Mealybugs Complex of Citrus in Bengkulu Province

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Abstract. Mealybug (Hemiptera: Pseudococcidae) attacks many citrus plants over the world. This study reveals mealybug species attack on citrus grown at three different altitude levels: lowlands (<400 m above sea level (asl)), moderate lands (400-800 m asl), and highlands (>800 m asl) in Bengkulu Province. The results record nine species of mealybugs namely *Dysmicoccus arachidis* Williams, *Dysmicoccus lepelleyi* (Betrem), *Ferrisia dasylirii* (Cockerell), *Ferrisia virgate* (Cockerell), *Paracoccus tripurae* Williams, *Pseudococcus comstocki* (Kuwana), *Pseudococcus cryptus* Hempel, *Planococcus dischidiae* (Takahashi) and *Rastrococcus chinensis* Ferris. The species of *R. chinensis* is only found in the lowlands. Furthermore, *P. comstocki* is only found in the moderate lands and *P. discidiae* is only found in the highlands. *D. arachidis*, *F. dasylirii*, and *R. chinensis* are new insects pest on citrus. The key of those species is also included.

Key Words : *Biodiversity, citrus, mealybug, insect pest, taxonomy*

1. Introduction

The mealybug (Hemiptera: Coccomorpha: Pseudococcidae) is an insect group that cause damage to cultivated and non-cultivated crops. It covers all zoogeographic areas in the world [1]. This is the largest family number within consist of 2,012 species from 273 genera over the world. Furthermore, about 105 species of 32 genera are known to be in Indonesia region [1;2].

The insect can develop in a short time that it quickly reaches a high population [3;4;5]. This has the potential to cause considerable losses to the plant because it will lose strength, chlorosis, deformity (malformation) of twigs and branches die [5;6;7;8]. The mealybugs can also make the leaves burner because these insects produce honeydew which is a medium for the growth of sooty mold. The growth of the fungus will block light and air from the leaves, so that it can disrupt photosynthesis [9; 10]. The growth rate of the mealybug population is high when the availability of suitable places to live and food [11], humidity and temperature is optimal. According to [12], the optimum temperature for the development and physiological processes of mealybugs is 25◦C. The humidity plays a more dominant role in the body water content of mealybugs and their life cycle [13].

The mealybug has become one of the important pests that can attack many types of annual crops including citrus and it needs serious treatments [14]. In Indonesia, citrus plants have become one of the fruit commodities that have been widely cultivated with production levels reaching 70-80% [15]. The total production of oranges such as siam/ tangerine and large oranges in Indonesia reach 2,722,952 tons in 2020 and it continues to increase every year. Meanwhile, the citrus production in Bengkulu is still relatively low compared to other provinces such as East Java, Bali, North Sumatra, West Sumatra and Riau [16]. The low production of citrus is partly due to the attack of plant pests, one of which is the mealybug. There are 76 species of mealybugs reported to attack citrus plants in the world, 27 species of which were found to attack citrus plants in Indonesia [2;3]. Many mealybugs species are polyphagous causes different populations and intensity of attacks on each different type of host, therefore such information are absolutely necessary.

This study aims to identify mealybugs species and estimate the level of attack on citrus plants grown at three different altitude levels, namely low, medium and highlands in Bengkulu Province. The data on the diversity of species that attack plants is needed to determine appropriate control techniques.

2. Methods

2.1 Sampling, Slides Preparation and Species Identification

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Sampling was carried out from December 2021 to May 2022 in five regencies, namely Central Bengkulu (CB), Bengkulu Tengah (BT), Kepahiang (K), Lebong (L) and Rejang Lebong (RL) Regencies, with several locations at different altitudes: 0 m asl to 400 m asl, 400 m asl to 800 m asl and >800 m asl. Observations of mealybugs species were carried out at 10 locations at each altitude level. The citrus plants observed were minimum two years old plants. Sampling was conducted by purposive random sampling method. Samples of mealybugs were taken from all parts of the plant including shoots, stems, leaves, roots and fruit. Observations were made by carefully examining and observing the level of attack and population abundance by counting the number of fruit and twigs attacked by mealybugs in one quadrant of the canopy. The slides microscopic were prepared using the method of Kosztarab and Kozár (1988) [17] with some modifications. The identification was carried out based on identification key by Williams (2004) [18].

