

Pseudococcid mealybugs (Hemiptera: Pseudococcidae) complex of bamboo in Indonesian Sunda Shelf with ~~in~~ two new species records species

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Abstract

In this study, a survey for determining the pseudococcid mealybug (Hemiptera: Coccoomorpha: Pseudococcidae) complex of bamboo was conducted in several provinces in Sumatra and Java Island-Indonesia, a part of Indo-Asian regions. The research collected 85 mealybug specimens consisting of five species within 4 genera namely *Antonina* Signoret (2 species), *Chaetococcus* Maskell (1 species), *Dysmicoccus* Ferris (1 species), and *Palmicultor* Williams (1 species). *Antonina pretiosa* Ferris and *Dysmicoccus zeynepae* are newly recorded for the Indonesian Sunda shelf. ~~In addition, *Dysmicoccus* is the first reported genus of attacks on bamboo worldwide.~~ The identification key of Indonesian bamboo mealybugs and their distribution data are also updated.

Comment [rev1_1]: There are two *Dysmicoccus* speies reported on bamboo in previous publications:

<http://scalenet.info/associates/bambusa/dysmicoccus/>

Keywords: Biodiversity, Coccoomorpha, host plant, pests, Sternorrhyncha, taxonomy

Introduction

As a mega biodiversity's country, Indonesia is influenced by Asian and Australian biodiversity. In fact, at the beginning of the ice age, the western part of Indonesia such as Bali, Java, Kalimantan and Sumatra merged with the Asian continent (Sunda shelf), while the eastern part of Indonesia was integrated with the Australian continent (Sahul shelf) (Lohman *et al.* 2011). The high diversity of flora and fauna, including insect species, is a result of unique geological and evolutionary history in combination with the wide variety of habitats associated with its many islands (Arifin & Nakagoshi 2011). Nevertheless, the geographic dimension of Indonesian biodiversity, in particular, species endemism across geographical gradients, has not been taken into account.

A plant genus within a high diversity is bamboo (*Bambusa* sp.), a woody perennial evergreen plants belonging to the family Poaceae, ~~consisted of over 590 species in 44 genera (Dransfield & Widjaya 1995).~~ This Bamboo is one of the important exporting agricultural material products over the world: ~~consisted of over 590 species in 44 genera (Dransfield & Widjaya 1995).~~ This this plant is commonly used as pulp for paper mills, houses material, handicrafts, food product items and other people's daily lives (Fu *et al.* 2000).

Whilst bamboo is one of leading agricultural products in the world, the growing as well as the exporting process faces many problems, including insect pest infestations (Thanh *et al.* 2007). There are more than 400 insect species feeding on bamboos within which about 100 species gaining pest status, including mealybugs that can cause heavy damage to the plant (Hemiptera: Coccothraupidae: Pseudococcidae) (Kalshoven 1981; Gracia Morales *et al.* 2016). ~~This Pseudococcidae~~ is the second-largest family in Coccothraupidae after Diaspididae. As one of the important insect pests of worldwide, mealybugs play significant roles in transmitting virus, spreading among plants in intra-inter specific relations (Ben-Dov 1994). ~~The small, persistent, and tiny characters of the~~ Scale insects ~~is are~~ often become subjects of intercepted alien species in many countries due to the small, persistent, and tiny characters of them (Williams 2004; Kaydan *et al.* 2015).

In general, there are 2,041 mealybug species in 259 genera worldwide within which 109 species from 32 genera shuttled in Indonesia (García Morales *et al.* 2016; Zarkani *et al.* 2021, 2023). In fact, about 44 Pseudococcid species lives on bamboo in which 10 species (7 genera) namely *Antonina graminis* (Maskell), *Antonina milleri* Williams, *Antonina pretiosa* Ferris, *Antonina thaiensis* Takahashi, *Antonina zonata* Green, *Chaetococcus bambusae* (Maskell), *Extantococcus javanensis* Williams, *Hordeolicoccus nephelii* (Takahashi),

Palmicultor lumpurensis (Takahashi), and *Paracoccus interceptus* Lit are already existed in Indonesia (Williams 2004; Garcia Morales *et al.* 2016; Sartiami *et al.* 2016; Zarkani *et al.* 2021).

For the last decades, the study of bamboo mostly focused on genetic variability, chemical contains, and their utilities in agriculture as well as in medical sectors, but a few studies in insect faunal diversity. This study listed bamboo-feeding pseudococcids in the Sunda Shelf including new fauna records, as well as updated identification key of mealybugs complex of bamboo in Indonesia, ~~as well as updated review of the entire bamboo-feeding insects in the Sunda Shelf which has never been recorded before.~~

Materials and Methods

Mealybug specimens were collected from a series of sampling occasions on leaves, trunks, branches, and roots in bamboo trees in Bengkulu Province, West Sumatra Province, and East Sumatra Province, Indonesia from March to December 2022. The sampling sites are at an altitude of 0 – 1000 m above sea level. The specimens were mounted and preserved in slides and identified to genus. The slide mounting was carried out by preserving the adult female specimens under a binocular dissection microscope, LEICA EZ4HD using Kosztarab and Kozár (1988) methods.

Species identifications were made by observing the specific features of the mealybug species, ~~included-including~~ body size, shape, and color, using a phase-contrast compound microscope (LEICA DM2700) and were identified using the keys in Williams and Watson (1988), Williams and Granara de Willink (1992), and Williams (2004). The morphological parameters used are those used by Williams and Granara de Willink (1992) and Williams (2004). ~~Type specimens of the genus and species described~~Specimens are deposited in the Mealybugs Museum, Department of Plant Protection, Faculty of Agriculture, University of Bengkulu, Bengkulu, Indonesia (MMUB).

Comment [rev1_2]: You don not describe any species in this MS, thus referring to type depository is unnecessary. If collected specimens are stored at the Mealybug Museum, than leave the sentence here, if not, please delete it.

Results and Discussion

The research collected 85 mealybug specimens in Indonesian Sunda shelf regions consisted of 5 species within 4 genera. The identified species belong to the genus *Antonina* Signoret (2 species), *Chaetococcus* Maskell (1 species), *Dysmicoccus* Ferris (1 species), *Palmicultor* Williams (1 species). *Antonina pretiosa* Ferris and *Dysmicoccus zeynepae* are newly recorded for Indonesian Sunda shelf. In addition, *Dysmicoccus* is the first reported genus attacks on Bamboo in worldwide. The species marked with an asterisk (*) are legless mealybugs.

~~Here we increased the~~ Identification key to adult females of ~~Pseudococcid-pseudococcid~~ mealybugs (Hemiptera: Pseudococcidae) complex of bamboo trees in Indonesia (11 species), adapted from Williams and Watson (1988), Williams and Granara de Willink (1992) and Williams (2004).

- 1(0) Legs present..... 7
- Legs absent 2
- 2(1) Anal ring normally situated on body surface or at base of very short tube, bearing at least 6 setae. Venter with duct-like pores in a group posterior to each second spiracle. Ventral disc-like pores absent from abdomen
..... *Chaetococcus bambusae* Maskell
- Anal ring situated at base of anal tube, normally bearing 6 setae (rarely without setae). Venter without duct-like pores posterior to each second spiracle, but disc-like pores or very short, button-like microtubular ducts present in this position, sometimes also in a wider distribution on sub median to submarginal areas of abdomen 3
- 3(2) At least posterior segments of abdomen plate-like, at maturity becoming sclerotized from body margin to medial or sub medial areas. Trilocular pores, in profile, as deep as wide..... *Antonina pretiosa* Ferris
- Abdominal segments not plate-like, not becoming sclerotized from medial or sub medial areas. Trilocular pores, in profile, more or less flat 4
- 4(3) Multilocular disc pores forming a marginal band around entire body
..... *Antonina thaiensis* Takahashi
- Multilocular disc pores not forming a marginal band around entire body 5
- 5(4) Disc-like pores present on at least abdominal segments II-IV
..... *Antonina graminis* (Maskell)
- Disc-like pores present in a single cluster posterior to each second spiracle: if extending onto abdominal segment II, then never present on abdominal segment III and IV 6
- 6(5) Marginal setae same size as dorsal setae on head and thorax, present between antennae and around rest of body *Antonina milleri* Williams
- Marginal setae much longer than dorsal setae on head and thorax, absent from between antennae but present around rest of body *Antonina zonata* Green
- 7(1) Oral rim tubular duct present, each with well-developed rim.....

-*Paracoccus interceptus* Lit
- Oral rim tubular duct absent entirely 8
 - 8(7) Each eye associated with sclerotized patch containing discoidal pores, these pores sometimes as large as a multilocular disc pore; other similar disc pores also present, dispersed, at least on venter. Cerarii always numbering 18 pairs
.....*Hordeolicoccus nephelii* (Takahashi)
 - If eyes are associated with discoidal pores then these are few, small and inconspicuous. Cerarii numbering 1–17 pairs 9
 - 9(8) Anterior margins of hind coxa indistinct; spiracles and leg bases situated much closer to margin than to midline *Extanticoccus javanensis* Williams
 - Anterior margin of hind coxa distinct; spiracles and leg bases situated submedially, about halfway between margin and midline 10
 - 10(9) Derm around hind coxa with numerous minute pores
.....*Palmicultor lumpurensis* (Takahashi)
 - Derm around hind coxa without minute pores
.....*Dysmicoccus zeynepae* Zarkani & Kaydan

Antonina* Signoret

***Antonina pretiosa* Ferris* (Fig. 1&6)**

Material examined. INDONESIA, Sumatra, Bengkulu Province, Kepahiang district, Kabawetan, on *Bambusa* sp. (Poaceae), 600 m a.s.l, 03°34'54.4" S, 102°35'33" E, 12.vi.2022, coll. A. Zarkani (AZ1080-1081), 6 ♀♀; West Sumatra Province, Padang city, Nanggalo, on *Bambusa* sp. (Poaceae), 100 m a.s.l. 0°54'00.7" S, 100°21'54.1" E, 8.ii.2022, coll. A. Zarkani (AZ700-702), 9 ♀♀. East Sumatra Province, Palembang city, Ilir Barat 1, on *Bambusa* sp. (Poaceae), 230 m a.s.l. 2°58'36.0"S, 104°44'30.2"E, 12.iv.2022, coll. A. Zarkani (AZ880-881), 6 ♀♀.

Comments. *Antonina pretiosa* is oligophagous insect species which lives on 6 genera in Poaceae (García Morales *et al.* 2016; Zarkani *et al.* 2021). The species is widely distributed in the tropical and subtropical zones of the world. In Indonesia, the first record was reported by Gavrilov-Zimin (2013) in Sulawesi, a part of Indo-Australian regions and it has been a new record for Indonesian Sunda shelf.

FIGURE 1. *Antonina pretiosa* Ferris (Hemiptera: Pseudococcidae). (A) Anal ring situated at base of an anal tube (↓), Abdomen plate-like (↓); (B) Multilocular disc pore restricted to a few, situated lateral to opening of anal tube on dorsum; (C) Spiracular openings with associated with trilocular pores.

***Antonina thaiensis* Takahashi* (Fig. 2)**

Material examined. INDONESIA, Sumatra, Bengkulu Province, North Bengkulu district, Arga Makmur town, on *Bambusa* sp. (Poaceae), 300 m a.s.l, 3°26'16.4" S, 102°11'51.1" E, 12.viii.2022, coll. A. Zarkani (AZ1180-1181), 6 ♀♀; East Sumatra Province, Palembang city, Ilir Barat 1, on *Bambusa* sp. (Poaceae), 230 m a.s.l. 2°58'36.0"S, 104°44'30.2"E, 12.iv.2022, coll. A. Zarkani (AZ882-883), 6 ♀♀.

Comments. This is oligophagous species on genus *Bambusa* and *Phragmites* (Poaceae) (García Morales *et al.* 2016; Zarkani *et al.* 2021). In Indonesia, *A. thaiensis* has been recorded previously from Java (Sartiami *et. al.* 2016). It is also found in neighboring countries such as India, Malaysia, Philippines and Srilanka and Thailand (Williams 2004; Gracia Morales *et al.* 2016).

