ACTA ENTOMOLOGICA
MUSEI NATIONALIS PRAGAE
2025
65(2): 293–300
doi: 10.37520/aemnp.2025.022
ISSN 1804-6487 (online) – 0374-1036 (print)
www.aemnp.eu

RESEARCH ARTICLE

A new species of the genus *Ferrisia* (Hemiptera: Coccomorpha: Pseudococcidae) from southern Vietnam

Hirotaka TANAKA[1,2,*] & Hoang Khac LE[3]

[1] Faculty of Agriculture, Ehime University, Tarumi 3-5-7, Matsuyama, Ehime 790-8566, Japan; e-mail: coccoidea@gmail.com; ORCID: https://orcid.org/0000-0002-0367-361X
[2] The Kyushu University Museum, Hakozaki 6-10-1, Higashi-ku, Fukuoka, 812-8581, Japan; e-mail: coccoidea@gmail.com
[3] Entomology Laboratory, Department of Plant Protection, Faculty of Agronomy, Nong Lam University Ho Chi Minh, Ho Chi Minh 700000, Vietnam; e-mail: lkhoang@hcmuaf.edu.vn; ORCID: https://orcid.org/0009-0005-7030-176X
*) corresponding author

Accepted:
9th October 2025

Published online:
10th December 2025

Abstract. In this paper, a new species, *Ferrisia san* Tanaka, sp. nov. (Hemiptera: Sternorrhyncha: Coccomorpha: Pseudococcidae), is described and illustrated based on the morphology of adult female specimens collected on cassava, *Manihot esculenta* (Euphorbiaceae), from Ho Chi Minh City and Dong Nai province in southern Vietnam. This is the second species of *Ferrisia* Fullaway, 1923, a genus native to the Americas, to be found in Vietnam. The adult female of this new species has a combination of morphological features distinct from those of named species of *Ferrisia*: the small type of the ventral oral-collar tubular ducts is present anterior to the multilocular disc pore rows as well as on the ventral submarginal area, but never forms marginal clusters; the large type of the ventral oral-collar ducts is confined to the posterior abdomen; and the dorsal enlarged tubular ducts are sometimes associated with one or two discoidal pores, which are mostly on the outermost edges of the sclerotized area of the ducts. An updated key to species of *Ferrisia* is provided, and the potential risks of this new species for the cultivation of cassava in Vietnam, and its implications for international quarantine are discussed.

Key words. Hemiptera, Sternorrhyncha, Pseudococcidae, mealybug, alien species, cassava, international pest quarantine, *Manihot esculenta*, pest, taxonomy, Southeast Asia, Oriental Region

Zoobank: http://zoobank.org/urn:lsid:zoobank.org:pub:C5D5C824-6005-45D4-B2CA-5F067804685C

Introduction

The family Pseudococcidae, commonly referred to as the mealybugs, represents the second most species-rich group within the infraorder Coccomorpha (Hemiptera: Sternorrhyncha) (García Morales et al. 2025). Adult females of Pseudococcidae are soft-bodied insects, typically covered with a white, powdery wax and often possessing lateral or posterolateral wax filaments, or more rarely, covered with felted wax (Williams 2004). Members of the Coccomorpha, including the Pseudococcidae, are well-known plant-feeding insects that extract sap from phloem tissue. Some of the species within this infraorder are recognized as significant agricultural pests, particularly those affecting fruit crops (García Morales et al. 2025, Kondo & Watson 2022). Certain species within Coccomorpha and Pseudococcidae are not only injurious due to sap-sucking but also serve as vectors of viral plant diseases (Carter 1963, Hommay et al. 2022, Sartiami & Kondo 2022), further amplifying their economic importance in agriculture.

To date, 44 species of Pseudococcidae, belonging to 19 genera, have been recorded in Vietnam (García Morales et al. 2025). Approximately half of these are considered cosmopolitan agricultural and/or horticultural pests of economic significance. Compared to most neighboring countries and regions, such globally important pest species have been relatively well-documented taxonomically in Vietnam (Parsa et al. 2012, Williams 2004). However, taxonomic

investigations and faunal surveys focusing on non-pest mealybug species, as well as the identification of cryptic or closely-related taxa concealed under previously described pest species, remain sparse. Under these circumstances, it is likely that many mealybug species in Vietnam are either undescribed or yet to be recorded.

During our faunal survey of sap-sucking insect pests from cassava in Vietnam in 2016, an undescribed species belonging to the genus *Ferrisia* Fullaway, 1923 was discovered. In the present study, we describe and illustrate this species as new to science, based on the morphological features of the adult female. A revised key to the adult females of *Ferrisia* species is also provided.

Material and methods

The mealybug specimens examined in this study were collected by the first author (HT), with assistance from laboratory members under the supervision of the second author (HKL), during field surveys conducted in 2016. Slide-mounting of adult females followed the protocol outlined by Tanaka (2014). Morphological observations of slide-mounted adult females were performed using a phase-contrast compound light microscope (BH2-PH; Olympus Corporation, Tokyo, Japan). Terminology and descriptive format largely follow those of Williams (2004) and Tanaka et al. (2025).

