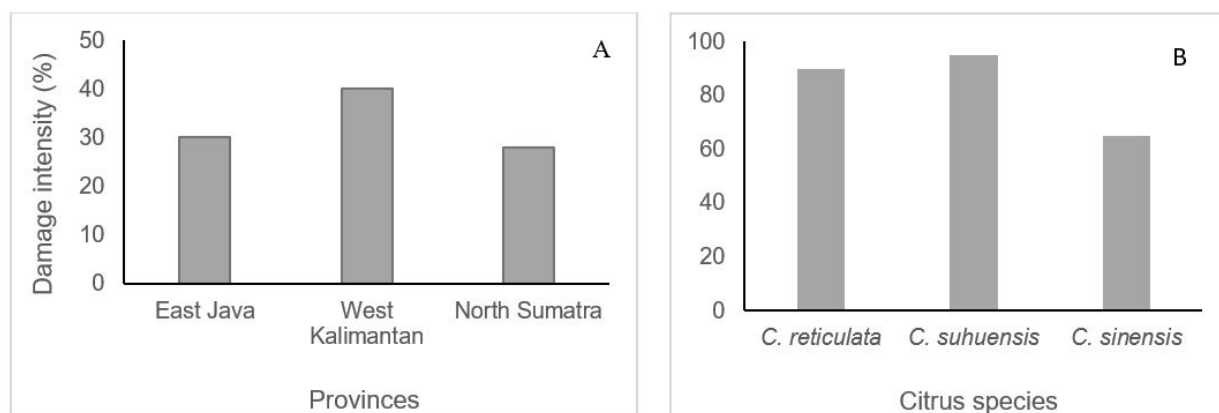


Fig. 6. Percentage of damage intensity caused by citrus rust mite on citrus based on provinces (A) and species (B).

Table 1. Natural enemies observed on plantations in three provinces

Group of natural enemies	Genera	Location of plantations
Predaceous mites	<i>Amblyseius</i> sp.	East Java
		North Sumatra
		West Kalimantan
Predaceous insects	Chrysopidae	North Sumatra
Entomo-acaropathogenic fungi	<i>Hirsutella</i> sp.	North Sumatra

CONCLUSION

The cause of rust on citrus fruit in three provinces is citrus rust mite, *Phyllocoptruta oleivora*. It belongs to Eriophyidae, with two adult legs with a regular segmentation, five-rayed feather claws, and a net pattern on prodorsum. The specific symptom produced by this mite is rust-colored symptoms. Damage intensity of citrus rust mites in three provinces averages 32.6%, ranging from 30% to 40% and ca. 90%, respectively. Predaceous mites, predaceous insects, and entomo-acaripathogenic fungi are found on the observed plantations. Predaceous mites, predaceous insects, and entomo-acaripathogenic fungi belong to Phytoseiidae, Chrysopidae, and *Hirsutiella*, respectively.

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Retno Dyah Puspitarini and Otto Endarto: *Citrus Rust Mite in Indonesia*

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