FIGURE 2. *Antonina thaiensis* Takahashi (Hemiptera: Pseudococcidae). (A) Anal ring situated at base of an anal tube; (B) Disc-like pores present on venter of abdomen; (C) Multilocular disc pore present encircling at least anterior spiracles; (D) Multilocular disc pores of 1 type only.

***Chaetococcus* Maskell**

***Chaetococcus bambusae* (Maskell)* (Fig. 3)**

Comment [rev1_3]: they are legless as well

Material examined. INDONESIA, Sumatra, Bengkulu Province, Bengkulu Tengah district, Wilayah Kosong, on *Bambusa* sp. (Poaceae), 355 m a.s.l., 3°42'41.4" S, 102°31'33.1" E, 5.iii.2019, coll. A. Zarkani (AZ247), 3 ♀♀. Rejang Lebong district, Sindang Kelingi, on *Bambusa* sp. (Poaceae), 1020 m a.s.l., 3°27'40.8" S, 102°42'40.8" E, 9.viii.2022, coll. A. Zarkani (AZ1001), 3 ♀♀, West Java, Bogor, on *Bambusa* sp. 222 m a.s.l. 6°34'40.0"S, 106°46'30.17"E, 2 ♀♀, 15.xii.2022, coll. D. Sartiami.

Comments. The species is oligophagous that feeds on 10 genera in Poacea (García Morales *et al.* 2016; Zarkani *et al.* 2021). It is a cosmopolitan insect, having been recorded from 44 countries (García Morales *et al.* 2016). In Indonesia, *C. bambusae* has been recorded previously from Flores and Irian Jaya (Gavrilov-Zimin 2013), Java (Sartiami *et al.* 2016) and Sumatra (Williams 2004).

FIGURE 3. *Chaetococcus bambusae* (Maskell) (Hemiptera: Pseudococcidae). (A) Multilocular disc pores confined to abdominal segments VII and VIII; (B) Duct-like pores present on venter in a group posterior to each second spiracle; (C) Large tubular ducts with collar about two-thirds the length of duct present around head margin; (D) Spiracles each associated with a crescentic band of small trilobular pores at atrium.

Dysmicoccus Ferris

Dysmicoccus zeynepae Zarkani & Kaydan (Fig. 4 & 7)

Material examined. INDONESIA, Sumatra, Bengkulu Province, Rejang Lebong district, Sindang Kelingi, on *Bambusa* sp. (Poaceae), 1020 m a.s.l., 3°27'40.8" S, 102°42'40.8" E, 9.viii.2022, coll. A. Zarkani (AZ1000), 3 ♀♀. West Sumatra Province, Padang city, Nanggalo, on *Bambusa* sp. (Poaceae), 100 m a.s.l. 0°54'00.7" S, 100°21'54.1" E, 8.ii.2022, coll. A. Zarkani (AZ703), 3 ♀.

Comments. *Dysmicoccus zeynepae* Zarkani & Kaydan is polyphagous species complex of *Durio zibethinus* (Malvaceae), *Lansium parasiticum* (Meliaceae), *Manilkara zapota* (Sapotaceae) and *Coffea robusta* (Rubiaceae) (Zarkani *et al.* 2023). The species is closed to *Dysmicoccus finitimus* Williams in having anal lobe and abdominal cerarii each containing a group of about 2–7 conical setae. However, it is different with some features such as no

multilocular disc pores and oral collar tubular ducts on dorsum within a few multilocular disc pores without oral collar tubular ducts on venter. This species is easily recognized by having small legs and translucent pore on hind coxa and femur. **This is the first report of *Dysmicoccus* infestation on bamboo trees worldwide.**

Comment [rev1_4]: There are two *Dysmicoccus* species reported on bamboo in previous publications:

<http://scalenet.info/associates/bambusa/dysmicoccus/>

Maybe you wanted to say, that this species was recorded on bamboo first time. And also, first *Dysmicoccus* species feeding on bamboo from Indonesia (definitely not worldwide).

FIGURE 4. *Dysmicoccus zeynepae* Zarkani & Kaydan (Hemiptera: Pseudococcidae). (A) Small legs; (B) Venter with a few multilocular disc pores and oral collar tubular ducts absent from both dorsum and venter.

Palmicultor Williams

Palmicultor lumpurensis (Takahashi) (Fig. 5 & 87)

Material examined. INDONESIA, Sumatra, Bengkulu Province, Kepahiang district, Kabawetan, on *Bambusa* sp. (Poaceae), 600 m a.s.l, 03°34'54.4" S, 102°35'33" E, 12.vi.2022, coll. A. Zarkani (AZ1080-1081), 6 ♀♀; East Sumatra Province, Palembang city, Ilir Barat 1, on *Bambusa* sp. (Poaceae), 230 m a.s.l. 2°58'36.0"S, 104°44'30.2"E, 12.iv.2022, coll. A. Zarkani (AZ884), 3 ♀♀.

Comments. This is an oligophagous species that feed on 11 genera of plants on Poaceae (García Morales *et al.* 2016; Zarkani *et al.* 2021). It is cosmopolitan, being found in 11 countries spread over all continents. In Indonesia, it has been recorded from Bali (Gavrilov-Zimin 2017) and Irian Jaya (Gavrilov-Zimin 2013). Indonesian specimens of *P. lumpurensis* differ from the illustration Williams (2004) provided by having less multilocular disc pores on the dorsum and the ventral surface (Fig. 7).

FIGURE 5. *Palmicultor lumpurensis* (Takahashi) (Hemiptera: Pseudococcidae). (A) Large- and small-type oral collar tubular ducts numerous on dorsum, present in rows across segments; (B) Multilocular disc pores numerous around dorsum and venter of head, thorax and abdomen; (C) Minute duct-like pores present on derm next to hind coxa.

FIGURE 6. Pseudococcid mealybug (Hemiptera: Pseudococcidae) complex of bamboo trees in Indonesian Sunda shelf regions. (A) Symbioses among ants and *Dysmicoccus zeynepae* Zarkani & Kaydan; (B) *Antonina pretiosa* Ferris; (C) Symbioses among ants and *Antonina*

thaiensis Takahashi; (D) *Chaetococcus bambusae* (Maskell); and (E) *Palmicultor lumpurensis* (Takahashi).

FIGURE 7. Adult female *Palmicultor lumpurensis* (Takahashi). Specimen from Indonesian Sunda shelf.

Acknowledgements

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References

- Ben-Dov Y. 1994. *A systematic catalogue of the mealybugs of the world (Insecta: Homoptera: Coccoidea: Pseudococcidae and Putoidae) with data on geographical distribution, host plants, biology and economic importance*. Intercept Limited, Andover, 686 pp.
- Dransfield S. & Widjaja E. A. 1995. *Plant Resources of South-East Asia, No 7. Bamboos*. Backhuys Publishers, Leiden. Pp. 15-49.
- Fu M., Xiao J. & Lou Y. 2000. *Cultivation and Utilization on Bamboo*. China Forestry Publishing House, Beijing, 137 pp.
- Gavrilov-Zimin I. A. 2013. New scale insects (Homoptera: Coccinea) from Sulawesi and New Guinea, with some other additions to the Indonesian fauna. *Tropical Zoology* 26(2): 64-86
- Gavrilov-Zimin I. A. 2017. Taxonomic and faunistic notes on scale insects (Homoptera: Coccinea) of Bali, Flores and New Guinea (Indonesia). *Biodiversity, Biogeography and Nature Conservation in Wallacea and New Guinea, III Entomological Society of Latvia Salaspils* 141-149.
- García Morales M., Denno B., Miller D. R., Miller G. L., Ben-Dov Y. & Hardy N. B. 2016. *ScaleNet: a literature-based model of scale insect biology and systematics*. Available from: <http://scalenet.info> (accessed 18 January 2023)
- Granara de Willink M. C. & Szumik C. 2007. Phenacoccinae de Centro y Sudamérica (Hemiptera: Coccoidea: Pseudococcidae): sistemática y filogenia. *Revista de la Sociedad Entomológica Argentina* 66: 29–129.

- Kalshoven L. G. E. 1981. *Coccoidea. Pests of crops in Indonesia*. Ichtiar Baru, Jakarta, 701 pp.
- Kosztarab M. & Kozár F. 1988. *Scale Insects of Central Europe*. Akadémiai Kiadó, Budapest, 456 pp.
- Lohman D. J., Bruyn Md., Page T., Rintelen Kv., Hall R., Ng, P. K. L., Shih H., Carvalho, G. R. & Rintelen Tv. 2011. Biogeography of the Indo-Australian Archipelago. *Annual Review of Ecology, Evolution, and Systematics* 42 (1): 205-226. Available from: <https://www.annualreviews.org/doi/10.1146/annurev-ecolsys-102710-145001> (Accessed 20 January 2023)
- Sartiami D., Watson G. W., Mohamad Roff M. N. & Idris A. B. 2016. New Indonesian country records and species information for mealybugs (Hemiptera Pseudococcidae) in Wirjati's historic collection. *Redia XCIX* 155-161.
- Thanh L. B., Nha N. T. & Hieu B. T. 2007. Research on the State of Insect Pests and Protectively Covering Method for Shoot of Bamboo Species Widely Planted in Vietnam. *Science and Technology Journal of Agriculture & Rural Development* 5: 94-99.
- Watson G. W., Muniappan R., Shepard B. M., Sembel D. T., Xiong J. J. & Rauf A. 2014. Sap-sucking insect records (Hemiptera: Sternorrhyncha and Thysanoptera: Thripidae) from Indonesia. *Florida Entomologist* 97: 1594–1597. <https://doi.org/10.1653/024.097.0432>
- Williams D. J. 2004. *Mealybugs of southern Asia*. The Natural History Museum, London. Southdene SDN BHD, Kuala Lumpur, 896 pp.
- Williams D. J. & Granara de Willink M. C. 1992. *Mealybugs of Central and South America*. CAB International, Wallingford, 635 pp.
- Williams D. J. & Watson G. W. 1988. *The Scale Insects of the Tropical South Pacific Region. Pt. 2. The Mealybugs (Pseudococcidae)*. CAB International, Wallingford, 260 pp.
- Zarkani A., Apriyanto D., Turanli F., Ercan C. & Kaydan M. B. 2021. A checklist of Indonesian scale insects (Hemiptera: Coccoomorpha). *Zootaxa* 5016 (2): 151–195. <https://doi.org/10.11646/zootaxa.5016.2.1>
- Zarkani A., Ercan C., Apriyanto D. & Kaydan M. B. 2023. Studies on mealybugs (Hemiptera: Coccoomorpha) in Indonesia, with description of a new species and three new country records. *Zootaxa* 5228(2): 157–172. <https://doi.org/10.11646/zootaxa.5228.2.4>

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FIGURE 7. ~~Adult female *Palmicultor lumpurensis* (Takahashi). Specimen from Indonesian Sunda shelf.~~

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Abstract

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Keywords: Biodiversity, Coccoomorpha, host plant, pests, Sternorrhyncha, taxonomy

Introduction

As a mega biodiversity²s country, Indonesia is influenced by Asian and Australian biodiversity. In fact, at the beginning of the ice age, the western part of Indonesia such as Bali, Java, Kalimantan and Sumatra merged with the Asian continent (Sunda shelf), while the eastern part of Indonesia was integrated with the Australian continent (Sahul shelf) (Lohman *et al.* 2011). The high diversity of flora and fauna, including insect species, is a result of unique geological and evolutionary history in combination with the wide variety of habitats associated with its many islands (Arifin & Nakagoshi 2011). Nevertheless, the geographic dimension of Indonesian biodiversity, in particular, species endemism across geographical gradients, has not been taken into account.

A plant genus within a high diversity is bamboo (*Bambusa* sp.), a woody perennial evergreen plants belonging to the family Poaceae, consisted of over 590 species in 44 genera (Dransfield & Widjaya 1995). ~~This Bamboo~~ is one of the important exporting agricultural material products over the world: ~~consisted of over 590 species in 44 genera (Dransfield & Widjaya 1995).~~ ~~This this~~ plant is commonly used as pulp for paper mills, houses material, handicrafts, food product items and other people's daily lives (Fu *et al.* 2000).