The species description is based on all available type specimens (n = 3). For each morphological character, the measurement for the holotype is provided, followed by the range observed in all type specimens (in parentheses), if different. All type specimens of the newly described species are deposited in the laboratory of Dr Hoang Khac Le at Nong Lam University, Ho Chi Minh City, Vietnam (NLUV). Collection data for the type material are presented as transcribed directly from the slide labels, with "/" denoting the end of each line on the label.

Results

Ferrisia Fullaway, 1923

Ferrisia Fullaway, 1923: 311. Type species: *Dactylopius virgatus* Cockerell, 1893, by monotypy.

Ferrisiana Takahashi, 1929: 429 (unjustified replacement name according to Morrison & Morrison 1966: 78).

Ferrisia san Tanaka, sp. nov.

(Figs 1, 2)

Type material. Holotype: ♀, 'Date: 7. viii. 2016. / Vietnam, HCMC [= Ho Chi Minh City], / Thu Duc District, / Ward Linh Trung, / Block 6, / Nong Lam University. / Host: *Manihot esculenta* / Hirotaka Tanaka coll.' (NLUV, mounted singly on a slide). Paratypes: ♀, same data as holotype; ♀, 'Date: 9. vii. 2016./ Vietnam, / Dong Nai province, / Hung Loc district, / Hung Loc / Agricultural Research / Center / Host: *Manihot esculenta* / Hirotaka Tanaka coll.' (both NLUV, each paratype mounted on a separate slide).

Description. ***Slide-mounted adult female*** (Figs 1, 2). Body elongate-oval, 3.1 (3.1–3.5) mm long and 1.3 (1.3–1.7) mm wide; derm membranous; segmentation discernible but not strongly developed. Anal lobes distinct; dorsal surface of each lobe well-sclerotized, ventral surface bearing long apical seta, 296 (260–296) µm long; anal lobe bar absent. Antennae 505–544 (469–673) µm long, 8-segmented, with numerous flagellate setae; subapical segment bearing one fleshy seta, apical segment with three fleshy setae. Eye located at body margin, not associated with discoidal pores. Legs well-developed, covered with numerous flagellate setae; hind trochanter + femur 490–497 (490–557) µm long; hind tibia + tarsus 518–523 (518–640) µm long; claw 30–34 (30–40) µm long, lacking denticle. Ratio of lengths of hind tibia + tarsus to trochanter + femur approximately 1.05–1.17 : 1; ratio of lengths of hind tibia to tarsus 3.25–4.72 : 1. Paired setose tarsal digitules present, subequal in length, with knobbed apices; claw digitules also knobbed. Hind femur and tibia bearing translucent pores about 1 µm on posterior (= dorsal) surface; hind coxa, trochanter and tarsus lacking translucent pores (Fig. 2). Labium 157 (130–232) µm long, mostly same length as clypeolabral shield. Circulus present, well-developed, divided by intersegmental line, situated between abdominal segments III and IV; 173 (160–173) µm long and 144 (103–150) µm wide. Ostioles present; each anterior ostiole with total of 13–16 (13–25) trilocular pores and 5–8 setae on both lips; each posterior ostiole with total of 25–32 (25–40) trilocular pores and 11–14 (9–17) setae. Anal ring 148 (130–148) µm wide, bearing six setae, each 166–200 (162–205) µm long. Cerarii present only on anal lobes (C_{18}). Each cerarius associated with well-sclerotized area, usually containing three (2–3) conical cerarian setae, each measuring 27–33 (16–33) µm in length and 5–10 (5–14) µm in basal width; accompanied by 4–6 (4–9) auxiliary setae and cluster of trilocular pores.

Dorsum. Dorsal setae flagellate, each 19–55 (15–55) µm long, evenly distributed; longest setae located on head, each with small, rounded (but mostly not knobbed) apex. Trilocular pores, each 3–4 µm wide, evenly scattered across surface. Total number of enlarged tubular ducts on whole dorsum 105 (78–105), each with opening approximately 7–9 µm in diameter and sclerotized rim 6–10 (4–10) µm wide, predominantly located in marginal to submarginal areas of all body segments, with a few present in submedial to medial areas. One or two discoidal pores associated with approximately 20 % (7–20 %) of enlarged tubular ducts, if present situated mostly at outer margin of sclerotized area, rarely situated on sclerotized area between duct opening and outer margin of sclerotized area and never in direct contact with duct opening. Oral collar tubular ducts not detected.

