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Parasitoids (Hymenoptera: Chalcidoidea) reared from
Pseudaulacaspis cockerelli (Cooley) (Hemiptera: Coccoidea)
in the Republic of Korea

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Parasitoids (Hymenoptera: Chalcidoidea) reared from *Pseudaulacaspis cockerelli* (Cooley) (Hemiptera: Coccoidea) in the Republic of Korea

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Abstract. Through this survey, four species of aphelinid, one species of encyrtid, and one species of signiphorid wasp (Hymenoptera: Chalcidoidea) were collected and identified as follows: *Aphytis japonicus* DeBach and Azim, *Encarsia berlesei* (Howard), *Marietta carnesi* (Howard), *Pteroptrix* sp. 2, *Arrhenophagus chionaspidis* Aurivillius, and *Chartocerus subaenus* (Förster). Among these, *C. subaenus* is recorded newly from the Korean parasitoid fauna. Also, three species of aphelinids and one species of signiphorid are newly added as parasitic wasps associated with *Pseudaulacaspis cockerelli* (Cooley) (Hemiptera: Coccoidea) from Korea. In this paper, the list of parasitoid species of *P. cockerelli* that occur in Korea is updated and a brief diagnosis and photographs of these species are provided.

Key words. Aphelinidae, Encyrtidae, Signiphoridae, parasitic wasps, false oleander scale.

Introduction

The false oleander scale, *Pseudaulacaspis cockerelli* (Cooley), was first reported in the Republic of Korea (Korea) in 1941 by Kanda and has become one of most common armored scale insects occurring on various ornamental plants across Korea (Paik 1978; Paik 2000; Kwon and Han 2003; Kwon et al. 2005). To date, the author examined specimens of this species from 69 host plant species including *Taxus cuspidata* Siebold and Zucc. (Taxaceae) and *Ginkgo biloba* L. (Ginkgoaceae), the most frequently recorded hosts. This species has two generations a year in Korea and is most prevalent in the temperate zone of the country. It is found on the upper and lower leaf surfaces and on the stems of their hosts. Besides its unwanted presence, it causes chlorotic spots on leaves that are visible from the upper and lower leaf surface near the point of scale attachment. Heavy infestations can cause leaves to become completely chlorotic and drop off prematurely (Leibee and Savage 1994; Paik 2000).

Insecticidal control of scale insects is generally considered most effective when applications are timed to coincide with the presence of the crawler stage. But, excessive use of insecticides actually increased the number of scale species in urban plantings (Raupp et al. 2001). A survey of the parasitoids of *P. cockerelli* to discover a good biological control agent for the false oleander scale was recently conducted in Korea. According to the Noyes' Universal Chalcidoidea Database (Noyes 2017), eleven species of parasitoids, including seven aphelinid species, three encyrtid species, and one signiphorid species, have been reported to parasitize or be associated with *P. cockerelli*. In Korea, *Aphytis albus* Li and Yang, *Marietta carnesi* (Howard), *Pteroptrix* sp. 1 (Aphelinidae), *Adelencyrtus kosef* (Li and Byun), and *Arrhenophagus chionaspidis* Aurivillius (Encyrtidae) had been recorded previously (Paik 1978; Li and Byun 2001; Li et al. 2001; Li et al. 2002; Li and Yang 2004). Through this survey, four species of aphelinid, one species of encyrtid, and one species of signiphorid wasps were collected and identified as follows; *Aphytis japonicus* DeBach and Azim, *Encarsia berlesei* (Howard), *Marietta carnesi* (Howard), *Pteroptrix* sp. 2, *Arrhenophagus chionaspidis* Aurivillius, and *Chartocerus subaenus* (Förster). Among these, *Chartocerus subaenus* (Förster) is newly recorded from the Korean parasitoid fauna. Also, three species of aphelinids and one species of signiphorid are newly added as parasitic wasps associated with *P. cockerelli* from Korea.

In this paper, the list of parasitoid species of *P. cockerelli* that occur in Korea is updated. A brief diagnosis and habitus photograph of each of the four species newly documented in Korea from this diaspidid host are also provided.