Whilst bamboo is one of leading agricultural products in the world, the growing as well as the exporting process faces many problems, including insect pest infestations (Thanh *et al.* 2007). There are more than 400 insect species feeding on bamboos within which about 100 species gaining pest status, including mealybugs that can cause heavy damage to the plant (Hemiptera: Coccoomorpha: Pseudococcidae) (Kalshoven 1981; Gracia Morales *et al.* 2016). ~~This Pseudococcidae~~ is the second-largest family in Coccoomorpha after Diaspididae. As one of the important insect pests of worldwide, mealybugs play significant roles in transmitting virus, spreading among plants in intra-inter specific relations (Ben-Dov 1994). ~~The small, persistent, and tiny characters of the~~ Scale insects ~~is are~~ often become subjects of intercepted alien species in many countries due to the small, persistent, and tiny characters of them (Williams 2004; Kaydan *et al.* 2015).

In general, there are 2,041 mealybug species in 259 genera worldwide within which 109 species from 32 genera shuttled in Indonesia (García Morales *et al.* 2016; Zarkani *et al.* 2021, 2023). In fact, about 44 Pseudococcid species lives on bamboo in which 10 species (7 genera) namely *Antonina graminis* (Maskell), *Antonina milleri* Williams, *Antonina pretiosa* Ferris, *Antonina thaiensis* Takahashi, *Antonina zonata* Green, *Chaetococcus bambusae* (Maskell), *Extantococcus javanensis* Williams, *Hordeolicoccus nephelii*

(Takahashi), *Palmicultor lumpurensis* (Takahashi), and *Paracoccus interceptus* Lit are already existed in Indonesia (Williams 2004; Garcia Morales *et al.* 2016; Sartiami *et al.* 2016; Zarkani *et al.* 2021).

For the last decades, the study of bamboo mostly focused on genetic variability, chemical contains, and their utilities in agriculture as well as in medical sectors, but a few studies in insect faunal diversity. This study listed bamboo-feeding pseudococcids in the Sunda Shelf including new fauna records, as well as updated identification key of mealybugs complex of bamboo in Indonesia, as well as updated review of the entire bamboo-feeding insects in the Sunda Shelf which has never been recorded before.

Materials and Methods

Mealybug specimens were collected from a series of sampling occasions on leaves, trunks, branches, and roots in bamboo trees in Bengkulu Province, West Sumatra Province, and East Sumatra Province, Indonesia from March to December 2022. The sampling sites are at an altitude of 0 – 1000 m above sea level. The specimens were mounted and preserved in slides and identified to genus. The slide mounting was carried out by preserving the adult female specimens under a binocular dissection microscope, LEICA EZ4HD using Kosztarab and Kozár (1988) methods.

Species identifications were made by observing the specific features of the mealybug species, ~~included-including~~ body size, shape, and color, using a phase-contrast compound microscope (LEICA DM2700) and were identified using the keys in Williams and Watson (1988), Williams and Granara de Willink (1992), and Williams (2004). The morphological parameters used are those used by Williams and Granara de Willink (1992) and Williams (2004). ~~Type specimens of the genus and species described~~Specimens are deposited in the Mealybugs Museum, Department of Plant Protection, Faculty of Agriculture, University of Bengkulu, Bengkulu, Indonesia (MMUB).

Results and Discussion

The research collected 85 mealybug specimens in Indonesian Sunda shelf regions consisted of 5 species within 4 genera. The identified species belong to the genus *Antonina* Signoret (2 species), *Chaetococcus* Maskell (1 species), *Dysmicoccus* Ferris (1 species), *Palmicultor* Williams (1 species). *Antonina pretiosa* Ferris and *Dysmicoccus zeynepae* are newly recorded for Indonesian Sunda shelf. In addition, *Dysmicoccus* is the first reported genus attacks on Bamboo in worldwide. The species marked with an asterisk (*) are legless mealybugs.

~~Here we increased the~~Identification key to adult females of ~~Pseudococcid~~pseudococcid mealybugs (Hemiptera: Pseudococcidae) complex of bamboo trees in Indonesia (11 species), adapted from Williams and Watson (1988), Williams and Granara de Willink (1992) and Williams (2004).

- | | | |
|------|--|------------------------------|
| 1(0) | Legs present | 7 |
| - | Legs absent | 2 |
| 2(1) | Anal ring normally situated on body surface or at base of very short tube, bearing at least 6 setae. Venter with duct-like pores in a group posterior to each second spiracle. Ventral disc-like pores absent from abdomen | |
| | <i>Chaetococcus bambusae</i> Maskell | |
| - | Anal ring situated at base of anal tube, normally bearing 6 setae (rarely without setae). Venter without duct-like pores posterior to each second spiracle, but disc-like pores or very short, button-like microtubular ducts present in this position, sometimes also in a wider distribution on sub median to submarginal areas of abdomen | 3 |
| 3(2) | At least posterior segments of abdomen plate-like, at maturity becoming sclerotized from body margin to medial or sub medial areas. Trilocular pores, in profile, as deep as wide. | |
| | <i>Antonina pretiosa</i> Ferris | |
| - | Abdominal segments not plate-like, not becoming sclerotized from medial or sub medial areas. Trilocular pores, in profile, more or less flat | 4 |
| 4(3) | Multilocular disc pores forming a marginal band around entire body | |
| | <i>Antonina thaiensis</i> Takahashi | |
| - | Multilocular disc pores not forming a marginal band around entire body | 5 |
| 5(4) | Disc-like pores present on at least abdominal segments II-IV | |
| | <i>Antonina graminis</i> (Maskell) | |
| - | Disc-like pores present in a single cluster posterior to each second spiracle: if extending onto abdominal segment II, then never present on abdominal segment III and IV | 6 |
| 6(5) | Marginal setae same size as dorsal setae on head and thorax, present between antennae and around rest of body | |
| | <i>Antonina milleri</i> Williams | |
| - | Marginal setae much longer than dorsal setae on head and thorax, absent from between antennae but present around rest of body | <i>Antonina zonata</i> Green |
| 7(1) | Oral rim tubular duct present, each with well-developed rim | |

Paracoccus interceptus Lit

- Oral rim tubular duct absent entirely 8
- 8(7) Each eye associated with sclerotized patch containing discoidal pores, these pores sometimes as large as a multilocular disc pore; other similar disc pores also present, dispersed, at least on venter. Cerarii always numbering 18 pairs

Hordeolicoccus nephelii (Takahashi)

- If eyes are associated with discoidal pores then these are few, small and inconspicuous. Cerarii numbering 1–17 pairs 9
- 9(8) Anterior margins of hind coxa indistinct; spiracles and leg bases situated much closer to margin than to midline *Extanticoccus javanensis* Williams

- Anterior margin of hind coxa distinct; spiracles and leg bases situated submedially, about halfway between margin and midline 10

- 10(9) Derm around hind coxa with numerous minute pores

Palmicultor lumpurensis (Takahashi)

- Derm around hind coxa without minute pores

Dysmicoccus zeynepae Zarkani & Kaydan

Antonina* Signoret

***Antonina pretiosa* Ferris* (Fig. 1&6)**

Material examined. INDONESIA, Sumatra, Bengkulu Province, Kepahiang district, Kabawetan, on *Bambusa* sp. (Poaceae), 600 m a.s.l, 03°34'54.4" S, 102°35'33" E, 12.vi.2022, coll. A. Zarkani (AZ1080-1081), 6 ♀♀; West Sumatra Province, Padang city, Nanggalo, on *Bambusa* sp. (Poaceae), 100 m a.s.l. 0°54'00.7" S, 100°21'54.1" E, 8.ii.2022, coll. A. Zarkani (AZ700-702), 9 ♀♀. East Sumatra Province, Palembang city, Ilir Barat 1, on *Bambusa* sp. (Poaceae), 230 m a.s.l. 2°58'36.0"S, 104°44'30.2"E, 12.iv.2022, coll. A. Zarkani (AZ880-881), 6 ♀♀.

Comments. *Antonina pretiosa* is oligophagous insect species which lives on 6 genera in Poaceaea (García Morales *et al.* 2016; Zarkani *et al.* 2021). The species is widely distributed in the tropical and subtropical zones of the world. In Indonesia, the first record was reported by Gavrilov-Zimin (2013) in Sulawesi, a part of Indo-Australian regions and it has been a new record for Indonesian Sunda shelf.

FIGURE 1. *Antonina pretiosa* Ferris (Hemiptera: Pseudococcidae). (A) Anal ring situated at base of an anal tube (), Abdomen plate-like (↓); (B) Multilocular disc pore restricted to a few, situated lateral to opening of anal tube on dorsum; (C) Spiracular openings with associated with trilocular pores.

***Antonina thaiensis* Takahashi* (Fig. 2)**

Material examined. INDONESIA, Sumatra, Bengkulu Province, North Bengkulu district, Arga Makmur town, on *Bambusa* sp. (Poaceae), 300 m a.s.l, 3°26'16.4" S, 102°11'51.1" E, 12.viii.2022, coll. A. Zarkani (AZ1180-1181), 6 ♀♀; East Sumatra Province, Palembang city, Ilir Barat 1, on *Bambusa* sp. (Poaceae), 230 m a.s.l. 2°58'36.0"S, 104°44'30.2"E, 12.iv.2022, coll. A. Zarkani (AZ882-883), 6 ♀♀.

Comments. This is oligophagous species on genus *Bambusa* and *Phragmites* (Poaceae) (García Morales *et al.* 2016; Zarkani *et al.* 2021). In Indonesia, *A. thaiensis* has been recorded previously from Java (Sartiami *et. al.* 2016). It is also found in neighboring countries such as India, Malaysia, Philippines and Srilanka and Thailand (Williams 2004; Gracia Morales *et al.* 2016).

FIGURE 2. *Antonina thaiensis* Takahashi (Hemiptera: Pseudococcidae). (A) Anal ring situated at base of an anal tube; (B) Disc-like pores present on venter of abdomen; (C) Multilocular disc pore present encircling at least anterior spiracles; (D) Multilocular disc pores of 1 type only.

***Chaetococcus* Maskell**

***Chaetococcus bambusae* (Maskell)* (Fig. 3)**

Material examined. INDONESIA, Sumatra, Bengkulu Province, Bengkulu Tengah district, Wilayah Kosong, on *Bambusa* sp. (Poaceae), 355 m a.s.l., 3°42'41.4" S, 102°31'33.1" E, 5.iii.2019, coll. A. Zarkani (AZ247), 3 ♀♀. Rejang Lebong district, Sindang Kelingi, on *Bambusa* sp. (Poaceae), 1020 m a.s.l., 3°27'40.8" S, 102°42'40.8" E, 9.viii.2022, coll. A. Zarkani (AZ1001), 3 ♀♀, West Java, Bogor, on *Bambusa* sp. 222 m a.s.l. 6°34'40.0"S, 106°46'30.17"E, 2 ♀♀, 15.xii.2022, coll. D. Sartiami.

Comments. The species is oligophagous that feeds on 10 genera in Poacea (García Morales *et al.* 2016; Zarkani *et al.* 2021). It is a cosmopolitan insect, having been recorded from 44 countries (García Morales *et al.* 2016). In Indonesia, *C. bambusae* has been recorded previously from Flores and Irian Jaya (Gavrilov-Zimin 2013), Java (Sartiami *et al.* 2016) and Sumatra (Williams 2004).

FIGURE 3. *Chaetococcus bambusae* (Maskell) (Hemiptera: Pseudococcidae). (A) Multilocular disc pores confined to abdominal segments VII and VIII; (B) Duct-like pores present on venter in a group posterior to each second spiracle; (C) Large tubular ducts with collar about two-thirds the length of duct present around head margin; (D) Spiracles each associated with a crescentic band of small trilocular pores at atrium.