Venter. Ventral setae relatively long and flagellate, each 13–185 (13–220) µm long; longest setae present on medial region of head, with small rounded or occasionally knobbed tips. Multilocular disc pores, each 8–9 (7–9) µm in diameter, present on medial areas of abdominal segments VI–IX; with 19 (11–19) pores on segment VI, 27 (18–27) on segment VII, and 17 (16–22) on segments VIII+IX. Trilocular pores, similar in size to those on dorsum, evenly distributed. Oral collar tubular ducts of two distinct size present: (i) Large type ducts, each 4–5 µm wide (generally wider than trilocular pores), 2–4 (2–7) ducts present on submarginal area of each posterior abdominal segment, and

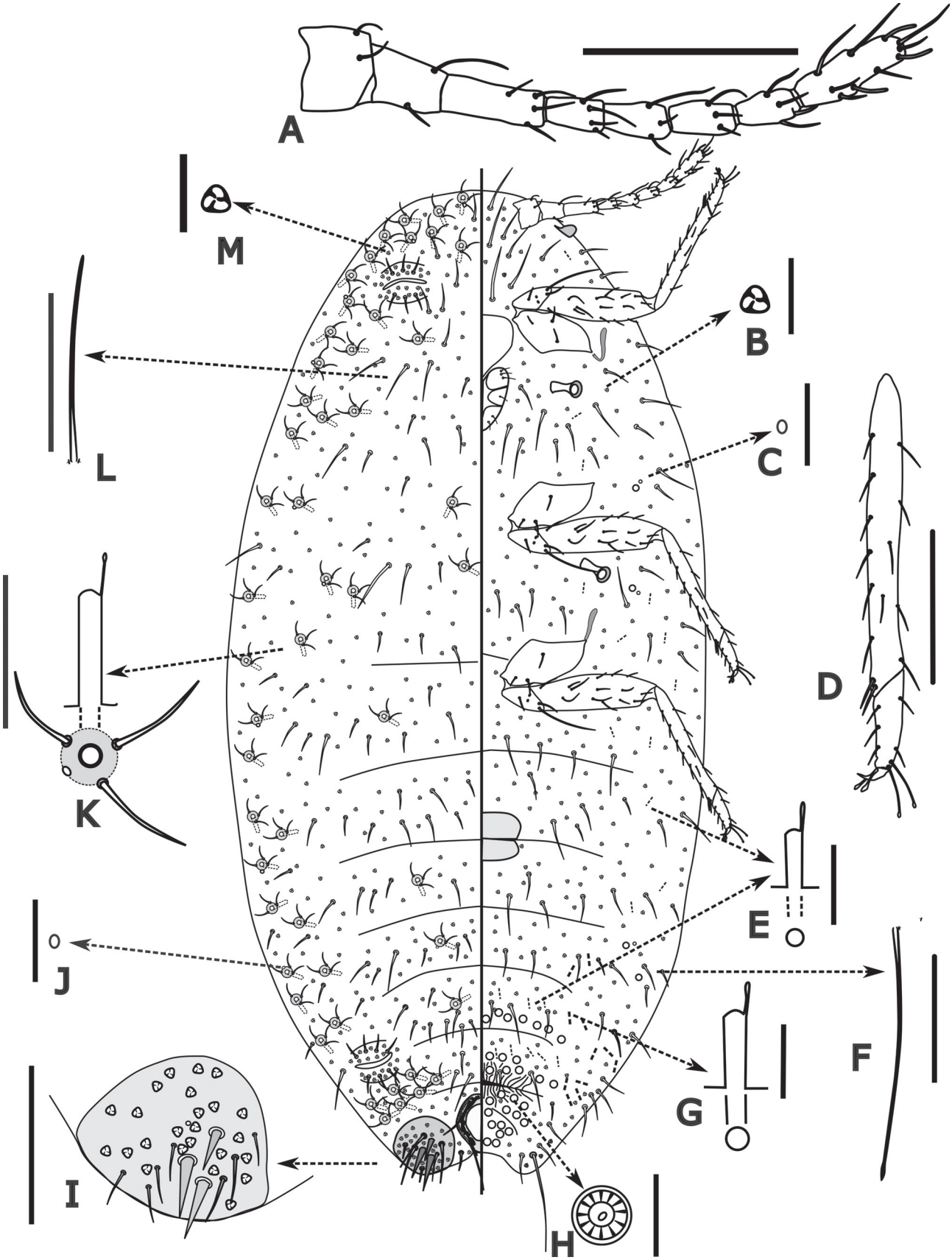

Fig. 1. *Ferrisia san* Tanaka, sp. nov. A – antenna; B – ventral trilocular pore; C – ventral discoidal pore; D – hind tibia, tarsus and claw; E – small-type ventral oral-collar duct; F – long ventral setae; G – large-type ventral oral-collar duct; H – multilocular disc pore; I – anal lobe cerarius (C_{18}); J – dorsal discoidal pore associated with dorsal enlarged tubular duct; K – dorsal enlarged tubular duct; L – long dorsal setae; M – dorsal trilocular pore. Scale bars: 200 µm for A and D; 50 µm for F, I, K and L; 10 µm for others.

