Journal of Asia-Pacific Biodiversity xxx (xxxx) xxx

Contents lists available at ScienceDirect

Journal of Asia-Pacific Biodiversity

journal homepage: http://www.elsevier.com/locate/japb

Short Communication

Two new records of mealybugs (Coccomorpha: Pseudococcidae) on succulent plants (Crassulaceae) from Korea

Jinyeong Choi [a], Young-Su Lee [b], Hee-A Lee [b], Seunghwan Lee [a,c,*]

[a] Insect Biosystematics Laboratory, Department of Agricultural Biotechnology, Seoul National University, Seoul 151-921, Republic of Korea
[b] Gyeonggi-do Agricultural Research and Extension Services, Hwaseong 18338, Republic of Korea
[c] Research Institute of Agriculture and Life Sciences, Seoul National University, Seoul 151-921, Republic of Korea

ARTICLE INFO

Article history:
Received 26 January 2021
Received in revised form
19 May 2021
Accepted 8 June 2021
Available online xxx

Keywords:
New records
Phenacoccus solani
Succulent plants
Taxonomy
Vryburgia distincta

ABSTRACT

Phenacoccus solani Ferris, 1918 and *Vryburgia distincta* (De Lotto, 1964) are herein reported occurring on succulent plants (*Echeveria* spp.) in South Korea. Both species have not been documented from South Korea except for quarantine inspection reports. In this study, diagnoses, descriptions, and photographs of the two species are provided with general information about their host plants and distributions.

Introduction

Succulents generally refer to plants with large living cells inside their leaves, roots, and/or stems for water storage. These water preserving plants are often found in the plant families Aizoaceae, Apocynaceae, Asparagaceae, Asphodelaceae, Cactaceae, Crassulaceae, Euphorbiaceae, and Orchidaceae (Griffiths and Males 2017). Although succulent plants may have originated from multiple regions of the world, South Africa has the highest diversity of succulents, with 4,600 species in 58 families (Smith et al 1997). Because of their peculiar morphology and beneficial values, succulent plants are particularly favored as ornamental plants, and many species are sold in the international trade (Fragoso et al 1999; Rutherford et al 2018). In South Korea, a variety of succulents have been imported from Australia, Brazil, China, Indonesia, Italy, Japan, Mexico, Netherlands, New Zealand, and the USA (Ji and Suh 2012).

The family Pseudococcidae, commonly known as mealybugs, is a group of plant sap-feeding insects, comprised of over 2,000 described species in 250 genera (as listed in ScaleNet; García Morales et al 2019). The mealybugs include many polyphagous species, most of which are serious pests in agriculture and/or horticulture, such as *Ferrisia virgata* (Cockerell), *Maconellicoccus hirsutus* (Green), *Planococcus citri* (Risso), *Pseudococcus viburni* (Signoret), and *Phenacoccus solenopsis* Tinsley (McKenzie 1967; Williams 2004). In general, mealybugs directly damage the health condition of plants by sucking plant sap and the excretion of honeydew, which induces sooty molds that inhibit photosynthesis. Additionally, mealybugs are well-known as major quarantine pests because they are obligate plant parasites with a sessile lifestyle on the host plant (Hong et al 2012; Suh et al 2013; Ren et al 2018).

In South Korea, 15 species in 12 genera of scale insects had been intercepted from imported succulent plants during 2006–2010 (Ji and Suh 2012). Among them, 11 species were determined as belonging to the family Pseudococcidae as follows: *Dysmicoccus neobrevipes* Beardsley, *Ferrisia virgata* (Cockerell), *Paracoccus solani* Ezzat & McConnell, *Phenacoccus solani* Ferris, *Planococcus citri* (Risso), *Pseudococcus viburni* (Signoret), *Spilococcus mamillariae* (Bouché), *Vryburgia amaryllidis* (Bouché), *V. distincta* (De Lotto), *V. trionymoides* (De Lotto), and *Vryburgia* sp. Except for *P. citri* and *P. viburni*, the other species have not been recorded from South Korea.