Dysmicoccus Ferris

***Dysmicoccus zeynepae* Zarkani & Kaydan (Fig. 4 & 7)**

Material examined. INDONESIA, Sumatra, Bengkulu Province, Rejang Lebong district, Sindang Kelingi, on *Bambusa* sp. (Poaceae), 1020 m a.s.l., 3°27'40.8" S, 102°42'40.8" E, 9.viii.2022, coll. A. Zarkani (AZ1000), 3 ♀♀. West Sumatra Province, Padang city, Nanggalo, on *Bambusa* sp. (Poaceae), 100 m a.s.l. 0°54'00.7" S, 100°21'54.1" E, 8.ii.2022, coll. A. Zarkani (AZ703), 3 ♀.

Comments. *Dysmicoccus zeynepae* Zarkani & Kaydan is polyphagous species complex of *Durio zibethinus* (Malvaceae), *Lansium parasiticum* (Meliaceae), *Manilkara zapota* (Sapotaceae) and *Coffea robusta* (Rubiaceae) (Zarkani *et al.* 2023). The species is closed to *Dysmicoccus finitimus* Williams in having anal lobe and abdominal cerarii each containing a group of about 2–7 conical setae. However, it is different with some features such as no multilocular disc pores and oral collar tubular ducts on dorsum within a few multilocular disc pores without oral collar tubular ducts on venter. This species is easily recognized by having small legs and translucent pore on hind coxa and femur. This is the first report of *Dysmicoccus* infestation on bamboo trees ~~worldwide~~.

FIGURE 4. *Dysmicoccus zeynepae* Zarkani & Kaydan (Hemiptera: Pseudococcidae). (A) Small legs; (B) Venter with a few multilocular disc pores and oral collar tubular ducts absent from both dorsum and venter.

***Palmicultor* Williams**

***Palmicultor lumpurensis* (Takahashi) (Fig. 5 & 87)**

Material examined. INDONESIA, Sumatra, Bengkulu Province, Kepahiang district, Kabawetan, on *Bambusa* sp. (Poaceae), 600 m a.s.l, 03°34'54.4" S, 102°35'33" E, 12.vi.2022, coll. A. Zarkani (AZ1080-1081), 6 ♀♀; East Sumatra Province, Palembang city, Ilir Barat 1, on *Bambusa* sp. (Poaceae), 230 m a.s.l. 2°58'36.0"S, 104°44'30.2"E, 12.iv.2022, coll. A. Zarkani (AZ884), 3 ♀♀.

Comments. This is an oligophagous species that feed on 11 genera of plants on Poaceae (García Morales *et al.* 2016; Zarkani *et al.* 2021). It is cosmopolitan, being found in 11 countries spread over all continents. In Indonesia, it has been recorded from Bali (Gavrilov-Zimin 2017) and Irian Jaya (Gavrilov-Zimin 2013). Indonesian specimens of *P. lumpurensis* differ from the illustration Williams (2004) provided by having less multilocular disc pores on the dorsum and the ventral surface (Fig. 7).

FIGURE 5. *Palmicultor lumpurensis* (Takahashi) (Hemiptera: Pseudococcidae). (A) Large- and small-type oral collar tubular ducts numerous on dorsum, present in rows across segments; (B) Multilocular disc pores numerous around dorsum and venter of head, thorax and abdomen; (C) Minute duct-like pores present on derm next to hind coxa.

FIGURE 6. Pseudococcid mealybug (Hemiptera: Pseudococcidae) complex of bamboo trees in Indonesian Sunda shelf regions. (A) Symbioses among ants and *Dysmicoccus zeynepae* Zarkani & Kaydan; (B) *Antonina pretiosa* Ferris; (C) Symbioses among ants and *Antonina thaiensis* Takahashi; (D) *Chaetococcus bambusae* (Maskell); and (E) *Palmicultor lumpurensis* (Takahashi).

FIGURE 7. Adult female *Palmicultor lumpurensis* (Takahashi). Specimen from Indonesian Sunda shelf.

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References

- Ben-Dov Y. 1994. *A systematic catalogue of the mealybugs of the world (Insecta: Homoptera: Coccoidea: Pseudococcidae and Putoidae) with data on geographical distribution, host plants, biology and economic importance*. Intercept Limited, Andover, 686 pp.
- Dransfield S. & Widjaja E. A. 1995. *Plant Resources of South-East Asia, No 7. Bamboos*. Backhuys Publishers, Leiden. Pp. 15-49.
- Fu M., Xiao J. & Lou Y. 2000. *Cultivation and Utilization on Bamboo*. China Forestry Publishing House, Beijing, 137 pp.
- Gavrilov-Zimin I. A. 2013. New scale insects (Homoptera: Coccinea) from Sulawesi and New Guinea, with some other additions to the Indonesian fauna. *Tropical Zoology* 26(2): 64-86
- Gavrilov-Zimin I. A. 2017. Taxonomic and faunistic notes on scale insects (Homoptera: Coccinea) of Bali, Flores and New Guinea (Indonesia). *Biodiversity, Biogeography and Nature Conservation in Wallacea and New Guinea, III Entomological Society of Latvia Salaspils* 141-149.
- García Morales M., Denno B., Miller D. R., Miller G. L., Ben-Dov Y. & Hardy N. B. 2016. *ScaleNet: a literature-based model of scale insect biology and systematics*. Available from: <http://scalenet.info> (accessed 18 January 2023)
- Granara de Willink M. C. & Szumik C. 2007. Phenacoccinae de Centro y Sudamérica (Hemiptera: Coccoidea: Pseudococcidae): sistemática y filogenia. *Revista de la Sociedad Entomológica Argentina* 66: 29–129.
- Kalshoven L. G. E. 1981. *Coccoidea. Pests of crops in Indonesia*. Ichtar Baru, Jakarta, 701 pp.
- Kosztarab M. & Kozár F. 1988. *Scale Insects of Central Europe*. Akadémiai Kiadó, Budapest, 456 pp.
- Lohman D. J., Bruyn Md., Page T., Rintelen Kv., Hall R., Ng, P. K. L., Shih H., Carvalho, G. R. & Rintelen Tv. 2011. Biogeography of the Indo-Australian Archipelago. *Annual Review of Ecology, Evolution, and Systematics* 42 (1): 205–226. Available from:

<https://www.annualreviews.org/doi/10.1146/annurev-ecolsys-102710-145001>

(Accessed 20 January 2023)

- Sartiami D., Watson G. W., Mohamad Roff M. N. & Idris A. B. 2016. New Indonesian country records and species information for mealybugs (Hemiptera Pseudococcidae) in Wirjati's historic collection. *Redia XCIX* 155-161.
- Thanh L. B., Nha N. T. & Hieu B. T. 2007. Research on the State of Insect Pests and Protectively Covering Method for Shoot of Bamboo Species Widely Planted in Vietnam. *Science and Technology Journal of Agriculture & Rural Development* 5: 94-99.
- Watson G. W., Muniappan R., Shepard B. M., Sembel D. T., Xiong J. J. & Rauf A. 2014. Sap-sucking insect records (Hemiptera: Sternorrhyncha and Thysanoptera: Thripidae) from Indonesia. *Florida Entomologist* 97: 1594–1597.
<https://doi.org/10.1653/024.097.0432>
- Williams D. J. 2004. *Mealybugs of southern Asia*. The Natural History Museum, London. Southdene SDN BHD, Kuala Lumpur, 896 pp.
- Williams D. J. & Granara de Willink M. C. 1992. *Mealybugs of Central and South America*. CAB International, Wallingford, 635 pp.
- Williams D. J. & Watson G. W. 1988. *The Scale Insects of the Tropical South Pacific Region. Pt. 2. The Mealybugs (Pseudococcidae)*. CAB International, Wallingford, 260 pp.
- Zarkani A., Apriyanto D., Turanli F., Ercan C. & Kaydan M. B. 2021. A checklist of Indonesian scale insects (Hemiptera: Coccoomorpha). *Zootaxa* 5016 (2): 151–195.
<https://doi.org/10.11646/zootaxa.5016.2.1>
- Zarkani A., Ercan C., Apriyanto D. & Kaydan M. B. 2023. Studies on mealybugs (Hemiptera: Coccoomorpha) in Indonesia, with description of a new species and three new country records. *Zootaxa* 5228(2): 157–172. <https://doi.org/10.11646/zootaxa.5228.2.4>

~~**FIGURE 6.** Pseudococcid mealybugs (Hemiptera: Pseudococcidae) complex of bamboo trees in Indonesian Sunda shelf regions. (A) Symbioses among ants and *Dysmicoccus zeynepae* Zarkani & Kaydan; (B) *Antonina pretiosa* Ferris; (C) Symbioses among ants and *Antonina thaiensis* Takahashi; (D) *Chaetococcus bambusae* (Maskell); and (E) *Palmicultor lumpurensis* (Takahashi).~~

FIGURE 7. ~~Adult female *Palmicultor lumpurensis* (Takahashi). Specimen from Indonesian Sunda shelf.~~

Mealybugs (Hemiptera, Coccoomorpha, Pseudococcidae) on parasitic plants (Loranthaceae) in Indonesia with description of a new species and a new country record

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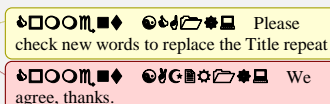
Abstract

Parasitic plants have been known to be attacked by insect pests since ancient times. However, little is known about the mealybug (Hemiptera, Coccoomorpha, Pseudococcidae) fauna associated with them. A series of surveys of mealybugs found on Loranthaceae, a semi-parasitic plant family, was conducted in several places in Bengkulu Province, southern Sumatra, Indonesia. In the study, 55 mealybug specimens were collected, consisting of eight species belonging to five genera, namely *Chorizococcus* McKenzie (1 species), *Dysmicoccus* Ferris (2 species), *Ferrisia* Fullaway (1 species), *Planococcus* Ferris (3 species) and *Pseudococcus* Westwood (1 species). *Chorizococcus ozeri* Zarkani & Kaydan, **sp. nov.** is new to science, whilst *Planococcus bagmaticus* Williams represents the first record in Indonesia. In addition, the mealybugs *Dysmicoccus lepellei* (Betrem), *Dysmicoccus zeynepae* Zarkani & Kaydan, *Ferrisia dasyliirii* (Cockerell), *Planococcus lilacinus* (Cockerell) and *Pseudococcus jackbeardsleyi* Gimpel & Miller are newly recorded from plants of the family Loranthaceae. Figures and illustrations of mealybug species with a taxonomic key of Asian *Chorizococcus* and a new country record based on morphological characters are also updated.

Keywords: Biodiversity, identification key, new record, parasitic plant, pests, Sternorrhyncha, taxonomy

Introduction

Loranthaceae is a primitive family of parasitic plants which are photosynthetic xylem feeders and cannot exist independently of the host plant (Musselman and Press 1995).



Parasitic plants often severely reduce agricultural plant production, which impact the plant community (Press and Phoenix 2005). Their productivity and populations are therefore co-dependent on both the quality of the plant hosts that they parasitize and the strength of competition from neighboring plants (Pennings and Callaway 2002). In addition, a decrease in the quality of the host plants will affect organisms at other trophic levels such as herbivores and pollinators, and ultimately also affect the conditions of the abiotic environment, including having an impact on the nutrient cycles, groundwater relations, local temperature, and atmospheric CO₂ concentrations (Press and Phoenix 2005).

Just as non-parasitic plants have been attacked by insect pests for many generations, parasitic plants have also been known to be attacked by insect pests since ancient times. However, little information about the mealybug fauna (Hemiptera, Coccothraupidae, Pseudococcidae) associated with parasitic plants is known. According to the scale insect database [ScaleNet](https://scalenet.info/), 18 species of mealybugs (Hemiptera, Pseudococcidae) have been reported to be associated with Loranthaceae worldwide, namely *Anisococcus parasitus* Williams & Granara de Willink, *Coccidohystrix insolita* (Green), *Dysmicoccus ambiguous* (Morrison), *Dysmicoccus debregeasiae* (Green), *Dysmicoccus viticis* (Green), *Erioides rimulae* Green, *Exallomochlus hispidus* (Morrison), *Macrocepicoccus loranthi* Morrison, *Nipaecoccus kosztaraborum* Williams & Granara de Willink, *Nipaecoccus nipae* (Maskell), *Paraputo loranthi* (Matile-Ferraro), *Planococcus bendovi* Williams, *Planococcus kenyae* (Le Pelley), *Porococcus coxatus* Ferris, *Porococcus pergandei* Cockerell, *Porococcus tinctorius* Cockerell, *Pseudococcus comstocki* (Kuwana) and *Pseudococcus viburni* (Signoret) (Garcia-Morales et al. 2016). In Indonesia, there are five species that have been reported that are associated with Loranthaceae, namely *C. insolita*, *D. debregeasiae*, *E. hispidus*, *P. bendovi*, and *P. viburni* (Garcia-Morales et al. 2016; Zarkani et al. 2021, 2022; Sartiami et al. 2022).