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2.2 Population and Attack Rate

The insect population was calculated in a quadrant of the canopy with the largest population in the affected fruit, leaf and twig unit. The abundance of mealybug population was observed visually. A comparison of the population of mealybugs was carried out based on different locations and altitudes. The intensity of the attack was calculated by counting the number of affected fruits, leaves and twigs in one quadrant of the canopy using the following formula:

$$PS\ (\%) = \frac{Nh}{Nt} \times 100$$

PS = Attack percentage
Nh = Number of affected citrus fruit and twigs
Nt = Total fruit and twigs of citrus plants

3. Result and Discussion

3.1 Species Identification

Nine species of mealybugs were found attack citrus trees in Bengkulu Province namely *Dysmicoccus arachidis* Williams, *Dysmicoccus lepelleyi* (Betrem), *Ferrisia dasylirii* (Cockerell), *Ferrisia virgate* (Cockerell), *Paracoccus tripurae* Williams, *Pseudococcus comstocki* (Kuwana), *Pseudococcus cryptus* Hempel, *Planococcus dischidiae* (Takahashi) and *Rastrococcus chinensis* Ferris. Mostly such mealybug species spread randomly at all sites in different altitude levels and locations. However, *R. chinensis*, *P. comstocki*, and *P. discidiae* were the only species found in altitude of <100 m asl, 400 - 800 m asl, and >800 m above sea level, respectively (Table 1).

The highest number of mealybug species was found in the *Gerga* variety, which consisted of five species such as *D. lepellyi*, *F. virgata*, *P. tripurae*, *P. discidiae*, *P. cryptus* and *P. comstocki*. Since the species of *P. discidiae* was only found in *Gerga* variety, the species of *D. arachidis* was found in *Siamese* variety. Other species were found in all of the various citrus varieties.

There were 9 species within 6 genera of mealybugs attack on citrus in Bengkulu. However, Garcia et al. (2016) [2] reported about 76 mealybugs within 20 genera consisting of 1 species of *Coccus*, 1 species of *Crisicoccus*, 1 species of *Delettococcus*, 7 species of *Dysmycoccus*, 1 species of *Exallomochlus*, 5 species of *Ferrisia*, 2 species of *Formicococcus*, 1 species of *Hypogeococcus*, 1 species of *Ityococcus*, 1 species of *Laingiococcus*, 1 species of *Leptococcus*, 1 species of *Maconellicoccus*, 1 species of *Maculicoccus*, 6 species of *Nipaecoccus*, 6 species of *Paracoccus*, 6 species of *Phenacoccus*, 6 species of Planococcus, 15 species of *Pseudococcus*, and 9 species of *Rastrococcus* and 1 species of *Spilococcus* live on citrus trees worldwide. A few numbers of the mealybug species recorded in Indonesia were probably due to less exploration of mealybugs. Indeed, Indonesia is not a producer of citrus. Zarkani *et al*. (2020, 2021, 2022) [3; 19; 20] explored more broadly and found some new record species for Indonesian scale insect faunas.

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The species of *D. arachidis*, *F. dasylirii*, and *R. chinensis* living on citrus were new insects complexed on citrus in the world. Even though, there was no evidence to group of the species as primary pests, the attack rate reached from 2.70 % to 56.11 %. Three largest attack rates were reached by *F. virgata*, *R. chinensis*, and *P. tripure* with 56.11%, 43.30% and 38.09%, respectively. Garcia et al. (2016) [2] reported there are 5 species of genus *Ferrisia* attacked citrus plants in the world including *F. virgata*, *F. cristinae*, *F. malvastra*, *F. terani*, and *F. uzinuri*. However, in Bengkulu, *F.*

dasylirii was found attacks citrus trees in Talang Pauh (Bengkulu Tengah) and Selamat-Sidoardjo (Rejang Lebong). In addition, *D. arachidis* was found in Pagar Gunung and Bandung Jaya (Kepahiang) and Bangun Jaya (RL), then *R. chinensis* was in Talang Empat (Kepahiang) and Kancing (Bengkulu Tengah).

Table 1. Mealybugs (Hemiptera: Pseudococcidae) complex of citrus trees in Bengkulu Province