In this study, we report for the first time the occurrence of two species of mealybugs, *P. solani* and *V. distincta*, from Korean succulent plantations. Here we provide morphological information for species determination, as well as host and distribution data for

* Corresponding author.
E-mail address: seung@snu.ac.kr (S. Lee).
Peer review under responsibility of National Science Museum of Korea (NSMK) and Korea National Arboretum (KNA).

https://doi.org/10.1016/j.japb.2021.06.008
pISSN2287-884X eISSN2287-9544/

Please cite this article as: Choi J et al., Two new records of mealybugs (Coccomorpha: Pseudococcidae) on succulent plants (Crassulaceae) from Korea, Journal of Asia-Pacific Biodiversity, https://doi.org/10.1016/j.japb.2021.06.008

these two species in order to prevent the additional introduction and spread of these species.

Material and methods

The specimens were mounted on microscope slides following the method of Danzig & Gavrilov-Zimin (2014). The photomicrographs of slide-mounted specimens were taken with a digital camera (Infinity3, Lumenera Corporation, Ottawa, Ontario) mounted on a compound light microscope (DM 4000B, Leica Microsystem, Wetzlar, Germany). The morphological terminology used follows that of McKenzie (1967). The specimens are deposited in either (i) Seoul National University, Seoul, Republic of Korea (SNU) and (ii) Gyeonggi Province Agricultural Research & Extension Services, Hwaseong-si, Republic of Korea (GARES).

Systematic accounts

Genus *Phenacoccus* Cockerell, 1893: 318.

Type species: *Phenacoccus aceris* (Signoret, 1875): by original designation.

Diagnosis. Body elongated to broadly oval. Antenna usually 8 or 9 segmented (occasionally 6 or 7). Legs usually well-developed; translucent pores usually absent on coxae of hind legs, sometimes present on hind femur and tibia; claw mostly with a denticle. Circulus 1–3 present or absent. Anterior and posterior pair of ostioles both present or only posterior pair present. Multilocular disc-pores usually present on venter, sometimes also present on dorsum. Trilocular pores present on dorsum and venter. Oral collar tubular ducts of simple type, usually present but sometimes absent. Oral-rim tubular ducts absent. Quinquelocular pores present or absent. Dorsal setae conical to lanceolate, of different sizes. Cerarii numbering 1–18 pairs, usually each bearing 2 or more conical to lanceolate setae, and a group of trilocular pores, plus sometimes with additional cerarii on medial area of dorsum (partially adapted from McKenzie 1967; Williams 2004; Danzig and Gavrilov-Zimin 2014).

Remarks. Phenacoccus contains 179 described species from all zoogeographical regions (García Morales et al 2019). This genus is the largest group in the Pseudococcidae, mostly including species with 9-segmented antennae and claws with denticles (McKenzie 1967). However, phylogenetic studies have revealed that *Phenacoccus* is clearly non-monophyletic and needs taxonomic revision (Downie and Gullan 2004; Hardy et al 2008; Kaydan et al 2015). Hitherto, five species of *Phenacoccus* were known from Korea (*P. poriferus* Borchsenius was transferred to *Fonscolombia* as *Fonscolombia porifera* (Borchsenius) (Danzig and Gavrilov-Zimin 2014; NIBR 2019).

Phenacoccus solani Ferris, 1918
(Figures 1, 2)
Phenacoccus solani Ferris, 1918: 60.

Diagnosis. Cerarii numbering 18 pairs. Anal lobe cerarii (C18) with 2 lanceolate setae, plus 1–3 smaller setae. Other cerarii mostly with 2 conical setae only. Antenna 8-segmented. Circulus 1 present. Dorsal setae lanceolate. Translucent pores present on surface of each tibia. Claw with a denticle. Multilocular disc-pores present on venter only, mainly present on medial area of abdominal segments V–IX (occasionally restricted to VII–IX). Oral collar tubular ducts present on venter but absent on dorsum. Quinquelocular pores and oral-rim tubular ducts entirely absent.

Description. Adult female.

Living appearance. Body elongate oval, yellowish, with thin covering of white powdery wax, very short lateral filaments around entire body margin, and caudal filaments slightly longer and thicker than lateral filaments. Ovisac and eggs not seen.

Slide-mounted material. Body elongate oval. Anal lobes normally developed, each with an apical seta but without anal lobe bar.

Dorsum. Derm membranous. Cerarii numbering 18 pairs. Anal lobe cerarii (C18) each bearing 2 lanceolate setae, plus 1–3 smaller setae, and a group of trilocular pores. Other cerarii mostly each with 2 conical setae and a few trilocular pores. Anterior and posterior pair of ostioles both present. Dorsal setae short, lanceolate. Multilocular disc-pores absent. Trilocular pores present. Quinquelocular pores, oral collar tubular ducts, and oral-rim tubular ducts absent.