For decades, the study of parasitic plants focused mainly on genetic variability, chemical contents, and their impact on their host plants. In this study we report several species of mealybugs found on Loranthaceae in Indonesia and provide an updated list of parasitic plant-feeding scale insects in the world. These specialized pests could be evaluated as natural control agents of parasitic plants in the future.

Material and methods

Adult mealybug females were collected from a series of sampling occasions on leaves, trunk, and branches of Loranthaceae trees in Bengkulu Province, southern Sumatra, Indonesia from March to December 2022. The sampling sites are at an altitude of 0–1100 m above sea level.

Please provide a url address, assuming it is online

https://scalenet.info/

Reference of ScaleNet

The specimens were mounted and preserved in slides and identified to genus level. The slide mounting was carried out under a binocular dissection microscope, LEICA EZ4HD by using the method described Kosztarab and Kozár (1988).

Species identifications were made by observing the specific features of the mealybug species using a phase-contrast compound microscope (LEICA DM2700) and were identified using the keys in Williams and Watson (1988), Williams and Granara de Willink (1992) and Williams (2004). The morphological parameters used are those used by Williams and Granara de Willink (1992), Williams (2004) and Zarkani et al. (2023). The body width and length were measured in mm which is the largest transverse measurement perpendicular to the longitudinal axis and the longest longitudinal, respectively. Other measurements are given in μm in which the standardized measurements of anatomical features, for example, antennal segments, leg segments, anal ring, pores are given. Antennae length is the sum of all segments of the antennae. Leg length is the sum of the lengths of the trochanter + femur, tibia + tarsus, and claw. In the taxonomic illustrations, the dorsal morphology is shown on the left side whilst the ventral morphology is shown on the right side. Type specimens of the genus and species described are deposited in the Mealybugs Museum, Department of Plant Protection, Faculty of Agriculture, University of Bengkulu, Bengkulu, Indonesia (MMUB).

Results and Discussion

A series of surveys carried out in southern Sumatra on Loranthaceae resulted in the collection of 55 mealybug specimens consisting of eight species belonging to five genera. The identified species belong to the genera *Chorizococcus* McKenzie (1 species), *Dysmicoccus* Ferris (2 species), *Ferrisia* Fullaway (1 species), *Planococcus* Ferris (3 species) and *Pseudococcus* Westwood (1 species). One species is new to science, *Chorizococcus ozeri* Zarkani & Kaydan, whilst another, *Planococcus bagmaticus* Williams is a newly recorded in Indonesia. In addition, this is the first report of the genus *Chorizococcus* attacking Loranthaceae worldwide. Furthermore, the mealybugs *Dysmicoccus lepellei* (Betrem), *Dysmicoccus zeynepae* Zarkani & Kaydan, *Ferrisia dasyliirii* (Cockerell), *Planococcus lilacinus* (Cockerell) and *Pseudococcus jackbeardsleyi* Gimpel & Miller were found for the first time associated with Loranthaceae in the world.

Currently, a total of 18 mealybug species (Hemiptera, Pseudococcidae) have been reported on plants of the family Loranthaceae worldwide (García-Morales et al. 2016); hence within this study, the number of mealybug species on these parasitic plants is increased to 26 species. The species marked with an asterisk (*) below are recorded for the first time from

Indonesia. Furthermore, the species that are new host records on Loranthaceae worldwide are indicated with a plus mark (+).

***Chorizococcus* McKenzie**

Type species: *Chorizococcus wilkeyi* McKenzie, by original designation.

Genus diagnosis (adapted from Williams, 2004). Body of adult female membranous, varying in shape from elongate oval with almost parallel sides, to broadly oval. With 1-5 pairs of cerarii present on posterior segments of abdomen and sometimes a pair on head also, each cerarius bearing 2 conical setae; auxiliary setae absent from cerarii anterior to anal lobe pair. Oral rim ducts, sometimes of 2 sizes, present on dorsum and frequently also on venter. Oral collar tubular ducts usually present, at least on venter; if present on dorsum, then restricted to margins. Antennae each normally with 7 or 8 segments. Legs well developed, with translucent pores usually present, at least on hind coxae. Claw normally stout, without a denticle. Tarsal digitules minutely knobbed. Multilocular disc pores present on venter, rarely found on dorsum. Circulus present or absent, when present usually divided by an intersegmental line. Anal ring normal, bearing 6 setae. Anterior and posterior ostioles present.

***Chorizococcus ozeri* Zarkani & Kaydan, sp. nov.**

(Figs 1, 2)

Material examined (all deposited at MMUB). **Holotype.** Adult female, left label: AZ1204, 13.vii.2022, Indonesia, Sumatra, Bengkulu, *ex Loranthus* sp., 03°45'10"S, 102°16'59"E, 120 m a.s.l.; right label: *Chorizococcus ozeri* Zarkani & Kaydan, 3 ♀♀, coll. A. Zarkani, det. M.B. Kaydan. The holotype specimen is ringed with red ink on the coverslip. **Paratypes.** 3 ♀♀, INDONESIA: (AZ1205), same data as holotype; 3 ♀♀, AZ206, Sumatra, Bengkulu on semi-parasitic plant, *Loranthus* sp. (Loranthaceae), living on avocado (*Persea americana* Mill.), 03°45'10"S, 102°16'59"E, 13.vii.2022, coll. A. Zarkani.

Description of adult female.

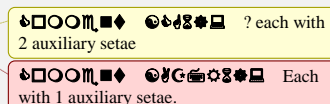
Appearance in life (Fig. 1). Adult females produce a powdery white wax covering the dorsal surface of their bodies. Living on parasitic roots, branches, leaves, and flowers of its host plant, commonly attended by ants of the genus *Dolichoderus* Lund.

Slide-mounted adult female (based on the holotype and 3 paratypes) (Fig. 2):

Body oval, 2.25–2.28 mm long, 1.40–1.50 mm wide. Eyes situated on margins, each 17.5–30 µm wide. Antenna 7 segmented, 370–380 µm long, with 4 fleshy setae, each 20–25 µm long; apical segment 87.5–92.5 µm long, 30.0–32.5 µm wide, with apical seta 30.0–32.5 µm long. Clypeolabral shield 112.5–132.5 µm long, 87.5–100 µm wide. Labium 3 segmented, 67.5–87.5 µm long, 67.5–75.0 µm wide. Anterior spiracles each 57.5–75.0 µm long, 30.0–42.5 µm wide across atrium; posterior spiracles each 62.5–75.0 µm long, 32.5–37.5 µm wide across atrium. Circulus rounded or quadrate, 11.3–12.5 µm wide. Legs well developed; segment lengths for each posterior leg: coxa 125–175 µm, trochanter + femur 237.5–307.5 µm, tibia + tarsus 225–300 µm, claw 25.0–27.5 µm. Ratio of length of tibia + tarsus to trochanter + femur, 0.95–0.98: 1; ratio of length of tibia to tarsus, 1.81–2.16: 1; ratio of length of trochanter + femur to greatest width of femur, 3.8–4.39: 1; coxa with translucent pores, femur and tibia without translucent pores. Tarsal digitules capitate, each 37.5–50.0 µm long. Claw digitules capitate, each about 20.0–22.5 µm long. Both pairs of ostioles present, anterior ostioles each with a total for both lips of 6–11 trilocular pores and without setae; posterior ostioles each with a total for both lips of 6–9 trilocular pores and without setae. Anal ring about 80.0–87.5 µm wide, bearing 6 setae, each seta 87.5–100.0 µm long.

Dorsum. Derm membranous, with 13 pairs of cerarii around body margin, each cerarius with enlarged conical setae set up in 2 rows and each with 1 auxiliary setae. Each anal lobe cerarius set on membranous cuticle and containing 2 enlarged conical setae, each 15–25 µm long, plus 8–10 trilocular pores and 2–3 hair-like auxiliary setae, each about 10–12 µm long. Dorsal setae conical, thinner than most cerarian setae, each 5.0–7.5 µm long, median setae 10.0–12.5 µm long, scattered throughout dorsum. Trilocular pores, each 2.5–3.8 µm in diameter, scattered. Multilocular disc pores and tubular ducts absent.

Venter. Setae flagellate, each 87.5–122.5 µm long, longest setae located medially on head. Apical setae on anal lobes unusually short, each 125.0–127.5 µm long. Multilocular disc pores, each 6.25–7.5 µm in diameter, present on abdominal segments, distributed as follows (mean numbers): IV: 18, V: 42, VI: 44, VII: 28, and VIII: 18. Trilocular pores, each 2.5–3.8 µm across, scattered throughout venter. Oral collar tubular ducts with two types: large type each 7.5–10.0 µm long, 2.5–3.1 µm wide, present one on each marginal abdominal segments V–VIII and mesothorax, and more abundantly on mid areas of thorax.



Comments. *Chorizococcus ozeri* is most similar to *Chorizococcus srinagaricus* Williams in having no oral rim tubular ducts on the venter; dorsal rim tubular ducts few, present mainly either in medial areas or marginal areas. However, *C. ozeri* can be distinguished from *C. srinagaricus* in having (character states for *C. srinagaricus* given in parentheses): (i) oral rim tubular ducts present mainly in marginal areas of dorsum (mainly in medial areas of dorsum); (ii) oral collar tubular ducts absent on dorsum (present); (iii) ventral oral collar tubular ducts present around abdomen only (present on entire body surface); (iv) large discoidal pores absent from venter (present); and (v) translucent pores on hind coxa present (absent).

Please provide an authority on first mention
Chorizococcus srinagaricus Williams

It is also similar to *Chorizococcus sorgi* Williams in lacking oral collar tubular ducts entirely from ventral margins of head and thorax; multilocular disc pores and oval collar tubular ducts absent from the area lateral to each first coxa. However, *C. ozeri* can be distinguished from *C. sorgi* in having (character states for *C. sorgi* given in parentheses): (i) cerarii confined to anal lobes only (present on at least 3 posterior cerarii); (ii) no oral rim tubular ducts on venter (oral rims present on venter); and (iii) multilocular disc pores in two rows on venter (in one row).

Please provide an authority on first mention
Chorizococcus sorgi Williams

Etymology. This species is named after Emin Ozer (Business Sustainability Lead Turkiye, Syngenta Tarim San. ve Tic. A.Ş., Yeni Mahalle 87071 Sk. Bozkurtlar Rezidans No: 52 K/D:12/25, Seyhan - Adana / TURKIYE), one of the best partners and mentor of the Kaydan's Laboratory.

Host plants. *Loranthus* sp. (Loranthaceae) (Fig. 2).

Distribution. Indonesia (Sumatra, Bengkulu Province).