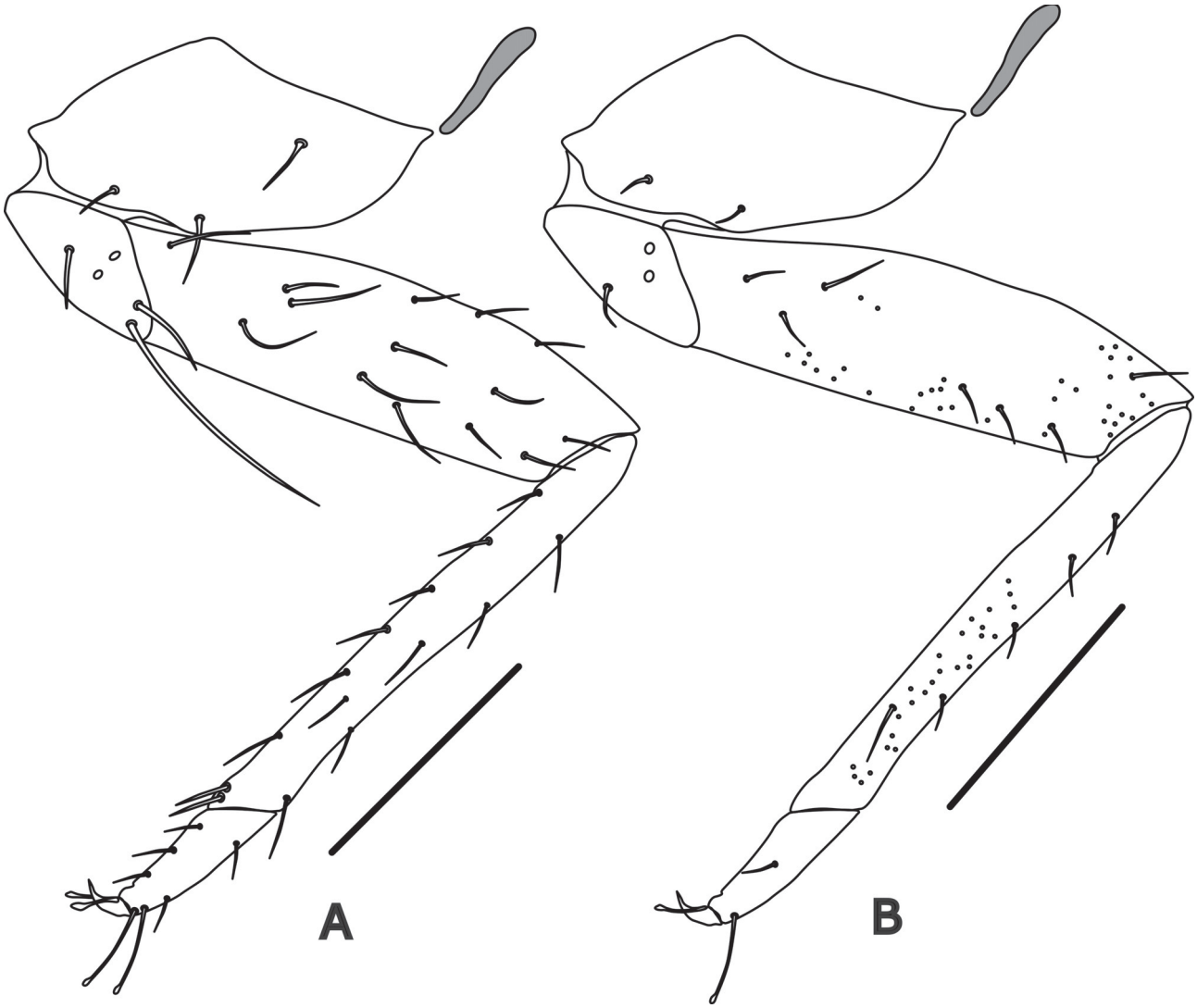

Fig. 2. A hind leg of *Ferrisia san* Tanaka, sp. nov. showing the translucent pores on the dorsal surface of the femur and tibia. A – anterior (= ventral) surface; B – posterior (= dorsal) surface. Scale bars: 200 μm.

1–4 (1–5) ducts present on marginal area of each posterior abdominal segment; (ii) Small type ducts, each 2–3 μm wide, situated just anterior to multilocular disc pore rows on medial area of posterior abdominal segments VI and VII, with 3–6 ducts present on each of latter segments, and also present sparsely on marginal to submarginal regions of anterior abdomen, thorax and head. Discoidal pores, similar in diameter to those on dorsum, approximately 1 μm wide, sparsely distributed along marginal to submarginal regions of posterior abdominal segments and sometimes associated with small-type oral collar tubular duct on venter.

Comparative notes. The new species is similar to *Ferrisia dasylirii* (Cockerell, 1896) in having two or three conical cerarian setae on each anal lobe cerarius, a fairly similar number and distribution of the dorsal enlarged ducts, the dorsal discoidal pores mostly contacting the outer margin of the sclerotized area around the opening of the dorsal enlarged tubular ducts and not contacting the rim of the duct openings, and in the absence of translucent pores on hind coxa (as in non-Californian specimens of *F. dasylirii*). However, *Ferrisia san* sp. nov. differs from *F. dasylirii* (contrasting character state in *F. dasylirii* in parentheses) in lacking clusters of small ventral oral collar tubular ducts in the submarginal area of the venter (some clusters of small oral collar ventral tubular ducts present on the ventral margins of the last two or three abdominal segments) and small ventral oral collar ventral tubular ducts present in the submarginal area of the head and thorax (small oral collar ventral tubular ducts absent on the head and thorax).