Venter. Antenna 8-segmented (occasionally 9). Circulus 1 present. Legs well-developed, slender. Translucent pores present on surface of each tibia; claw with a denticle. Ventral setae flagellate. Multilocular disc-pores mainly present in rows on medial area of abdominal segments V–IX. Trilocular pores present. Quinquelocular pores absent. Oral collar tubular ducts of one size, present mostly across medial and marginal areas of posterior abdominal segments, plus a few on medial area of anterior thorax. Oral-rim tubular ducts absent.

Host plants. According to ScaleNet (García Morales et al 2019), *P. solani* has been recorded from plants belonging to 90 genera in 36 families. In Korea, it was found on *Echeveria* sp. (Crassulaceae).

Distribution. Afrotropical region (Egypt, South Africa, and Zimbabwe), Australian region (Australia), Oriental region (India,

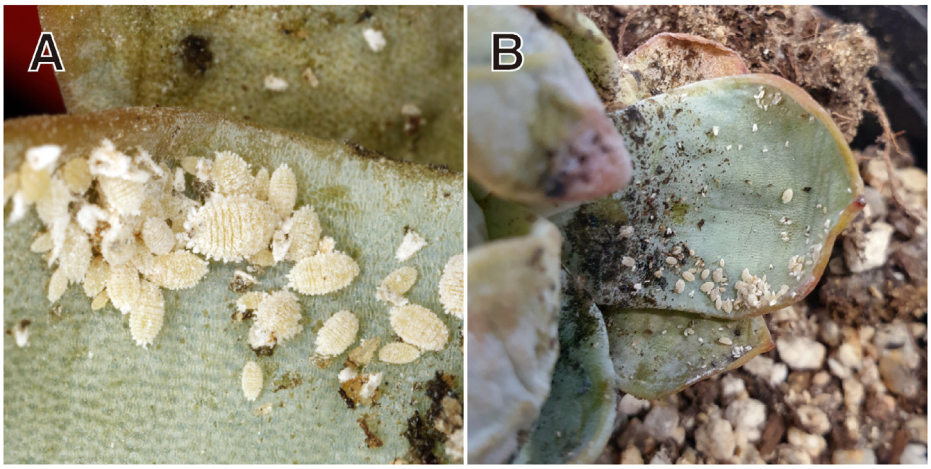

Figure 1. *Phenacoccus solani* Ferris, 1918: A, Population of *P. solani*; B, Field appearance of *P. solani* occurring on *Echeveria* sp.

Please cite this article as: Choi J et al., Two new records of mealybugs (Coccomorpha: Pseudococcidae) on succulent plants (Crassulaceae) from Korea, Journal of Asia-Pacific Biodiversity, https://doi.org/10.1016/j.japb.2021.06.008