Key to adult female *Chorizococcus* found in southern Asia

- 1(0) Cerarii confined to anal lobes only..... 2
- Cerarii present on at least 3 posterior segments of abdomen and sometimes on head... 5
- 2(1) Oral rim tubular ducts of 2 sizes present on venter, in considerable number around margins and submarginal areas..... *kandyensis* (Green)
- Oral rim tubular ducts of 1 size only, either absent from venter or present in small number only, on margins and medial areas 3
- 3(2) Ventral oral rim tubular ducts present, scattered on head, thorax and abdomen. Dorsal oral rim tubular ducts numerous laterally, relatively few present medially
 *graminis* Khalid & Shafee

- Ventral oral rim tubular ducts absent. Dorsal oral rim tubular ducts few, present mainly either in medial areas or margin areas. 4
- 4(1) Dorsal oral rim tubular ducts present mainly in medial areas. Dorsal and ventral oral collar tubular ducts present throughout dorsum and venter. Large discoidal pores, some almost as large as multilocular disc pores, present on venter. Translucent pores on hind coxa apparently absent
..... *srinagaricus* Williams
- Dorsal oral rim tubular ducts present mainly in margin areas. Dorsal oral collar tubular ducts absent. Ventral oral collar tubular ducts present around abdomen only. Large discoidal pores absent from venter. Translucent pores on hind coxa present
..... *ozeri* Zarkani & Kaydan
- 5(1) Ventral multilocular disc pores present around vulva only, numbering 2-4
..... *alami* Khalid & Shafee
- Ventral multilocular disc pores present across abdominal segments, at least as far forward as abdominal segment IV, numbering more than 10 6
- 6(5) Oral collar tubular ducts present on ventral margins of head and thorax; a group of tubular ducts associated with 1 or 2 multilocular disc pores situated lateral to each first coxa
..... *irretitus* Williams
- Oral collar tubular ducts absent entirely from ventral margins of head and thorax; multilocular disc pores and oval collar tubular ducts absent from lateral to each first coxa
..... *sorgi* Williams



FIGURE 2. An aggregation of *Chorizococcus ozeri* Zarkani & Kaydan, sp. n., on a semi-parasitic plant, *Loranthus* sp. (Loranthaceae).

Dysmicoccus Ferris

location ?add
Here is it : 03°45'10"S, 102°16'59"E

Dysmicoccus lepellei* (Betrem)

Material examined. INDONESIA, Sumatra, Bengkulu Province, North Bengkulu District, Kemumu, on *Loranthus* sp. (Loranthaceae), living on cacao (*Theobroma cacao* L.), 600 m a.s.l., 03°26'00"S, 102°15'15"E, 11.v.2022, coll. A. Zarkani (AZ983-984), 6 ♀♀.

Comments. The species is polyphagous on 25 plant genera within 17 families: Anacardiaceae, Annonaceae, Arecaceae, Asparagaceae, Clusiaceae, Euphorbiaceae, Fagaceae, Malvaceae, Meliaceae, Moraceae, Musaceae, Myrtaceae, Rubiaceae, Rutaceae, Sapindaceae, Sapotaceae, and Zingiberaceae (García-Morales et al. 2016; Zarkani et al. 2021). In Indonesia, *D. lepellei* has been recorded previously from Java, Lombok and Sumatra (Ben-Dov 1994; Williams 2004). It is also found in neighboring countries such as Cambodia, Malaysia, Singapore, Thailand, and Vietnam (Williams 2004; García-Morales et al. 2016; Zarkani et al. 2021).

Dysmicoccus zeynepae* Zarkani & Kaydan

Material examined. INDONESIA, Sumatra, Bengkulu Province, Seluma District, Napal Jungur, on *Loranthus* sp. (Loranthaceae), living on Jengkol (*Pithecellobium lobatum* Benth), 205 m a.s.l., 03°57'12"S, 102°30'09"E, 5.iii.2023, coll. A. Zarkani (AZ1248), 3 ♀♀.

Comments. *Dysmicoccus zeynepae* is a polyphagous species found on ornamental plants and tropical fruits such as *Durio zibethinus* Murray (Malvaceae), *Lansium parasiticum* Corrêa (Meliaceae), *Manilkara zapota* Linnaeus (Sapotaceae) and *Coffea robusta* Lindl. ex de williamson (Rubiaceae) (Zarkani et al. 2023). The species is known to have some special features such as small legs, no multilocular disc pores and oral collar tubular ducts on dorsum, with a few multilocular disc pores without oral collar tubular ducts on venter and having translucent pores on the hind coxa and femur. This is the first report of *Dysmicoccus* infestation on Loranthaceae worldwide.

Ferrisia Fullaway

Ferrisia dasylyrii* (Cockerell)

Material examined. INDONESIA, Sumatra, Bengkulu Province, Bengkulu City, Teluk Segara, on *Loranthus* sp. (Loranthaceae), living on cucumber tree (*Averrhoa bilimbi* L.), 30 m a.s.l., 03°47'18"S, 102°15'15"E, 12.vi.2022, coll. A. Zarkani (AZ1080-1081), 3 ♀♀.

Comments. The species is polyphagous on ornamental plants and fruits belonging to 30 plant families and 54 genera. It is cosmopolitan, being found in 24 countries; in Indonesia it was first recorded from Bengkulu Province, Southern Sumatra on *Durio zibethinus* Murray (Malvaceae), *Gliricidia sepium* (Jacq.) (Fabaceae), *Hibiscus* spp. (Malvaceae), *Psidium guajava* L. (Myrtaceae), *Solanum torvum* Swartz (Solanaceae) and *Theobroma cacao* L. (Malvaceae) (Zarkani et al. 2020).

Planococcus Ferris

Planococcus bagmaticus Williams*⁺

(Fig. 3)

Material examined. INDONESIA, Sumatra, Bengkulu Province, Seluma City, Air Periukan, on *Loranthus* sp. (Loranthaceae), living on cacao tree (*Theobroma cacao* L.), 30 m a.s.l., 04°01'37"S, 102°24'50"E, 08.vii.2022, coll. A. Zarkani (AZ1112-1114), 6 ♀♀.

Comments: The holotype and paratypes specimens were recorded from Nepal, all in a single slide and deposited at Entomological Institute, Hokkaido University, Sapporo, Japan (HUSJ) and Natural History Museum, United Kingdom, London (BMNH), respectively. It was originally recorded from *Trachelospermum* sp. (Apocynaceae) (Williams 2004). This is the second report of the species after Takagi collected the species from Kathmandu Valley, Bagmati, Godavari-Nepal in 1975 (Williams 2004). It is the only known species of *Planococcus* in southern Asia with dorsal multilocular disc pores. The species is closed to *Planococcus epulus* De Lotto described from Kenya which also has dorsal multilocular disc pores, but *P. epulus* possesses dorsal transverse rows of oral collar tubular ducts, whereas in *P. bagmaticus*, all dorsal oral collar tubular ducts are restricted to small lateral groups on abdominal segments VI and VII. The species was sometimes found mixed with specimens of *P. jackbeardsleyi*.

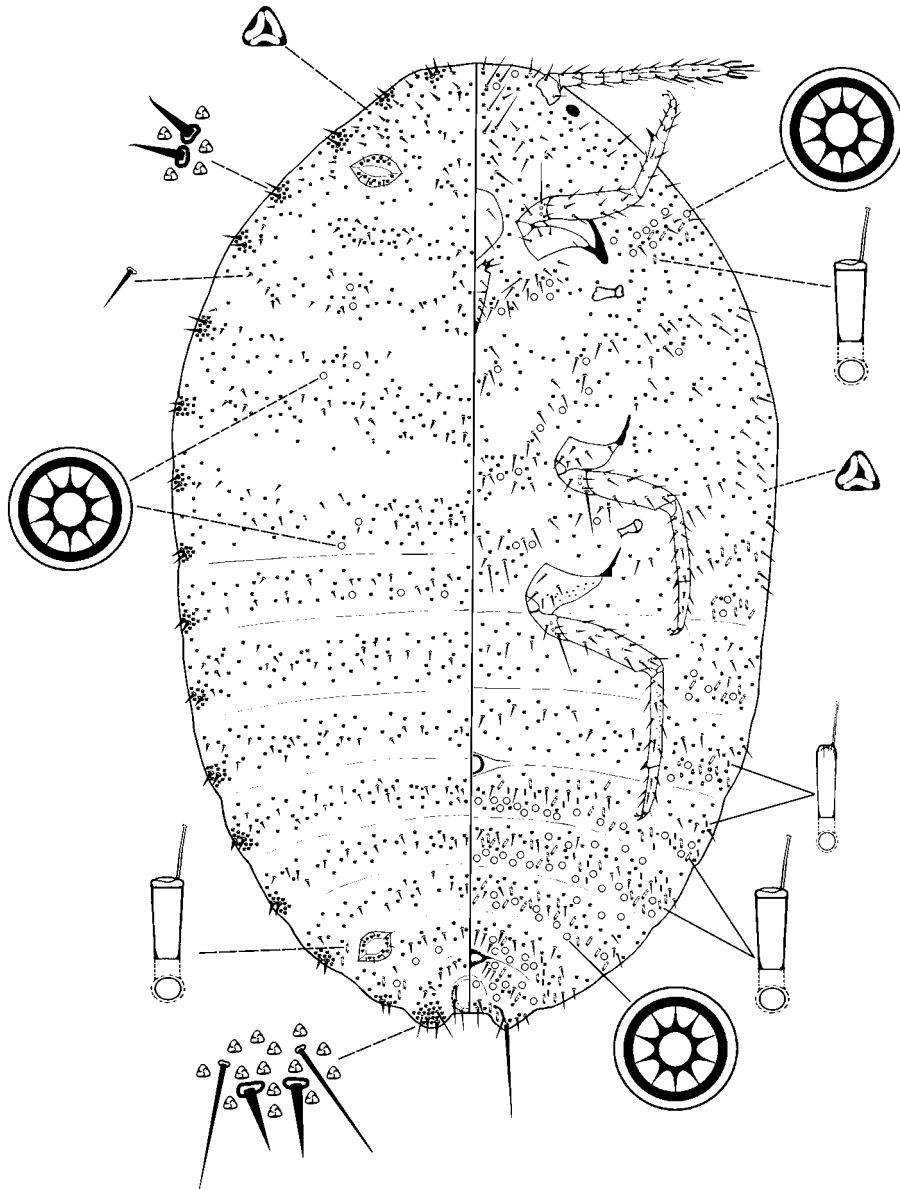
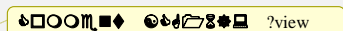



FIGURE 3. Adult female of *Planococcus bagmaticus* Williams. Specimen from Indonesia.

Planococcus bendovi Williams

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Acknowledgements

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References

- Ben-Dov Y (1994) A systematic catalogue of the mealybugs of the world (Insecta: Homoptera: Coccoidea: Pseudococcidae and Putoidae) with data on geographical distribution, host plants, biology and economic importance. Intercept Limited, Andover, U.K., 686 pp.
- Gavrillov-Zimin IA (2013) New scale insects (Homoptera: Coccinea) from Sulawesi and New Guinea, with some other additions to the Indonesian fauna. *Tropical Zoology* 26(2): 64-86
- Gavrillov-Zimin IA (2017) Taxonomic and faunistic notes on scale insects (Homoptera: Coccinea) of Bali, Flores and New Guinea (Indonesia). *Biodiversity, Biogeography and Nature Conservation in Wallacea and New Guinea*, III Entomological Society of Latvia Salaspils 141-149.
- García-Morales M, Denno B, Miller DR, Miller GL, Ben-Dov Y, Hardy NB (2016) ScaleNet: a literature-based model of scale insect biology and systematics. Available from: <http://scalenet.info> (accessed 18 January 2023)
- Kosztarab M, Kozár F (1988) *Scale Insects of Central Europe*. Akadémiai Kiadó, Budapest, 456 pp.
- Musselman LJ, Press MC (1995) Introduction to parasitic plants. In: Press MC, Graves JD (eds) *Parasitic Plants*. Chapman & Hall, London, UK, 1-13.
- Pennings SC, Callaway RM (2002) Parasitic plants: Parallels and contrasts with herbivores. *Oecologia* 131: 479-489. <https://doi.org/10.1007/s00442-002-0923-7>
- Press MC, Phoenix GK (2005) Impacts of parasitic plants on natural communities. *New Phytologist* 166: 737-751. <https://doi.org/10.1111/j.1469-8137.2005.01358.x>