Materials and Methods

To collect as many parasitoid specimens as possible, attempts were made to rear them from the samples of the false oleander scale, *P. cockerelli* infesting leaves and twigs of *Akebia quinata* (Houtt) Decne. (Lardizabalaceae), *Chaenomeles speciosa* (Sweet) Nak. (Rosaceae), *Cornus controversa* Hemsl. (Cornaceae), *Diospyros kaki* L.f. (Ebenaceae), *Ginkgo biloba* L. (Ginkgoaceae), *Ligustrum obtusifolium* Siebold and Zucc. (Oleaceae), and *Taxus cuspidata* Siebold and Zucc. (Taxaceae) from 2014 to 2017. Of these, the parasitoids used in this study were collected from *P. cockerelli* infesting *D. kaki*, *L. obtusifolium*, and *T. cuspidata*. Some specimens of the species reported in this paper were mounted on microscope slides in Hoyer's mounting medium for identification and others were stored in alcohol. They are deposited in the Collection of Plant Quarantine Technology Center. Noyes' Universal Chalcidoidea Database provided a comprehensive summary of information on the nomenclature, hosts, and distribution of Aphelinidae, Encyrtidae, and Signiphoridae of the world (Noyes 2017). Herein the author provides a brief diagnosis and photographs of major characters, based on morphological characters of the adult female and male from the false oleander scale. Terminology for the morphological structure used in the diagnoses follows that of Gibson et al. (1997). Photographs were taken using an AxioCam MRc5 camera through ZEISS Axio Imager M2 Microscope. An asterisk (*) is used to indicate a new host and distribution record. Abbreviations of collection regions in Korea are as follows: GG, Gyeonggido; CN, Chungcheongnamdo; GB, Gyeongsangbukdo; GN, Gyeongsangnamdo; JB, Jeollabukdo; JN, Jeollanamdo; JJ, Jeju-do.

Results

Aphelinidae associated with *P. cockerelli* in Korea

There are five species of aphelinid parasites associated with *P. cockerelli* in Korea. However, only a single species, *E. berlesei*, is prevalent, whereas the others are not frequently encountered.

1. *Aphytis albus* Li and Yang

Diagnosis. Body whitish yellow; forewing with a linea calva; antenna six-segmented; head without distinct black bars and margins; mesoscutum with usually 10–13 setae; propodeal crenulae strongly overlapping; tarsi five-segmented (Li and Yang 2004).

Material examined. Recorded from Korea by Li and Yang (2004), but not collected during this project.

2. **Aphytis japonicus* DeBach and Azim (Fig. 1)

Diagnosis. Body entirely yellow; forewing with a linea calva; antenna six-segmented; head without distinct black bars and margins; mesoscutum with usually 10 setae; propodeal crenulae nonoverlapping; tarsi five-segmented.

Material examined. Korea. JJ: 72 Sumokwon-gil, Jeju-si, 1 female and 2 males, ex. *P. cockerelli* on *T. cuspidata*, 1-xi-2017 (S.J. Suh).

3. **Encarsia berlesei* (Howard) (Fig. 2)

Diagnosis. Body generally brown to dark brown except posterior mesoscutum and posterior mesosoma yellow; forewing hyaline, slightly infuscated below marginal vein; antenna eight-segmented, F1 (flagellar segment) about twice as long as wide, slightly longer than F2, F3–F6 with longitudinal sensilla; placoid sensilla on scutellum separated by about twice their diameter; mid lobe of mesoscutum with 7–8 setae; ovipositor about as long as middle tibia and basitarsus combined; tarsi five-segmented.

Material examined. Korea. GG: 476 Dongtanjiseong-ro, Yeongtong-gu, Suwon-si, 3 females, ex. *P. cockerelli* on *T. cuspidata*, 11-vii-2014 (S.J. Suh). CN: 260 Unkyo-ri, Dupo-myeon, Asan-si, 29 females,

ex. *P. cockerelli* on *T. cuspidata*, 3-vii-2016 (S.J. Suh). GB: 213-1 Chimsan-dong, Buk-gu, Daegu-si, 1 female, ex. *P. cockerelli* on *L. obtusifolium*, 27-vii-2014 (S.J. Suh). GN: Dusan-ri, Munsan-eup, Jinju-si, 3 females, ex. *P. cockerelli* on *D. kaki*, 28-iv-2015 (B.G. Jeong). JB: 30 Garinae-ro, Deokjin-gu, Jeonju-si, 1 female, ex. *P. cockerelli* on *L. obtusifolium*, 25-xii-2015 (S.J. Suh). JJ: 72 Sumokwon-gil, Jeju-si, 5 females, ex. *P. cockerelli* on *T. cuspidata*, 1-xi-2017 (S.J. Suh).

4. *Marietta carnesi* (Howard) (Fig. 3)

Diagnosis. Body yellow to silvery white; forewing with hyaline cells or infuscated patterns, without hyaline cells along margin and apex; antenna six-segmented (1,1,2,2), scape slender, about 6.0× as long as broad; midlobe of mesoscutum with 14 to 16 setae; gasteral dorsum infuscate brown with sides from base to apex silvery white and a narrow dark brown cross-band on tergum I to V extending to silvery sides, a dark spot on each of silvery sides; legs whitish to pale yellow, with dark brown complete or incomplete bands, tarsi five-segmented.