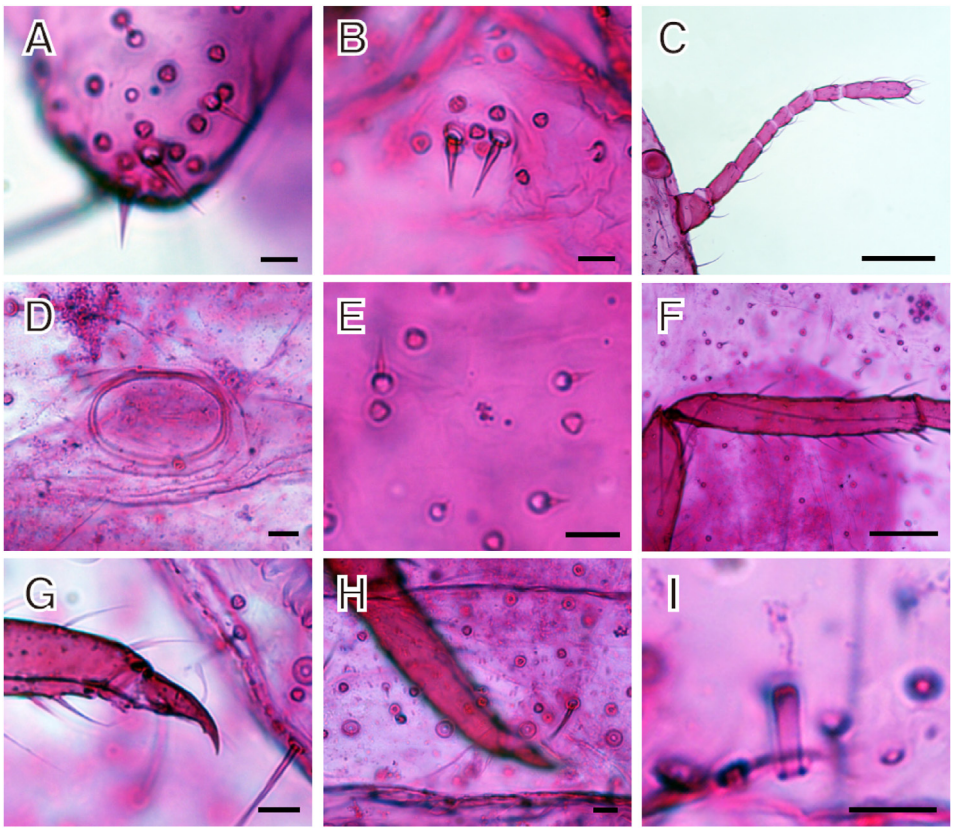

Figure 2. *Phenacoccus solani* Ferris, 1918: A, Anal lobe cerarius; B, Penultimate cerarius; C, Antennae; D, Circulus; E, Dorsal setae and trilocular pores; F, Translucent pores on tibia of metathoracic leg; G, Denticle on claw; H, Multilocular disc-pores on abdominal segment VII; I, Oral collar tubular ducts on venter. <scale bar: 10 μm (A-B); 100 μm (C); 10 μm (D-E); 50 μm (F); 10 μm (G-I)>.

Singapore, Thailand, and Vietnam), Palearctic region (China, France, Germany, Iran, Israel, Italy, Japan, Spain, Turkey, and UK), Nearctic region (Canada and USA) and Neotropical region (Brazil, Colombia, Cuba, Ecuador, Mexico, and Peru) (as listed in ScaleNet; García Morales et al 2019); first record for South Korea.

Material examined. 5♀♀, Hwajeong-dong, Deogyang-gu, Goyang-si, Gyeonggi-do, 26 viii 2020 (HA Lee), on *Echeveria* sp. (named as *Echeveria* laurinze) (Crassulaceae).

Remarks. Phenacoccus solani is similar to *P. solenopsis* Tinsley but differs in having 8-segmented antennae (rarely 9), small circulus without intersegmental line, and multilocular disc-pores usually present on the last 4 or 5 abdominal segments (V–IX) (rarely restricted to the last 3 abdominal segments (VII–IX)), whereas *P. solenopsis* has 9-segmented antennae, larger circulus with intersegmental line, and multilocular disc-pores restricted to the last 3 abdominal segments (VII–IX) (McKenzie 1967; Williams 2004). Although the examined specimens in this study have multilocular disc-pores restricted to the 3 abdominal segments (VII–IX), the number of antennal segments (Figure 2C), and the shape and size of circulus (Figure 2D) were more close to the characteristics of

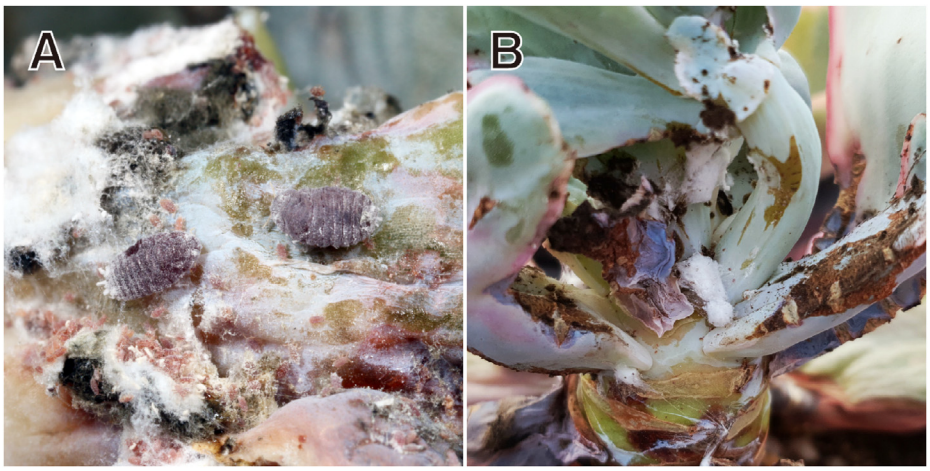

Figure 3. *Vryburgia distincta* (De Lotto, 1964): A, Population of *V. distincta*; B, Field appearance of *V. distincta* occurring on *Echeveria* sp.