The new species can be clearly distinguished from the other *Ferrisia* species known in Vietnam, *F. virgata* (Cockerell, 1893) (contrasting character states in *F. virgata* in parentheses), by the absence of clusters of small oral collar tubular ducts in the posterior submarginal area of the venter (such clusters present), and by the presence of dorsal enlarged ducts associated with discoidal pores that either contact the outer margin of the sclerotized area or project beyond the sclerotized margin surrounding each duct opening (associated discoidal pores do not contact or extend beyond the sclerotized area).

Etymology. The specific epithet is derived from *sắn*, the Vietnamese name for cassava, the host plant of this new

species. It is treated as a noun in apposition.
Host plant. *Manihot esculenta* Crantz (Euphorbiaceae).

Key to species of *Ferrisia* based on adult females

Modified from Kaydan & Gullan (2012) to include *F. san* described herein and *F. kaki* described by Pacheco da Silva et al. (2016):

1 Anterior ostioles absent. 2
– Anterior ostioles present. 5
2 Anal lobe cerarii each with 2–4 cerarian setae; anal ring with 12–36 setae; multilocular disc pores fewer than 6, usually 1–3 or absent. .... ***F. setosa*** (Lobdell, 1930)
– Anal lobe cerarii each with 2 cerarian setae; anal ring with 6 setae; multilocular disc pores present at least anterior and posterior to vulva and numbering more than 6. 3
3 Dorsal enlarged tubular ducts numbering > 10 (usually 100–120); ventral oral collar tubular ducts of more than one size, smaller ducts always present in clusters on body margin, at least on abdominal segments VII and VIII but sometimes on margins of most segments. ..... ***F. gilli*** Gullan, 2003
– Dorsal enlarged tubular ducts numbering ≤ 10, sometimes absent; ventral oral collar tubular ducts of one size only and never in clusters on body margin. 4
4 Rim of each dorsal enlarged tubular duct, if ducts present, usually with 1 or 2 minute pores (2.5–5.0 μm in diameter) and at least one duct with these minute pores paired; ventral oral collar tubular ducts on abdominal segments present in small numbers (fewer than 50). ..... ***F. claviseta*** (Lobdell, 1930)
– Rim of each dorsal enlarged tubular duct, if ducts present, usually with 1 or 2 minute pores (2.0–3.0 μm in diameter) but pores never in pairs; ventral oral collar tubular ducts on abdominal segments numbering more than 50. ..... ***F. quaintancii*** (Tinsley, 1898)
5 Ventral oral collar tubular ducts of at least two sizes, smaller ducts present singly or in segmental clusters on body margin, at least on last 2–3 abdominal segments. 6
– Ventral oral collar tubular ducts of one size or rarely two sizes, often very few, smaller ducts never in clusters on body margin. 13
6 Cluster of small ventral oral collar tubular ducts present marginally only on each of last two or three abdominal segments. 7
– Cluster of small ventral oral collar tubular ducts present marginally at least on each two abdominal segments. 12
7 Discoidal pores in sclerotized area of enlarged tubular ducts on dorsum never contacting rim of duct opening (be careful not to confuse sockets of broken setae with discoidal pores); discoidal pores associated with larger ventral oral collar tubular ducts almost never touching rim of duct opening. 8
– Discoidal pores in sclerotized area of enlarged tubular ducts on dorsum nearly always touching sclerotized rim of duct opening; discoidal pores often associated with larger ventral oral collar tubular ducts and touching rim of duct opening (except for some ducts of *F. cristinae* with pores not touching rim). 9
8 Discoidal pores associated with sclerotized area around rim of dorsal enlarged tubular ducts on anterior abdomen usually not touching outer margin of sclerotized area and almost never projecting out from margin; other more variable features: small oral collar tubular ducts in marginal clusters on posterior abdomen with distal end rounded; antennae usually ≤ 600 μm, often ≤ 560 μm long; usually ≥ 15 multilocular disc pores on venter of abdominal segment VI, often forming at least a partial double row medially; translucent pores present on dorsal surface of hind coxa, especially posterolaterally, although often few in number; one or both anal lobes sometimes with an extra one or two conical cerarian setae, slenderer than the other two setae; outline of abdomen usually smoothly curvilinearly tapered to anal lobes. .... ***F. virgata*** (Cockerell, 1893)
– Most discoidal pores associated with sclerotized area around rim of dorsal enlarged tubular ducts on abdomen located on outer margin of sclerotized area and often with pore and its surrounding sclerotization projecting out from margin; other more variable features: small oral collar tubular ducts in marginal clusters on posterior abdomen with distal end slightly tapered towards attachment of inner ductule (these ducts rare or clusters absent in some Neotropical specimens); antenna usually ≥ 600 μm long; usually ≤ 15 multilocular disc pores on venter of abdominal segment VI, typically forming a single, sometimes irregular row; translucent pores absent from dorsal and ventral surface of hind coxa or, if present, antennae ≥ 600 μm long; anal lobes usually with just two robust conical cerarian setae (except some specimens from *Dasylirion*); outline of abdomen slightly indented anterior to level of posterior ostioles in specimens from tropical locations. ..... ***F. dasylirii*** (Cockerell, 1896)
9 Translucent pores absent from hind coxa; each anal lobe with ≥ 60 trilocular pores; small oral collar tubular ducts usually in tight segmental clusters on ventral margins of posterior two or three abdominal segments, distributed 0–7 on each side of segment VI, 6–25 on each side of VII, 8–21 on each side of VIII. ..... ***F. kondoi*** Kaydan & Gullan, 2012
– Translucent pores numbering > 20 on each hind coxa; each anal lobe with ≤ 50 trilocular pores; small oral collar tubular ducts on ventral margins of posterior two or three abdominal segments either not forming tight clusters or in small clusters, each side of each segment usually with ≤ 6 ducts. 10
10 Ventral oral collar tubular ducts present on abdominal submargin (not those in posterior marginal clusters) sometimes with two contiguous elliptical to elongate triangular discoidal pores in sclerotized rim of duct (check with 100× objective). .... ***F. williamsi*** Kaydan & Gullan, 2012
– Ventral oral collar tubular ducts on abdominal sub-