- Sartiami D, Adisuseno WA, Rachmatika N, Anwar R, Watson GW (2022) *Coccidohystrix insolita* (Green) (Hemiptera: Pseudococcidae) from Indonesia and its note on the three solanaceous plants. *Serangga* 27(3): 162–171.
<https://doi.org/10.1653/024.097.0432>
- Williams DJ (2004) Mealybugs of southern Asia. The Natural History Museum, London.
Southdene SDN BHD, Kuala Lumpur, 896 pp.
- Williams DJ, Granara de Willink MC (1992) Mealybugs of Central and South America. CAB International, Wallingford, 635 pp.
- Williams DJ, Watson GW (1988) The Scale Insects of the Tropical South Pacific Region. Pt. 2. The Mealybugs (Pseudococcidae). CAB International, Wallingford, 260 pp.
- Zarkani A, Apriyanto D, Turanli F, Kaydan MB (2020) New record of *Ferrisa dasylirii* (Cockerell) (Hemiptera: Coccoomorpha: Pseudococcidae) in Indonesia. *Serangga* 25 (3): 93–100.
- Zarkani A, Apriyanto D, Turanli F, Ercan C, Kaydan MB (2021) A checklist of Indonesian scale insects (Hemiptera: Coccoomorpha). *Zootaxa* 5016(2): 151–195.
<https://doi.org/10.11646/zootaxa.5016.2.1>
- Zarkani A, Apriyanto D, Djamilah, Nadrawati, Priyatiningsih, Sunardi T, Cansu E, Kaydan MB (2022) *Planococcus bendovi* Williams (Hemiptera: Coccoomorpha: Pseudococcidae), a First Record of Mealybug in Southeast Asia. *Serangga* 27(1): 1-11.
- Zarkani A, Ercan C, Apriyanto D, Kaydan MB (2023). Studies on mealybugs (Hemiptera: Coccoomorpha) in Indonesia, with description of a new species and three new country records. *Zootaxa* 5228(2): 157–172. <https://doi.org/10.11646/zootaxa.5228.2.4>

Pseudococcid mealybug (Hemiptera: Pseudococcidae) complex of bamboo in Indonesian Sunda Shelf with two new species records

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Abstract

In this study, a survey for determining the pseudococcid mealybug (Hemiptera: Coccoomorpha: Pseudococcidae) complex of bamboo was conducted in several provinces in Sumatra and Java Island-Indonesia, a part of Indo-Asian regions. The research collected 85 mealybug specimens consisting of five species within 4 genera namely *Antonina* Signoret (2 species), *Chaetococcus* Maskell (1 species), *Dysmicoccus* Ferris (1 species), and *Palmicultor* Williams (1 species). *Antonina pretiosa* Ferris and *Dysmicoccus zeynepae* are newly recorded for the Indonesian Sunda shelf. The identification key of Indonesian bamboo mealybugs and their distribution data are also updated.

Keywords: Coccoomorpha, host plant, pests, Sternorrhyncha, taxonomy

Introduction

Comment [rev1_1]: There are two *Dysmicoccus* speies reported on bamboo in previous publications:

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As a mega biodiversity country, Indonesia is influenced by Asian and Australian biodiversity. In fact, at the beginning of the ice age, the western part of Indonesia such as Bali, Java, Kalimantan and Sumatra merged with the Asian continent (Sunda shelf), while the eastern part of Indonesia was integrated with the Australian continent (Sahul shelf) (Lohman *et al.* 2011). The high diversity of flora and fauna, including insect species, is a result of unique geological and evolutionary history in combination with the wide variety of habitats associated with its many islands (Arifin & Nakagoshi 2011). Nevertheless, the geographic dimension of Indonesian biodiversity, in particular, species endemism across geographical gradients, has not been taken into account.

A plant genus within a high diversity is bamboo (*Bambusa* sp.), woody perennial evergreen plants belonging to the family Poaceae, consisted of over 590 species in 44 genera (Dransfield & Widjaya 1995). Bamboo is one of the important exporting agricultural material products over the world: this plant is commonly used as pulp for paper mills, houses material, handicrafts, food product items and other people's daily lives (Fu *et al.* 2000).

Whilst bamboo is one of leading agricultural products in the world, the growing as well as the exporting process faces many problems, including insect pest infestations (Thanh *et al.* 2007). There are more than 400 insect species feeding on bamboos within which about 100 species gaining pest status, including mealybugs that can cause heavy damage to the plant (Hemiptera: Coccothraupidae: Pseudococcidae) (Kalshoven 1981; Garcia Morales *et al.* 2016). Pseudococcidae is the second-largest family in Coccothraupidae after Diaspididae. As one of the important insect pests worldwide, mealybugs play significant roles in transmitting virus, spreading among plants in intra-inter specific relations (Ben-Dov 1994). Scale insects are often become subjects of intercepted alien species in many countries due to the small, persistent, and tiny characters of them (Williams 2004; Kaydan *et al.* 2015).

In general, there are 2,041 mealybug species in 259 genera worldwide within which 109 species from 32 genera shuttled in Indonesia (García Morales *et al.* 2016; Zarkani *et al.* 2021, 2023). In fact, about 44 Pseudococcid species lives on bamboo in which 10 species (7 genera) namely *Antonina graminis* (Maskell), *Antonina milleri* Williams, *Antonina pretiosa* Ferris, *Antonina thaiensis* Takahashi, *Antonina zonata* Green, *Chaetococcus bambusae* (Maskell), *Extantococcus javanensis* Williams, *Hordeolicoccus nephelii* (Takahashi), *Palmicultor lumpurensis* (Takahashi), and *Paracoccus interceptus* Lit are already existed in Indonesia (Williams 2004; Garcia Morales *et al.* 2016; Sartiami *et al.* 2016; Zarkani *et al.* 2021).

For the last decades, the study of bamboo mostly focused on genetic variability, chemical contains, and their utilities in agriculture as well as in medical sectors, but a few studies in insect faunal diversity. This study listed bamboo-feeding pseudococcids in the Sunda Shelf including new fauna records, as well as updated identification key of mealybug complex of bamboo in Indonesia. .

Materials and Methods

Mealybug specimens were collected from a series of sampling occasions on leaves, trunks, branches, and roots in bamboo trees in Bengkulu Province, West Sumatra Province, and East Sumatra Province, Indonesia from March to December 2022. The sampling sites are at an altitude of 0 – 1000 m above sea level. The specimens were mounted and preserved in slides and identified to genus. The slide mounting was carried out by preserving the adult female specimens under a binocular dissection microscope, LEICA EZ4HD using Kosztarab and Kozár (1988) methods.

Species identifications were made by observing the specific features of the mealybug species, including body size, shape, and color, using a phase-contrast compound microscope (LEICA DM2700) and were identified using the keys in Williams and Watson (1988), Williams and Granara de Willink (1992), and Williams (2004). The morphological parameters used are those used by Williams and Granara de Willink (1992) and Williams (2004). Specimens are deposited in the Mealybugs Museum, Department of Plant Protection, Faculty of Agriculture, University of Bengkulu, Bengkulu, Indonesia (MMUB).

Results and Discussion

The research collected 85 mealybug specimens in Indonesian Sunda shelf regions consisted of 5 species within 4 genera. The identified species belong to the genus *Antonina* Signoret (2 species), *Chaetococcus* Maskell (1 species), *Dysmicoccus* Ferris (1 species), *Palmicultor* Williams (1 species). *Antonina pretiosa* Ferris and *Dysmicoccus zeynepae* are newly recorded for Indonesian Sunda shelf and marked with a plus mark (+). In addition, the species marked with an asterisk (*) are legless mealybugs.

Identification key to adult females of pseudococcid mealybug (Hemiptera: Pseudococcidae) complex of bamboo trees in Indonesia (11 species), adapted from Williams and Watson (1988), Williams and Granara de Willink (1992) and Williams (2004).

Comment [rev1_3]: You don not describe any species in this MS, thus referring to type depository is unnecessary. If collected specimens are stored at the Mealybug Museum, than leave the sentence here, if not, please delete it.

Comment [AZ4R3]: Thanks, we deleted it.

1(0)	Legs present.....	7
-	Legs absent.....	2
2(1)	Anal ring normally situated on body surface or at base of very short tube, bearing at least 6 setae. Venter with duct-like pores in a group posterior to each second spiracle. Ventral disc-like pores absent from abdomen	
 <i>Chaetococcus bambusae</i> Maskell	
-	Anal ring situated at base of anal tube, normally bearing 6 setae (rarely without setae). Venter without duct-like pores posterior to each second spiracle, but disc-like pores or very short, button-like microtubular ducts present in this position, sometimes also in a wider distribution on sub median to submarginal areas of abdomen	3
3(2)	At least posterior segments of abdomen plate-like, at maturity becoming sclerotized from body margin to medial or sub medial areas. Trilocular pores, in profile, as deep as wide.....	<i>Antonina pretiosa</i> Ferris
-	Abdominal segments not plate-like, not becoming sclerotized from medial or sub medial areas. Trilocular pores, in profile, more or less flat.....	4
4(3)	Multilocular disc pores forming a marginal band around entire body	
 <i>Antonina thaiensis</i> Takahashi	
-	Multilocular disc pores not forming a marginal band around entire body	5
5(4)	Disc-like pores present on at least abdominal segments II-IV	
 <i>Antonina graminis</i> (Maskell)	
-	Disc-like pores present in a single cluster posterior to each second spiracle: if extending onto abdominal segment II, then never present on abdominal segment III and IV	6
6(5)	Marginal setae same size as dorsal setae on head and thorax, present between antennae and around rest of body	<i>Antonina milleri</i> Williams
-	Marginal setae much longer than dorsal setae on head and thorax, absent from between antennae but present around rest of body	<i>Antonina zonata</i> Green
7(1)	Oral rim tubular duct present, each with well-developed rim	
 <i>Paracoccus interceptus</i> Lit	
-	Oral rim tubular duct absent entirely	8
8(7)	Each eye associated with sclerotized patch containing discoidal pores, these pores sometimes as large as a multilocular disc pore; other similar disc pores also present, dispersed, at least on venter. Cerarii always numbering 18 pairs	
 <i>Hordeolicoccus nephelii</i> (Takahashi)	

- If eyes are associated with discoidal pores then these are few, small and inconspicuous.
Cerarii numbering 1–17 pairs 9
- 9(8) Anterior margins of hind coxa indistinct; spiracles and leg bases situated much closer to margin than to midline *Extanticoccus javanensis* Williams
- Anterior margin of hind coxa distinct; spiracles and leg bases situated submedially, about halfway between margin and midline 10
- 10(9) Derm around hind coxa with numerous minute pores
.....*Palmicultor lumpurensis* (Takahashi)
- Derm around hind coxa without minute pores
.....*Dysmicoccus zeynepae* Zarkani & Kaydan

Antonina* Signoret

***Antonina pretiosa* Ferris*⁺ (Fig. 1&6)**

Material examined. INDONESIA, Sumatra, Bengkulu Province, Kepahiang district, Kabawetan, on *Bambusa* sp. (Poaceae), 600 m a.s.l, 03°34'54.4" S, 102°35'33" E, 12.vi.2022, coll. A. Zarkani (AZ1080-1081), 6 ♀♀; West Sumatra Province, Padang city, Nanggalo, on *Bambusa* sp. (Poaceae), 100 m a.s.l. 0°54'00.7" S, 100°21'54.1" E, 8.ii.2022, coll. A. Zarkani (AZ700-702), 9 ♀♀. East Sumatra Province, Palembang city, Ilir Barat 1, on *Bambusa* sp. (Poaceae), 230 m a.s.l. 2°58'36.0"S, 104°44'30.2"E, 12.iv.2022, coll. A. Zarkani (AZ880-881), 6 ♀♀.

Comments. *Antonina pretiosa* is oligophagous insect species which lives on 6 genera in Poaceae (García Morales *et al.* 2016; Zarkani *et al.* 2021). **The species is easily diagnosed by having disc-like pores in ventral submedian cluster, forming a band from abdominal segment II posteriorly around abdomen. Multilocular disc pores restricted to a few, situated lateral to opening of anal tube on dorsum.** The species is widely distributed in the tropical and subtropical zones of the world. In Indonesia, the first record was reported by Gavrilov-Zimin (2013) in Sulawesi, a part of Indo-Australian regions and it has been a new record for Indonesian Sunda shelf.

Comment [AZ5]: We added some diagnosis characteristics of the species

FIGURE 1. *Antonina pretiosa* Ferris (Hemiptera: Pseudococcidae). (A) Anal ring situated at base of an anal tube (↓), Abdomen plate-like (↓); (B) Multilocular disc pore restricted to a

few, situated lateral to opening of anal tube on dorsum; (C) Spiracular openings with associated with trilocular pores.