Please cite this article as: Choi J et al., Two new records of mealybugs (Coccomorpha: Pseudococcidae) on succulent plants (Crassulaceae) from Korea, Journal of Asia-Pacific Biodiversity, https://doi.org/10.1016/j.japb.2021.06.008

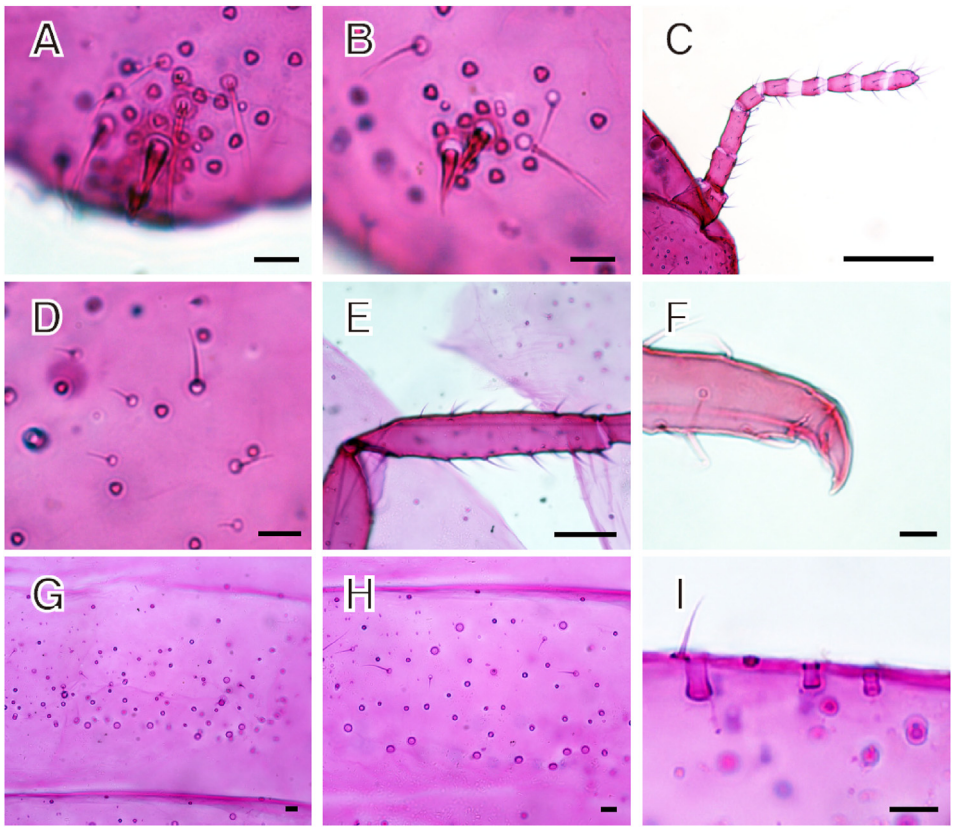

Figure 4. *Vryburgia distincta* (De Lotto, 1964): A, Anal lobe cerarius; B, Penultimate cerarius; C, Antennae; D, Dorsal setae, E, Translucent pores on tibia of metathoracic leg; F, Denticle on claw; G, Multilocular disc-pores on abdominal segment V; H, Multilocular disc-pores on abdominal segment VI; I, Three sizes of oral collar tubular ducts. <scale bar: 10 μm (A-B); 100 μm (C); 10 μm (D); 50 μm (E); 10 μm (F–I)>.

P. solani. Because the distribution of multilocular disc-pores in *P. solani* also can be restricted to the abdominal segments VII–IX, we identified the specimens as *P. solani*. In this study, *P. solani* is newly documented in South Korea. *P. solani* differs from the other species of *Phenacoccus* from Korea in lacking dorsal tubular ducts, whereas all the other species have numerous dorsal tubular ducts. Previously, this species was intercepted on *Aeonium* sp. (from Italy), *Crassula* (from Japan), *Echeveria* (from China, the Netherlands, Indonesia, Brazil, and Japan), *Graptoveria* (from Japan), and *Pachyphytum* (from the Netherlands) at the ports of entry of Korea (Ji and Suh 2012; Suh et al 2013). *P. solani* might be an invasive species that was probably introduced by the import of succulent plants from other countries. Further research is needed to know the exact origin of this species.