margin (not those in posterior marginal clusters) often with a circular discoidal pore in sclerotized rim of duct or on nearby derm in at least some ducts. 11

11 Multilocular disc pores only present on abdominal segments VII to IX; 87–99 enlarged tubular ducts present on dorsum; translucent pores on hind legs totalling 16–31 on all segments combined; translucent pores on hind coxae 2.5–3.0 μm in diameter; small oral collar tubular ducts on posterior ventral abdominal segments numbering 1–3 on each side of VII, 0–1 on each side of VIII+IX. ..... ***F. kaki*** Kaydan & Pacheco da Silva, 2016

– Multilocular disc pores present on abdominal segments VI to IX; 95–113 enlarged tubular ducts on dorsum; translucent pores on hind legs totalling 80–93 on all segments combined, with 22–55 on each hind coxa; translucent pores on hind coxae 0.5–2.0 μm in diameter; small oral collar tubular ducts on last ventral abdominal segments numbering 3–6 on each side of VII, 3–6 on each side of VIII+IX. ..... ***F. cristinae*** Kaydan & Gullan, 2012

12 Clusters of small oral collar tubular ducts present on margins of head, each segment of thorax and abdomen; each small oral collar duct with a rounded inner end; diameter of each discoidal pore associated with small oral collar tubular ducts about same diameter as rim of duct opening. ..... ***F. milleri*** Kaydan & Gullan, 2012

– Clusters of small oral collar tubular ducts present only on margins of each abdominal segment; each small oral collar duct with inner end slanted towards attachment of inner ductule; diameter of each discoidal pore associated with small oral collar tubular ducts much smaller than diameter of rim of duct opening. ..... ***F. ecuadorensis*** Kaydan & Gullan, 2012

13 Multilocular disc pores entirely absent. ..... ***F. meridionalis*** Williams, 1985

– Multilocular disc pores present at least next to vulva. 14

14 Multilocular disc pores present on abdominal segment VI in a distinct row of 3–19 pores. 15

– Multilocular disc pores usually absent on abdominal segment VI, rarely one or two pores present. 18

15 Dorsal enlarged tubular ducts present on all segments, at least on margins and medially, generally numbering 80–120. 16

– Dorsal enlarged tubular ducts generally numbering 10–30, generally restricted to body margin. 17

16 Ventral oral collar tubular duct of only one size. Translucent pores present on hind coxae, femora and tarsi. ..... ***F. uzinuri*** Kaydan & Gullan, 2012

– Ventral oral collar tubular duct of two sizes. Translucent pores present on hind femora and tarsi but absent on hind coxae. ..... ***F. san*** Tanaka, **sp. nov.**

17 Ventral oral collar tubular ducts totalling 50–70; diameter of each discoidal pore associated with oral collar tubular ducts about twice diameter of rim of duct opening; body length ≥ 1.8 mm long and ≥ 1 mm wide. ..... ***F. colombiana*** Kaydan & Gullan, 2012

– Ventral oral collar tubular ducts totalling 13–23; diameter of each discoidal pore associated with oral collar tubular ducts never twice diameter of rim of duct opening (usually about same diameter); body ≤ 1.8 mm long and ≤ 1.0 mm wide [on bromeliads]. ..... ***F. pitcairnia*** Kaydan & Gullan, 2012

18 Multilocular disc pores present only posterior to vulva; dorsal enlarged tubular ducts never numbering more than 2; hind trochanter + femur < 300 μm. ..... ***F. multiformis*** Granara de Willink, 1991

– Multilocular disc pores present on area anterior and posterior to vulva; dorsal enlarged tubular ducts totalling more than 100; hind trochanter + femur ≥ 300 μm. 19

19 Body shape slender; dorsal enlarged tubular ducts on head and median area of abdominal segments with associated setae situated inside sclerotized area surrounding each duct opening. ..... ***F. terani*** Williams & Granara de Willink, 1992

– Body shape broadly oval; dorsal enlarged tubular ducts on head and median area of abdominal segments with associated setae situated on edge of small sclerotized area surrounding each duct opening. ..... ***F. malvastra*** (McDaniel, 1962)

Discussion

Taxonomic confusion of *Ferrisia* species in Vietnam and Southeast Asia. Species of *Ferrisia* have long posed taxonomic challenges, particularly prior to the revision by Kaydan & Gullan (2012), who provided the most comprehensive and detailed treatment of the genus. Their work enabled, for the first time, relatively straightforward identification of species within *Ferrisia*.