Antonina thaiensis Takahashi* (Fig. 2)

Material examined. INDONESIA, Sumatra, Bengkulu Province, North Bengkulu district, Arga Makmur town, on *Bambusa* sp. (Poaceae), 300 m a.s.l., 3°26'16.4" S, 102°11'51.1" E, 12.viii.2022, coll. A. Zarkani (AZ1180-1181), 6 ♀♀; East Sumatra Province, Palembang city, Ilir Barat 1, on *Bambusa* sp. (Poaceae), 230 m a.s.l. 2°58'36.0"S, 104°44'30.2"E, 12.iv.2022, coll. A. Zarkani (AZ882-883), 6 ♀♀.

Comments. This is oligophagous species on genus *Bambusa* and *Phragmites* (Poaceae) (García Morales *et al.* 2016; Zarkani *et al.* 2021). In Indonesia, *A. thaiensis* has been recorded previously from Java (Sartiami *et al.* 2016). It is also found in neighboring countries such as India, Malaysia, Philippines and Srilanka and Thailand (Williams 2004; Gracia Morales *et al.* 2016).

FIGURE 2. *Antonina thaiensis* Takahashi (Hemiptera: Pseudococcidae). (A) Anal ring situated at base of an anal tube; (B) Disc-like pores present on venter of abdomen; (C) Multilocular disc pore present encircling at least anterior spiracles; (D) Multilocular disc pores of 1 type only.

Chaetococcus Maskell

Chaetococcus bambusae (Maskell)* (Fig. 3)

Material examined. INDONESIA, Sumatra, Bengkulu Province, Bengkulu Tengah district, Wilayah Kosong, on *Bambusa* sp. (Poaceae), 355 m a.s.l., 3°42'41.4" S, 102°31'33.1" E, 5.iii.2019, coll. A. Zarkani (AZ247), 3 ♀♀. Rejang Lebong district, Sindang Kelingi, on *Bambusa* sp. (Poaceae), 1020 m a.s.l., 3°27'40.8" S, 102°42'40.8" E, 9.viii.2022, coll. A. Zarkani (AZ1001), 3 ♀♀, West Java, Bogor, on *Bambusa* sp. 222 m a.s.l. 6°34'40.0"S, 106°46'30.17"E, 2 ♀♀, 15.xii.2022, coll. D. Sartiami.

Comments. The species is oligophagous that feeds on 10 genera in Poacea (García Morales *et al.* 2016; Zarkani *et al.* 2021). It is a cosmopolitan insect, having been recorded from 44 countries (García Morales *et al.* 2016). In Indonesia, *C. bambusae* has been recorded

Comment [rev1_6]: they are legless as well

Comment [AZ7R6]: Yes, We marked the name with an asterisk

previously from Flores and Irian Jaya (Gavrilov-Zimin 2013), Java (Sartiarni *et al.* 2016) and Sumatra (Williams 2004).

FIGURE 3. *Chaetococcus bambusae* (Maskell) (Hemiptera: Pseudococcidae). (A) Multilocular disc pores confined to abdominal segments VII and VIII; (B) Duct-like pores present on venter in a group posterior to each second spiracle; (C) Large tubular ducts with collar about two-thirds the length of duct present around head margin; (D) Spiracles each associated with a crescentic band of small trilobular pores at atrium.

Dysmicoccus Ferris

Dysmicoccus zeynepae Zarkani & Kaydan⁺ (Fig. 4 & 7)

Material examined. INDONESIA, Sumatra, Bengkulu Province, Rejang Lebong district, Sindang Kelingi, on *Bambusa* sp. (Poaceae), 1020 m a.s.l., 3°27'40.8" S, 102°42'40.8" E, 9.viii.2022, coll. A. Zarkani (AZ1000), 3 ♀♀. West Sumatra Province, Padang city, Nanggalo, on *Bambusa* sp. (Poaceae), 100 m a.s.l. 0°54'00.7" S, 100°21'54.1" E, 8.ii.2022, coll. A. Zarkani (AZ703), 3 ♀.

Comments. *Dysmicoccus zeynepae* Zarkani & Kaydan is polyphagous species complex of *Durio zibethinus* (Malvaceae), *Lansium parasiticum* (Meliaceae), *Manilkara zapota* (Sapotaceae) and *Coffea robusta* (Rubiaceae) (Zarkani *et al.* 2023). The species is closed to *Dysmicoccus finitimus* Williams in having anal lobe and abdominal cerarii each containing a group of about 2–7 conical setae. However, it is different with some features such as no multilocular disc pores and oral collar tubular ducts on dorsum within a few multilocular disc pores without oral collar tubular ducts on venter. This species is easily recognized by having small legs and translucent pore on hind coxa and femur. This species was recorded on bamboo first time. And also, first *Dysmicoccus* species feeding on bamboo from Indonesia.

FIGURE 4. *Dysmicoccus zeynepae* Zarkani & Kaydan (Hemiptera: Pseudococcidae). (A) Small legs; (B) Venter with a few multilocular disc pores and oral collar tubular ducts absent from both dorsum and venter.

Comment [AZ8]: There are two *Dysmicoccus* speies reported on bamboo in previous publications:

<http://scalenet.info/associates/bambusa/dysmicoccus/>

Maybe you wanted to say, that this species was recorded on bamboo first time. And also, first *Dysmicoccus* species feeding on bamboo from Indonesia (definitely not worldwide).

ME: Thanks, we increased the sentence.

***Palmicultor* Williams**

***Palmicultor lumpurensis* (Takahashi) (Fig. 5 & 7)**

Material examined. INDONESIA, Sumatra, Bengkulu Province, Kepahiang district, Kabawetan, on *Bambusa* sp. (Poaceae), 600 m a.s.l, 03°34'54.4" S, 102°35'33" E, 12.vi.2022, coll. A. Zarkani (AZ1080-1081), 6 ♀♀; East Sumatra Province, Palembang city, Ilir Barat 1, on *Bambusa* sp. (Poaceae), 230 m a.s.l. 2°58'36.0"S, 104°44'30.2"E, 12.iv.2022, coll. A. Zarkani (AZ884), 3 ♀♀.

Comments. This is an oligophagous species that feed on 11 genera of plants on Poaceae (García Morales *et al.* 2016; Zarkani *et al.* 2021). It is cosmopolitan, being found in 11 countries spread over all continents. In Indonesia, it has been recorded from Bali (Gavrilov-Zimin 2017) and Irian Jaya (Gavrilov-Zimin 2013). Indonesian specimens of *P. lumpurensis* differ from the illustration Williams (2004) provided by having less multilocular disc pores on the dorsum and the ventral surface (Fig. 7).

FIGURE 5. *Palmicultor lumpurensis* (Takahashi) (Hemiptera: Pseudococcidae). (A) Large- and small-type oral collar tubular ducts numerous on dorsum, present in rows across segments; (B) Multilocular disc pores numerous around dorsum and venter of head, thorax and abdomen; (C) Minute duct-like pores present on derm next to hind coxa.

FIGURE 6. Pseudococcid mealybug (Hemiptera: Pseudococcidae) complex of bamboo trees in Indonesian Sunda shelf regions. (A) Symbioses among ants and *Dysmicoccus zeynepae* Zarkani & Kaydan; (B) *Antonina pretiosa* Ferris; (C) Symbioses among ants and *Antonina thaiensis* Takahashi; (D) *Chaetococcus bambusae* (Maskell); and (E) *Palmicultor lumpurensis* (Takahashi).

FIGURE 7. Adult female *Palmicultor lumpurensis* (Takahashi). Specimen from Indonesian Sunda shelf.

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References

- Ben-Dov Y. 1994. *A systematic catalogue of the mealybugs of the world (Insecta: Homoptera: Coccoidea: Pseudococcidae and Putoidae) with data on geographical distribution, host plants, biology and economic importance*. Intercept Limited, Andover, 686 pp.
- Dransfield S. & Widjaja E. A. 1995. *Plant Resources of South-East Asia, No 7. Bamboos*. Backhuys Publishers, Leiden. Pp. 15-49.
- Fu M., Xiao J. & Lou Y. 2000. *Cultivation and Utilization on Bamboo*. China Forestry Publishing House, Beijing, 137 pp.
- Gavrilov-Zimin I. A. 2013. New scale insects (Homoptera: Coccinea) from Sulawesi and New Guinea, with some other additions to the Indonesian fauna. *Tropical Zoology* 26(2): 64-86
- Gavrilov-Zimin I. A. 2017. Taxonomic and faunistic notes on scale insects (Homoptera: Coccinea) of Bali, Flores and New Guinea (Indonesia). *Biodiversity, Biogeography and Nature Conservation in Wallacea and New Guinea, III Entomological Society of Latvia Salaspils* 141-149.
- García Morales M., Denno B., Miller D. R., Miller G. L., Ben-Dov Y. & Hardy N. B. 2016. *ScaleNet: a literature-based model of scale insect biology and systematics*. Available from: <http://scalenet.info> (accessed 18 January 2023)
- Granara de Willink M. C. & Szumik C. 2007. Phenacoccinae de Centro y Sudamérica (Hemiptera: Coccoidea: Pseudococcidae): sistemática y filogenia. *Revista de la Sociedad Entomológica Argentina* 66: 29–129.
- Kalshoven L. G. E. 1981. *Coccoidea. Pests of crops in Indonesia*. Ichtiar Baru, Jakarta, 701 pp.
- Kosztarab M. & Kozár F. 1988. *Scale Insects of Central Europe*. Akadémiai Kiadó, Budapest, 456 pp.
- Lohman D. J., Bruyn Md., Page T., Rintelen Kv., Hall R., Ng, P. K. L., Shih H., Carvalho, G. R. & Rintelen Tv. 2011. Biogeography of the Indo-Australian Archipelago. *Annual Review of Ecology, Evolution, and Systematics* 42 (1): 205-226. Available from: <https://www.annualreviews.org/doi/10.1146/annurev-ecolsys-102710-145001> (Accessed 20 January 2023)

- Sartiami D., Watson G. W., Mohamad Roff M. N. & Idris A. B. 2016. New Indonesian country records and species information for mealybugs (Hemiptera Pseudococcidae) in Wirjati's historic collection. *Redia XCIX* 155-161.
- Thanh L. B., Nha N. T. & Hieu B. T. 2007. Research on the State of Insect Pests and Protectively Covering Method for Shoot of Bamboo Species Widely Planted in Vietnam. *Science and Technology Journal of Agriculture & Rural Development* 5: 94-99.
- Watson G. W., Muniappan R., Shepard B. M., Sembel D. T., Xiong J. J. & Rauf A. 2014. Sap-sucking insect records (Hemiptera: Sternorrhyncha and Thysanoptera: Thripidae) from Indonesia. *Florida Entomologist* 97: 1594–1597.
<https://doi.org/10.1653/024.097.0432>
- Williams D. J. 2004. *Mealybugs of southern Asia*. The Natural History Museum, London. Southdene SDN BHD, Kuala Lumpur, 896 pp.
- Williams D. J. & Granara de Willink M. C. 1992. *Mealybugs of Central and South America*. CAB International, Wallingford, 635 pp.
- Williams D. J. & Watson G. W. 1988. *The Scale Insects of the Tropical South Pacific Region. Pt. 2. The Mealybugs (Pseudococcidae)*. CAB International, Wallingford, 260 pp.
- Zarkani A., Apriyanto D., Turanli F., Ercan C. & Kaydan M. B. 2021. A checklist of Indonesian scale insects (Hemiptera: Coccoomorpha). *Zootaxa* 5016 (2): 151–195.
<https://doi.org/10.11646/zootaxa.5016.2.1>
- Zarkani A., Ercan C., Apriyanto D. & Kaydan M. B. 2023. Studies on mealybugs (Hemiptera: Coccoomorpha) in Indonesia, with description of a new species and three new country records. *Zootaxa* 5228(2): 157–172. <https://doi.org/10.11646/zootaxa.5228.2.4>