Genus *Vryburgia* De Lotto, 1967
Vryburgia De Lotto 1967: 21.
Type species: *Pseudococcus bechuanae* Brain, 1915: by original designation.

Diagnosis. Body narrowly to broadly oval. Antenna 6–8 segmented. Legs well-developed; translucent pores usually present; claw with or without a denticle. Circulus present or absent. Anterior and posterior pair of ostioles both present. Multilocular disc-pores present on venter. Trilocular pores present on dorsum and venter. Oral collar tubular ducts present on dorsum and venter. Oral-rim tubular ducts present or absent. Quinquelocular pores absent. Dorsal setae flagellate. Cerarii usually numbering 1–5 pairs on posterior abdominal segments, each bearing 2 conical setae, plus several auxiliary setae and a few trilocular pores (partially adapted from Cox 1987; Williams 2004).

Remarks. Vryburgia contains 10 described species from Afrotropical, Australian, Palearctic, and Nearctic regions (mainly Afrotropical region) (García Morales et al 2019). This genus is similar to *Chorizococcus* Mckenzie but is differentiated from the latter by the presence of dorsal oral collar tubular ducts distributed across the segments in addition to transverse rows of oral rim tubular ducts; in contrast, *Chorizococcus* does not have oral collar tubular ducts on dorsum (if present, restricted to margin) (Williams 2004). Currently, any species of *Vryburgia* were not known from Korea.

Vryburgia distincta (De Lotto, 1964)
(Figures 3, 4)
Phenacoccus distinctus De Lotto, 1964: 366.

Diagnosis. Cerarii numbering 2 pairs. Anal lobe cerarii (C18) with 2 conical setae, plus about 7 auxiliary setae. Penultimate cerarii (C17), each with 2 conical, plus 1 or 2 auxiliary setae. Antenna 8-segmented. Circulus absent. Dorsal setae flagellate. Translucent pores present on surface of each tibia. Claw with a denticle. Multilocular disc-pores present on dorsum and venter. Oral collar tubular ducts of three or four sizes, entirely present on surface of dorsum and venter. Quinquelocular pores absent. Oral-rim tubular ducts present.

Description. Adult female.

Living appearance. Body narrowly to broadly oval, dark reddish or violet in color, with thin covering of white powdery wax, lateral filaments restricted to posterior body margin, and caudal filaments

Please cite this article as: Choi J et al., Two new records of mealybugs (Coccomorpha: Pseudococcidae) on succulent plants (Crassulaceae) from Korea, Journal of Asia-Pacific Biodiversity, https://doi.org/10.1016/j.japb.2021.06.008

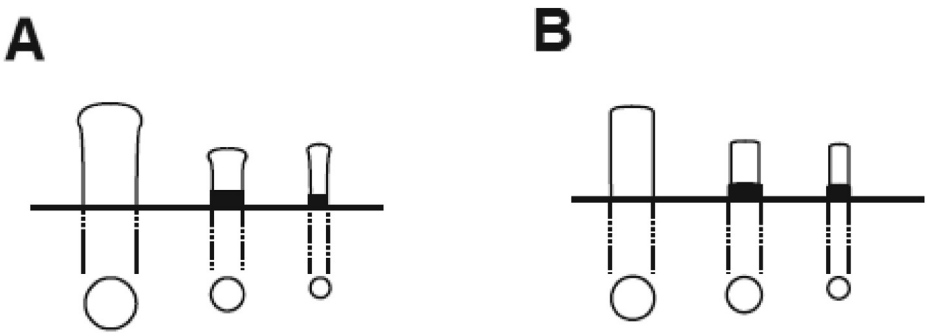

Figure 5. Oral collar tubular ducts.: A, Ducts of *Vryburgia distincta* (De Lotto, 1964); B, Ducts of *V. trionymoides* (De Lotto, 1961).

longer and thicker than lateral filaments. Ovisac white. Eggs orange in color.

Slide-mounted material. Body narrowly oval. Anal lobes normally developed, each with an apical seta but without anal lobe bar.