Material examined. Korea. GG: 476 Dongtanjiseong-ro, Yeongtong-gu, Suwon-si, 4 females, ex. *P. cockerelli* on *T. cuspidata*, 11-vii-2014 (S.J. Suh). CN: 260 Unkyo-ri, Dupo-myeon, Asan-si, 2 males, ex. *P. cockerelli* on *T. cuspidata*, 3-vii-2016 (S.J. Suh). JJ: 72 Sumokwon-gil, Jeju-si, 1 female, ex. *P. cockerelli* on *T. cuspidata*, 1-xi-2017 (S.J. Suh).

Remarks. This species is a hyperparasitoid.

5. **Pteroptrix* sp. 2 (Fig. 4)

Diagnosis. Male: Body 0.5 mm long, usually dark brown except posterior scutellum; antenna eight-segmented; scape with a sensory structure on basal third of the segment; F1, F3–F6 with a few longitudinal sensilla; F2 shortest; tarsi four-segmented.

Material examined. Korea. GG: 476 Dongtanjiseong-ro, Yeongtong-gu, Suwon-si, 1 male, ex. *P. cockerelli* on *T. cuspidata*, 11-vii-2014 (S.J. Suh).

Remarks. A single species of *Pteroptrix* was recorded to be associated with *P. cockerelli* in Korea, but was not determined. The males of *Pteroptrix* are likely to be hyperparasitoids; the females are primary parasitoids.

Encyrtidae associated with *P. cockerelli* in Korea

There are two species of encyrtids associated with *P. cockerelli* in Korea, of which *A. chionaspidis* is more prevalent.

6. *Adelencyrtus kosef* (Li and Byun)

Diagnosis. Body robust, green to blue with metallic lustre; forewing with hyaline infuscated patterns; head triangular in profile, strongly inflexed inwards at top of antennal scrobes; lowermost eye margin with a line of silvery white setae adjacent to it; antennal torulus separated from mouth margin; antennal clava apically rounded, longer than funicle; funicle with only apical joint yellowish, first three funicle segments equal in size, each much shorter than any one of segments four to sixth; mesoscutum with squamiform-reticulate sculpture; gaster about as long as thorax, ovipositor about 1.5× as long as mid tibia; tarsi five-segmented (Li et al. 2002).

Material examined. Recorded from Korea by Li et al. (2002), but was not collected during this project.

7. *Arrhenophagus chionaspidis* Aurivillius (Fig. 5)

Diagnosis. Body dark brown; antennae, ocelli, tegula, and legs yellowish brown; forewing hyaline with marginal fringe short, marginal, postmarginal, and stigma veins absent; clypeal margin of mouth strongly emarginated at base of each mandible; antenna five-segmented, three funicle segments narrow

and aneliform, clava large and unsegmented; mesonotum and axillae reticulate, scutellum protruding posteriorly with fine sculpture; gaster slightly shorter than thorax, ovipositor about two-thirds length of middle tibia; tarsi four-segmented.

Material examined. Korea. GG: 476 Dongtanjiseong-ro, Yeongtong-gu, Suwon-si, 2 females, ex. *P. cockerelli* on *T. cuspidata*, 11-vii-2014 (S.J. Suh). CN: 260 Unkyo-ri, Dupo-myeon, Asan-si, 28 females, ex. *P. cockerelli* on *T. cuspidata*, 3-vii-2016 (S.J. Suh). GN: Dusan-ri, Munsan-eup, Jinju-si, 4 females, ex. *P. cockerelli* on *D. kaki*, 28-iv-2015 (B.G. Jeong).

Signiphoridae associated with *P. cockerelli* in Korea

The species of Signiphoridae are generally secondary parasites, mainly of scale insects and whiteflies. One species *C. subaenus* was associated with *P. cockerelli* in Korea.

8. **Chartocerus subaenus* (Förster) (Fig. 6)

Diagnosis. Body glossy black except all tarsi yellowish, fore tibiae pale; mandible bidentate; antenna seven-segmented (1,1,4,1), funicle four-segmented; pronotum half or less as long as mesoscutum; forewing with alternating broad hyaline and dark bands, hindwing hyaline; forewing with fringe shorter than 1/2 width of the wing; basitarsus of middle leg clearly shorter than tibia; metasoma subequal in length to the head and mesosoma combined; male genitalia about 1/2 length of middle tibia, ventral surface of phallobase with distinct longitudinal thickening at midline, running from between bases of digiti almost to apex, digitus with apical denticle about 1/3 its length; tarsi five-segmented.

Material examined. Korea. GB: 80 Daehak-ro, Buk-gu, Daegu-si, 1 female and 1 male, ex. *P. cockerelli* on *L. obtusifolium*, 27-vii-2014 (S.J. Suh).

Remarks. This species is recorded for the first time in Korea.