The first record of *Ferrisia* in Vietnam was that of *F. virgata* (Danzig & Konstantinova 1990). However, Williams (2004) noted that specimens from early records of *F. virgata* require re-examination to confirm their identity. Williams (2004) also reported *F. virgata* from Vietnam, though he acknowledged that this was based on preliminary findings during his study of the genus. Furthermore, his illustration of *F. virgata* depicts discoidal pores located at the outermost edge of the sclerotized area surrounding the orifice of dorsal enlarged tubular ducts, a feature that differs slightly from the redescription of *F. virgata* provided by Kaydan & Gullan (2012). These discrepancies suggest that *Ferrisia* specimens identified as *F. virgata* in Vietnam require careful re-evaluation to determine whether true *F. virgata* is indeed present, and if so, whether it infests cassava or not.

Parsa et al. (2012) documented the invasion of *Phenacoccus manihoti* Matile-Ferrero, 1977, one of the most destructive pests of cassava, into Southeast Asia. They also presented a potential distribution model for the species across the region and provided a key to the mealybug species recorded on *Manihot* spp., including cassava (*Manihot esculenta*), worldwide. However, the key by Parsa et al. (2012), which includes just four *Ferrisia* species, presents a problem: all *Ferrisia* specimens bearing multilocular

disc pores on abdominal segment VI of the venter would key out as true *F. virgata*, but *F. san* sp. nov. also has these pores on the venter of abdominal segment VI and thus would be erroneously identified as *F. virgata*. Thus, it is highly likely that misidentifications of this nature exist elsewhere in Southeast Asia. Therefore, *Ferrisia* species infesting cassava in the region require thorough taxonomic re-examination.

Pest status of the new species in cassava cultivation in southern Vietnam. Graziosi et al. (2016) reported eight mealybug species infesting cassava in Southeast Asia: *Ferrisia virgata*, *Maconellicoccus hirsutus* (Green, 1908), *Paracoccus marginatus* Williams & Granara de Willink, 1992, *Phenacoccus manihoti*, *Phenacoccus madeirensis* Green, 1923, *Phenacoccus solenopsis* Tinsley, 1898, and *Pseudococcus jackbeardsleyi* Gimpel & Miller, 1996. In our cassava pest survey conducted in 2016 in southern Vietnam, four species were detected: *Paracoccus marginatus*, *Phenacoccus manihoti*, *Pseudococcus jackbeardsleyi*, and *F. san*. The latter was initially identified using the key in Parsa et al. (2012) and was thus misidentified as *F. virgata*.

Among these four species, *F. san* was the rarest during our survey. Based on observed population sizes, it appears to be the least abundant and least impactful mealybug species asociated with cassava in southern Vietnam. However, if this mealybug serves as a vector for viral or other cassava diseases, its impact assessment would require significant re-evaluation. Presently, cassava mosaic disease (CMD), caused by the Sri Lankan cassava mosaic virus (SLCMV), is widespread in southern Vietnam (Uke et al. 2022). While the primary vector of SLCMV is believed to be the *Bemisia tabaci* (Gennadius, 1889) species complex, as confirmed through multiple virus transmission experiments (Uke et al. 2022), it remains important to investigate whether *F. san* may also be capable of transmitting this virus.

It is well-documented that in their native ecosystems, where natural enemies regulate their populations, many pest insects including mealybugs rarely reach damaging levels. However, when introduced to new environments devoid of natural enemies, these same species can become highly invasive and economically significant pests (Nagrare et al. 2009, Orek 2024). To mitigate such risks, it is essential to thoroughly investigate the current distribution of *F. san* and to promote appropriate cassava cultivation and propagation practices, particularly in the handling and trade of seedlings and harvested material, that minimize the potential for accidental spread and introduction of mealybugs.

Potential risks associated with international trade and quarantine. As highlighted above, members of the Coccomorpha, including the species described in this study, often become significant pests when introduced into new regions where such biocontrol agents are absent. Consequently, international plant protection and quarantine agencies maintain heightened vigilance concerning the unintentional spread of Coccomorpha species through trade.

Cassava is a key agricultural export crop for Vietnam. However, because of the pest risk posed by species such as *F. san*, the export of raw, unprocessed cassava material may be restricted or prohibited by certain importing countries. To reduce the risk of pest dissemination and facilitate international trade, it may be advisable to prioritize the export of processed cassava products, such as dried tips, over raw plant material.