Dorsum. Derm membranous. Cerarii numbering 2 pairs, present on posterior of abdomen. Anal lobe cerarii (C18), each bearing 2 conical setae, plus about 7 auxiliary setae and a group of trilocular pores, situated on slightly sclerotized area. Penultimate cerarii (C17), each with 2 conical, plus 1 or 2 auxiliary setae and a few trilocular pores. Anterior and posterior pair of ostioles both present. Dorsal setae short, flagellate. Multilocular disc-pores few present on medial and marginal areas of abdominal segments, plus solitary pores on medial area of thorax. Trilocular pores present. Quinquelocular pores absent. Oral collar tubular ducts of three or four sizes, present on all segments of body. Oral-rim tubular ducts present but similar to large tubular ducts.

Venter. Antenna 8-segmented with a pseudoarticulation on apical segment. Circulus absent. Legs well-developed, normal. Translucent pores present on surface of each tibia; claw with a denticle. Ventral setae flagellate. Multilocular disc-pores present in rows on medial area of abdominal segments V–IX, plus solitary pores on anterior abdomen and medial area of thorax. Trilocular pores present. Quinquelocular pores absent. Oral collar tubular ducts of three or four sizes, present on all segments of body. Oral-rim tubular ducts present but similar to large tubular ducts.

Host plants. According to ScaleNet (García Morales et al 2019), *V. distincta* has been recorded from *Crassula* sp. (Crassulaceae) and *Galenia africana* (Aizoaceae). In Korea, it was found on *Echeveria* sp. (Crassulaceae).

Distribution. Afrotropical region (South Africa) (as listed in ScaleNet; García Morales et al 2019); first record for South Korea.

Material examined. 10♀♀, Wonheung-dong, Deogyang-gu, Goyang-si, Gyeonggi-do, 13 vii 2020 (HA Lee), on *Echeveria* sp. (named as *Echeveria* flying cloud) (Crassulaceae).

Remarks. Vryburgia distincta is very similar to *V. trionymoides* (De Lotto). Based on the original descriptions and illustrations of De Lotto (1961, 1964), there are two major differences in the morphology of the two species. *V. distincta* has multilocular disc-pores on abdominal segments IV–IX, two or three rows of pores on abdominal segments V–VI, and tubular ducts mostly with slightly swollen inner end (Figure 5A). Whereas *V. trionymoides* has multilocular disc-pores on abdominal segments V–IX, a single row of pores on abdominal segments V–VI, and tubular ducts with parallel sides (without any swollen part) (Figure 5B). The examined specimens in this study have multilocular disc-pores on the abdominal segments V–IX, a single row of pores on abdominal segment V (Figure 4G) but one or two rows of pores on abdominal segment VI (Figure 4H), and tubular ducts with swollen inner end (Figure 4I). Although the distribution of multilocular disc-pores is similar to that of *V. trionymoides*, the shape of tubular ducts is closer to that of *V. distincta*. Because the distribution of multilocular disc-pores often varies according to the individuals and/or developmental stages (Danzig and Gavrilov-Zimin 2014), we identified the specimens as *V. distincta* by putting more weight on the similarity of the tubular ducts. In this study, *Vryburgia* is firstly reported from South Korea for the first time based on *V. distincta*. Previously, this species was intercepted on *Crassula* (from the Netherlands) and *Echeveria* (from the USA) at the ports of entry of Korea (Ji and Suh 2012; Suh et al 2013). *V. distincta* might be an invasive species that was probably introduced by the import of succulent plants from other countries. Further research is needed to know the exact origin of this species.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This work was supported by grants from (i) the National Institute of Biological Resources (NIBR), funded by the Ministry of Environment (MOE) of the Republic of Korea (NIBR202102204), (ii) the Basic Science Research Program through the National Research Foundation of Korea (NRF), funded by the Ministry of Education (NRF2020R1I1A206948412), and (iii) the Korea Environment Industry & Technology Institute (KEITI) through Exotic Invasive Species Management Program, funded by Korea Ministry of Environment (MOE) (2018002270005).

References

Brain CK. 1915. *The Coccidae of South Africa*, vol. 5. Cape Town: Transactions of the Royal Society of South Africa. pp. 65–194.

Cockerell TDA. 1893. Note on the genus *Pseudococcus* Westwood. *Entomological News* 4:317–318.

Cox JM. 1987. Pseudococcidae (Insecta: Hemiptera). In: Duval CT, editor. *Fauna of New Zealand. Duval, 11*. Wellington: DSIR Science Information Publishing Centre. pp. 1–229.