Discussion

This work provides an updated list of the parasitoids associated with *P. cockerelli*, including *Chartocerus subaenus* (Förster), which is newly recorded in Korea, adds to our understanding of the Korean fauna of the chalcidoid insects, and aids in the correct identification of species. Chalcidoid wasps are the most significant group of biological control agents, especially for hemipterous and lepidopterous insects. Thus, the species of parasitoids recorded in this survey may be good candidates as biological control agents against the false oleander scale in Korea and other countries.

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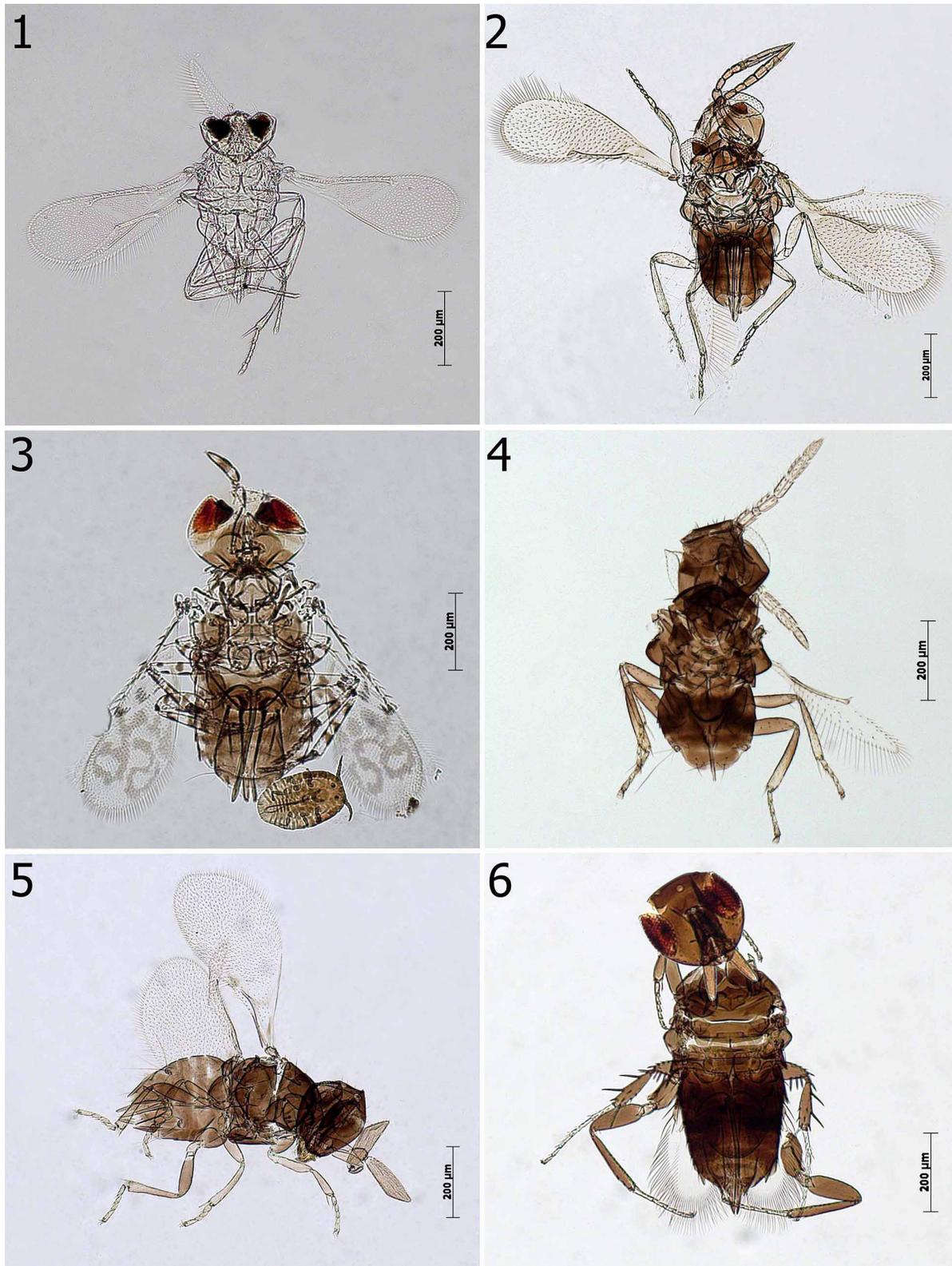
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Figures 1–6. Six species of parasitoids associated with *Pseudaulacaspis cockerelli* (Cooley) in Korea. **1)** *Aphytis japonicus* DeBach and Azim, male. **2)** *Encarsia berleseii* (Howard), female. **3)** *Marietta carnesi* (Howard), female. **4)** *Pteroptrix* sp. 2, male. **5)** *Arrhenophagus chionaspidis* Aurivillius, female. **6)** *Chartocerus subaenus* (Förster), female.