Taxon	Sites	Altitudes (m asl)	Host Plants	Attack Rates (%)	Population (per quadrant canopy)
Dysmicoccus arachidis Beardsley	Pagar Gunung (K)	609	Siamese	21.05	28
	Bandung Jaya (K)	869	Siamese	7.54	15
	Bangun Jaya (RL)	967	Siamese	16.45	13
Dysmicoccus lepellyi Betrem	Talang Pauh (BT)	28	Kalamansi	8.87	23
	Mandi Angin (K)	516	Gerga	5.40	6
	Suro Baru (K)	614	Kalamansi	12.19	13
	Tangsi Duren (K)	964	Siamese	2.70	5
Ferrisia dasyliri Cockerell	Talang Pauh (BT)	28	Bali	8.87	12
	Selamat-Sidoardjo (RL)	892	Kalamansi	8.75	6
Ferrisia virgata Cockerell	Sukarami (CB)	66	Nipis	56.11	121
	Kampung Sajad (RL)	920	Gerga	6.38	17
Paracoccus tripure Williams	Permu (K)	523	Gerga	38.09	41
	Sentral Baru (RL)	883	Siamese	23.52	26
	Kp. Melayu (CB)	895	Siamese	11.10	11
	Palseratus (L)	913	Siamese	6.90	3
Planococcus dischidiae Nelzel'skii	Paldelapan (L)	951	Gerga	3.07	4
	Air Bening (RL)	1050	Gerga	4.00	4
	Transad (RL)	1063	Gerga	3.00	2
Pseudococcus cryptus Hempel	Taba Pasmah (BT)	17	Kalamansi	10.70	11
	Pulau Panggung (BT)	18	Nipis	17.14	34
	Kembang Seri (CB)	18	Nipis	28.57	101
	Talang Pauh (BT)	28	Bali	8.87	12
	Daspetah (K)	623	Gerga	8.88	8
	Hujan Mas Atas (K)	615	Gerga	16.27	23
Pseudococcus comstocki Kuwana	Hujan Mas Bawah (K)	543	Gerga, Nipis	9.61	23
Rastrococcus chinensis Ferris	Talang Empat (K)	22	Kalamansi	43.30	105
	Kancing (BT)	40	Nipis	11.36	18

Note: CB: Central Bengkulu, BT: Bengkulu Tengah regency, L: Lebong, K: Kepahiang regency, RL: Rejang Lebong regency.

The key identifications of 6 genera of mealybugs attack on citrus trees in Indonesia were increased and provided as follows (after [18]).

1. Dorsal tubular duct large, each with an opening surrounded by a circular, sclerotized area containing 1 or more setae within its borders, or with setae adjacent to its margins .... *Ferrisia* Cockerell
- Dorsal tubular duct, if present, without combination of these characters 2
2. Cerarii always conspicuous, each having numerous truncate-conical setae, flat cerarian setae at the apex of ..... *Rastrococcus* Ferris
- Cerarii, if present, bearing pointed, conical, lanceolate or flagellate setae, never conical 3
3. Oral rim tubular duct present 4
- Oral rim tubular duct completely absent 5
4. Venters of each anal lobe with anal lobe bars and additional setae are present only in the cerarii of the anal lobe. ..... *Paracoccus* Ezzat & McConnel
- Venters of each anal lobe with triangular to quadratic sclerotized areas occupy most of the lobe, never with the bars of the anal lobe ..... *Pseudococcus* Westwood

5. Anal lobe bars present. Cerarii numbered 18 pairs .....*Planococcus* Ferris
- Anal lobe bars absent. Cerarii number less than 18 pairs .....*Dysmycoccus* Ferris

3.2 Population and Attack Rate

The abundance of populations and attack rates were obtained at all different altitudes which an altitude from 0 m asl to 400 m asl was the highest pest population level and attack rate, e.i., 45 ± 44,8 per canopy quadrant with a standard deviation of 44.85 and an attack rate of 20.72 ± 0.2 % (Tabel 2). In specific, it was at an altitude of 66 m asl, with a total population abundance of 121 per quadrant canopy and an attack rate of 56.11 % (see table 1). The lowest pest population level and attack rate were an altitude of 9 meters above sea level, with a total population abundance of 9 per canopy quadrant and an attack rate of 4.56 %. Data that has been obtained in areas with an altitude of 401 m asl-800 m asl is the highest pest population level at an altitude of 523 m asl, with a total pest population abundance of 41 per quadrant canopy and an attack rate of 38.09 %.

Table 2. Mealybug population and attack rate on citrus trees in Bengkulu based on different altitude levels

Altitude (m asl)	Average of Population Abundance (per quadrant canopy)	Average of Attack Rate (%)
0 ≤ 400	45 ± 44.8	20.72 ± 0.2
401 ≤ 800	18 ± 12.3	13.8 ± 0.1
>801	10 ± 7.3	8.5 ± 0.06