Danzig EM, Gavrilov-Zimin IA. 2014. *Palaearctic mealybugs (Homoptera: Coccinea: Pseudococcidae), Part I: Subfamily Phenacoccinae*. Petersburg: Zoological Institute of Russian Academy of Sciences. pp. 1–678.

De Lotto G. 1961. New Pseudococcidae (Homoptera: Coccoidea) from Africa. *Bulletin of the British Museum (Natural History) Entomology* 10:211–238.

De Lotto G. 1967. *The mealybugs of South Africa (Homoptera: Pseudococcidae), I*, vol. 12. Pretoria: Entomology Memoirs, Department of Agricultural Technical Services, Republic of South Africa. pp. 1–28.

De Lotto G. 1964. Observations on African mealy bugs (Hemiptera: Coccoidea). *Bulletin of the British Museum (Natural History) Entomology* 14:343–397.

Downie DA, Gullan PJ. 2004. Phylogenetic analysis of mealybugs (Hemiptera: Coccoidea: Pseudococcidae) based on DNA sequences from three nuclear genes, and a review of the higher classification. *Systematic Entomology* 29 (2):238–259.

Ferris GF. 1918. *The California species of mealy bugs*. Palo Alto: Stanford University Publications, University Series. pp. 1–78.
Fragoso G, Gillett H, Bishop R. 1999. *Succulent plants in trade from the wild: analysis of conservation status and international trade*. Cambridge: World Conservation Monitoring Centre. pp. 1–169.
García Morales M, Denno BD, Miller DR, et al. 2019. Available at: http://scalenet.info/[Date accessed: 1 August 2020].
Griffiths H, Males J. 2017. Succulent plants. *Current Biology* 27 (17):R890–R896.
Hardy NB, Gullan PJ, Hodgson CJ. 2008. A subfamily-level classification of mealybugs (Hemiptera: Pseudococcidae) based on integrated molecular and morphological data. *Systematic Entomology* 33:51–71.
Hong KJ, Lee JH, Lee GS, et al. 2012. The status quo of invasive alien insect species and plant quarantine in Korea. *Journal of Asia-Pacific Entomology* 15 (4):521–532.
Ji J, Suh SJ. 2012. A list of scale insects (Hemiptera: Coccoidea) intercepted in quarantine on imported succulent plants in Korea 2006–2010. *Insecta Mundi* 272:1–5.
Kaydan MB, Kozár F, Hodgson CJ. 2015. A review of the phylogeny of Palaearctic mealybugs (Hemiptera: Coccomorpha: Pseudococcidae). *Arthropod Systematics & Phylogeny* 73 (1):175–195.
McKenzie HL. 1967. *Mealybugs of California with taxonomy, biology, and control of North American species (Homoptera: Coccoidea: Pseudococcidae)*. Berkeley: University of California Press. pp. 1–526.
National Institute of Biological Resources. 2019. *National Species list of Korea. III. Insects (Hexapoda)*. Seoul: Designzip. pp. 1–988.
Ren JM, Ashfaq M, Hu X, et al. 2018. Barcode index numbers expedite quarantine inspections and aid the interception of nonindigenous mealybugs (Pseudococcidae). *Biological Invasions* 20 (2):449–460.
Rutherford C, Groves M, Sajeva M. 2018. *Succulent Plants*. London: Rutherford Groves Publishing. pp. 1–100.
Signoret V. 1875. Essai sur les cochenilles ou gallinsectes (Homoptères - Coccides), 15e partie. [Essay on the gall forming insects (Homoptera - Coccidae) - 15th Part.]. *Annales de la Société Entomologique de France (serie 5)* 5:305–352.
Smith G, van Jaarsveld EJ, Arnold TH, et al. 1997. *List of southern African succulent plants*. Pretoria: Umdaus Press. pp. 1–175.
Suh SJ, Yu HM, Hong KJ. 2013. List of intercepted scale insects at Korean ports of entry and potential invasive species of scale insects to Korea (Hemiptera: Coccoidea). *Korean Journal of Applied Entomology* 52 (2):141–160.
Williams DJ. 2004. *Mealybugs of Southern Asia*. London: The Natural History Museum. pp. 1–896.

Please cite this article as: Choi J et al., Two new records of mealybugs (Coccomorpha: Pseudococcidae) on succulent plants (Crassulaceae) from Korea, Journal of Asia-Pacific Biodiversity, https://doi.org/10.1016/j.japb.2021.06.008