Acknowledgements

The first author expresses sincere gratitude to Mr Dat Nguyen Tuan (Nong Lam University), Mr An Dang Thien (Southern Pesticide Control and Testing Center, Vietnam), and the members of the second author's (HKL) laboratory for their kind assistance during the sample collection expedition in Vietnam. The authors also thank Dr Vitor C. Pacheco da Silva (Universidad de la República de Uruguay) for kindly checking the diameter of the translucent pores in *Ferrisia kaki* and giving us the information. We also deeply appreciate reviewers of this paper for their kind and useful comments, corrections, and encouragement. This research was supported by the Science and Technology Research Partnership for Sustainable Development (SATREPS) in collaboration with the Japan Science and Technology Agency (JST; JPMJSA1508).

References

CARTER W. 1963: Mealybug wilt of pineapple; a reappraisal. *Annals of the New York Academy of Sciences* **105**: 741–764.

DANZIG E. M. & KONSTANTINOVA G. M. 1990: [On coccid (Homoptera, Coccinea) fauna of Vietnam]. *Trudy Zoologicheskogo Instituta Akademiya Nauk SSSR* **209**: 38–52 (in Russian).

GARCÍA MORALES M., DENNO B. D., MILLER D. R., MILLER G. L., BEN-DOV Y. & HARDY N. B. 2025: *ScaleNet: A Literature-Based Model of Scale Insect Biology and Systematics*. Database. Available online at: http://scalenet.info [last accessed on 12 July 2025].

GRAZIOSI I., MINATO N., ALVAREZ E., NGO D. T., HOAT T. X., AYE T. M., PARDO J. M., WONGTIEM P. & WYCKHUYS K. A. G. 2016: Emerging pests and diseases of South-east Asian cassava: a comprehensive evaluation of geographic priorities, management options and research needs. *Pest Management Science* **72**: 1071–1089.

HOMMAY G., BEUVE M. & HERRBACH E. 2022: Transmission of Grapevine leafroll-associated viruses and Grapevine virus A by vineyard-sampled soft scales (*Parthenolecanium corni*, Hemiptera: Coccidae). *Viruses* **14 (2679)**: 1–13.

KAYDAN M. B. & GULLAN P. J. 2012: A taxonomic revision of the mealybug genus *Ferrisia* Fullaway (Hemiptera: Pseudococcidae), with descriptions of eight new species and a new genus. *Zootaxa* **3543**: 1–65.

KONDO T. & WATSON G. W. 2022: *Encyclopedia of Scale Insect Pests.* CABI Wallingford, UK, 608 pp.

MORRISON H. & MORRISON E. R. 1966: An annotated list of generic names of the scale insects (Homoptera: Coccoidea). *Miscellaneous Publication United States Department of Agriculture* **1015**: 1–206.

NAGRARE V. S., KRANTHI S., BIRADAR V. K., ZADE N. N., SANGODE V., KAKDE G., SHUKLA R. M., SHIVARE D., KHADI B. M. & KRANTHI K. R. 2009: Widespread infestation of the exotic mealybug species, *Phenacoccus solenopsis* (Tinsley) (Hemiptera: Pseudococcidae), on cotton in India. *Bulletin of Entomological Research* **99**: 537–541.

OREK C. 2024: A review of management of major arthropod pests affecting cassava production in Sub-Saharan Africa. *Crop Protection* **175 (106465)**: 1–15.

PACHECO DA SILVA V. C., KAYDAN M. B., GERMAIN J. F., MALAUSA T. & BOTTON M. I. 2016: Three new species of mealybug (Hemiptera, Coccomorpha, Pseudococcidae) on persimmon fruit trees (*Diospyros kaki*) in southern Brazil. *ZooKeys* **584**: 61–82.

PARSA S., KONDO T. & WINOTAI A. 2012: The cassava mealybug (*Phenacoccus manihoti*) in Asia: first records, potential distribution, and an identification key. *PLOS One* **7 (10) (e47675)**: 1–11.

SARTIAMI D. & KONDO T. 2022: *Dysmicoccus* spp. (Hemiptera: Coccomorpha: Pseudococcidae). Pp. 162–177. In: KONDO T. &WATSON G. (eds): *Encyclopedia of Scale Insect Pests.* CABI International, Wallingford, 608 pp.

TANAKA H. 2014: How to make slide-mounted specimens of scale insects, a method of a Japanese coccidologist. *Shokubutu Boueki* **68**: 483–488.

TANAKA H., CHOI J. & KAMITANI S. 2025: Taxonomic review of three species of the genus *Pseudococcus* Westwood, 1840 (Hemiptera: Coccomorpha: Pseudococcidae) found in Okinawa Island, Japan, with description of a new species. *Zootaxa* **5637**: 579–593.

UKE A., TOKUNAGA H., UTSUMI Y., VU N. A., NHAN P. T., SREAN P., HY N. H., HAM L. H., LOPEZ-LAVALLE L. A. B., ISHITANI M., HUNG N., TUAN L. N., VAN HONG N., HUY N. Q., HOAT T. X., TAKASU K., SEKI M. & UGAKI M. 2022: Cassava mosaic disease and its management in Southeast Asia. *Plant Molecular Biology* **109**: 301–311.

WILLIAMS D. J. 2004: *Mealybugs of Southern Asia.* The Natural History Museum, London & Southdene, Kuala Lumpur, 896 pp.