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The lowest pest population level was at an altitude >800 m asl with a population abundance of 10 ± 7,3 and an attack rate of 8.5± 0,06 %. Data obtained in those areas showed the highest pest population level was at an altitude of 883 m above sea level, with a total population abundance of 26 per quadrant canopy and an attack rate of 23.52% (see Table 1). Furthermore, the lowest pest population level was at an altitude of 1063 m asl with a total population abundance of 2 per quadrant canopy and an attack rate of 3%. Here, the rainfall is one of the most influential factors on the population of mealybugs. Data that has been obtained from the Meteorology, Climatology and Geophysics Agency (BMKG) at an altitude of 0 m asl 400 m above sea level has low rainfall, it affects the development of mealybugs with increasing population abundance. Meanwhile, at an altitude of >800 m above sea level, the rainfall is quite high, causing less growth of mealybugs and resulting in lower abundance of mealybugs. The meteorological factors were abiotic factors that influence the development of insect populations [21]. Meteorological factors such as temperature, rainfall, and relative humidity greatly affect the population explosion. The optimum temperature for the development and physiological processes of mealybugs is about 25°C [12]. The growth rate of the mealybug population is high if there is an appropriate host plants [11].

Based on data species, the average attack rates of all mealybug species was about 3.3 % to 27.3 % (Table 3). Here, *R. chinensis* was the highest average population reaching 61 ± 62 per canopy quadrant and an average attack rate of 27.3±22.6 % at 2 locations. The species of *F. virgata* attacked at two locations within the second-highest pest population and the attack rate reached 69 ± 49.6 per canopy quadrant and 20±0.20 %, respectively. It was followed by *P. tripurae* found at 4 locations within the average number of pest populations was about 18 ± 16.4 per canopy quadrant and the average attack rate was 19.9 ± 0.20 %. Moreover, P. *cryptus* attacked at 5 locations which was the average number of pest populations and the average attack rate was 38 ± 36 per canopy quadrant and 16.3 ± 0.07% of the attack rate, respectively. The species of *D. arachidis* attacked at 3 locations, the average pest population was 15,01± 3.3 per canopy quadrant and the average attack rate was 14.25± 0.03 %. Other species were founded at less than 10 % attack rates.

Another factor affected the outbreak of mealybugs is the infirmly pesticides applied. The chemical pesticides kill insect pests quickly as well as natural enemies in the field. Almost the local farmers used pesticides to control insect pests even though the population of mealybugs is low. The excessive use of pesticides has a detrimental impact by causing pesticide resurgence and reducing the diversity of natural enemies directly [22].

Table 3. Average attack rate and population abundance by species

Taxon	Average of Population Abundance (per quadrant canopy)	Average of Attack Rates (%)
Dysmicoccus arachidis Beardsley	15,01± 3.3	14.25± 0.03
Dysmicoccus lepellyi Betrem	12 ± 8.3	7.3± 0,10
Ferrisia dasyliri Cockerell	15 ± 0.1	8.8± 0.30
Ferrisia virgata Cockerell	69 ± 49.6	20±0.20
Paracoccus tripurae Ganguli & Ghosh	18 ± 16.4	19.9 ± 0.20
Planococcus dischidiae Nedzel'skii	3 ± 1.2	3.3 ± 0.01
Pseudococcus cryptus Hempel	38 ± 36	16.3 ± 0.07
Pseudococcus comstocki Kuwana	23 ± 0.0	9.6 ± 0.0
Rastrococcus chinensis Ferris	61 ± 62	27.3±22.6

3. Conclusion

Nine species of mealybugs complex of citrus trees in Bengkulu namely *Dysmicoccus arachidis* Williams, *Dysmicoccus lepelleyi* (Betrem), *Ferrisia dasylirii* (Cockerell), *Ferrisia virgate* (Cockerell), *Paracoccus tripurae* Williams, *Pseudococcus comstocki* (Kuwana), *Pseudococcus cryptus* Hempel, *Planococcus dischidiae* (Takahashi) and *Rastrococcus chinensis* Ferris. The species of *R. chinensis* is only found in the lowlands. Furthermore, *P. comstocki* is only found in the moderate lands and *P. discidiae* is only found in the highlands. *D. arachidis, F. dasylirii*, and *R. chinensis* are new insects pest recorded on citrus trees.

References

[1] Ben-Dov, Y., D. R. Miller, and G. A. P. Gibson. 2002. ScaleNet, Classification.

[2] Garcia-Morales. M., B. D. Denno., D. R., Miller., Ben Dov, and N. B. Hardy. 2016. *ScaleNet:* a literature based model of scale insect biology and systematics. https://scalenet.info/. Accessed, 25 September 2021.

[3] Zarkani, A., D. Apriyanto, F. Turanli, C. Ercan, and M. B. Kaydan. 2021. A check list of the scale insect (Hemiptera: Pseudococcidae) in Indonesia. Zootaxa 5016 (2): 151–195.

[4] Ahmad, S. K., P. Q. Rizvi, and S. M. A. Badruddi. 2014. Comparison of life specific age parameters of whitefly *(Bemisia tabaci* Genn.*)* on some prefered host plants. Internasional Journal of Entomology Research 2: 41–45.

[5] Mastoi, M., A. Nur., R. Muhamad., A. Idris., A. Arfan., and Y. Ibrahim. 2014. Life table and demographic parameters of papaya mealybug, *Paracoccus marginatus* (Hemiptera: Pseudococcidae) on *Hibiscus rosa chinensis*. Journal Science International 26 (5): 2.323–2.329.

[6] Wardani, N. 2014. Parameter Neraca Hayati Populasi Kutu Putih *Phenacoccus Manihoti* Matile Ferrero *(Hemiptera: Pseudococidae)* pada Dua Varietas Ubi Kayu. Journal Hama Penyakit Tanaman Tropika 14(1): 64–70.

[7] McKenzie, H. L. 1967. *Mealybugs of California with Taxonomy, Biologyand Control of North American Species (Homoptera:Coccoidea:Pseudococcidae)*. University of California Press, Berkeley. 400 pp.

[8] Miller, D. R., and M. Kosztarab. 1979. Recent advances in the study of scale insects (Pest of various plants). Annual Review of Entomology 24: 1–27.

[9] Williams, D. J. 1985. Australian mealybugs. British Museum (Natural History). London. 431 pp.

[10] Miller, D. R, and G. L. Miller. 2002. Redescription of *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera:Coccoidea: Pseudococcidae) including descriptions of the immature stages and adult male. *Proceedings of The* Entomological Society of Washington 104: 1-23.

[11] Pamungkas, M. C. A. 2006. Pola sebaran *Aonidiella aurantii* pada tanaman apel di Desa Poncokusumo. *Skripsi.* Fakultas Pertanian Universitas Brawijaya, Malang.

[12] Thomson, L. J., S. Macfadyen., A. A. Hoffman. 2010. Predicting the effect of climate change on natural enimies of agricultural pests. Biological control. 253 pp.

[13] Heddy, S. M., and Kurniati. 1996. Prinsip-Prinsip Dasar Ekologi. Edisi 1. Raja Grafindo Persada, Jakarta. 126 pp.

[14] Mani, M., A. Krishnamoorthy., C. Shivaraju. 2011. Biological suppression of major mealybug species on horticultural crops in India. Journal Horticulture 6(2):85– 100.

[15] Dirjen Hortikultura. 2012. LAKIP Direktorat Jenderal Hortikultura Tahun 2012. Kementrian Pertanian. 180 pp.

[16] Badan Pusat Statistik. 2020. Produksi Tanaman buah-buahan 2021. https://www.bps.go.id/indicator/55/62/1produksi-tanaman-buah-buahan.html. Accessed, 25 September 2021.

[17] Kosztarab, M, and F. Kozar. 1988. Scale Insects of Central Europe. Akademiai Kiado, Budapest, Hungary, and Dr W. Junk Publishers, Dordrecht, The Netherlands. 456 pp.

[18] Williams, D. J. 2004. Mealybug of Shouthern Asia. The Natural History Museum. London (UK). 894 pp.

[19] Zarkani, A., D. Apriyanto, F. Turanli, and M. B. Kaydan. 2020. New record of *Ferrisa dasylirii* (Cockerell) (Hemiptera: Coccomorpha: Pseudococcidae) in Indonesia. Serangga 25: 93–100.

[20] Zarkani, A., D. Apriyanto, F. Turanli, C. Ercan, and M. B. Kaydan. 2022. A First Record of Mealybug, *Planococcus bendovi* Williams (Hemiptera: Coccomorpha: Pseudococcidae) in Southeast Asia. Serangga 27(1): 188–198.

[21] Zarkani, A., F. Turanli. E. Bayam, C. Sonmez, and E. Ozdemir. 2017. Incidence and economic impact of the mint aphid, *Eucarazzia elegans* (Ferrari) (Hemiptera: Aphididae) on common sage. Turkish Journal of Entomology 41(4): 383–392.

[22] Kaleb R., F. Pasara, and N. Khasanah. 2015. Keanekaragaman serangga musuh alami pada pertanaman bawang merah (*Allium ascalonicum* L) yang diaplikasi dengan bioinsektisida *Beauveria bassiana* (Bals.-Criv.) Journal Agroland 22(2):114–122.

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