A THESIS

FOR THE DEGREE OF MASTER OF SCIENCE

Systematic Review of Family Coccidae (Hemiptera: Coccoidea) in Korean Peninsula with Molecular Phylogeny

밀깍지벌레과(노린재목: 깍지벌레상과)의 계통분류학적 연구

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February, 2016

ABSTRACT

Systematic Review of Family Coccidae (Hemiptera: Coccoidea) in Korean Peninsula with Molecular Phylogeny

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The systematic studies had three main subjects: i) Taxonomic review of family Coccidae in Korean Peninsula; ii) Molecular phylogeny of family Coccidae; iii) Molecular analyses of genetic diversity and cryptic species of *Coccus hesperidum*.

In taxonomic study, a total of thirty-nine species of nineteen genera in the family Coccidae was reviewed with seven new records, *Ceroplastes floridensis* Comstock, *Leptopulvinaria kawaii* Tanaka & Amano, *Parthenolecanium fletcheri* (Cockerell), *Pulvinaria hydrangeae* Steinweden, *P. idesiae* Kuwana, *P. photiniae* Kuwana, and *Saissetia Miranda* (Cockerell & Parrott). Among previously recorded species, one species, *Pulvinaria torreyae*, was examined as misidentification. Diagnostic descriptions and identification keys with morphological illustrations and photographs were also given in the present study.

Phylogenetic study of the family Coccidae based on molecular fragments of mitochondrial DNA (COI), nuclear ribosomal RNA genes (18S and 28S), and elongation factor 1**α** (EF-1α) indicated that no subfamily is perfectly monophyletic except for Ceroplastinae which is clustered within the major clade of Coccinae. Four tribes of Coccinae are paraphyletic except for Saissetiini in ML tree, especially Coccini and Pulvinariini are irregularly scattered. Also, *Paralecanium* and *Megapulvinaria*, which are sister to Cardiococcinae or Filippiinae, are distinctively separated from the major clade of Coccinae. Eulecaniinae is paraphyletic in that *Didesmococcus* is nested within the clade of Coccinae.

Analyzing the genetic patterns of *C. hesperidum* revealed high degree of COI haplotype diversity and two cryptic species. In phylogenetic tree based on Maximum Likelihood (ML), all haplotypes of *Coccus hesperidum* were divided into three distinct clades, which was also supported by a haplotype network. Further, the K2P-distances showed that high genetic divergences among interclades.

Key words: Coccidae, soft scales, systematics, taxonomic review, molecular phylogeny, genetic diversity, cryptic species, the Korean Peninsula

Student number: 2014-20684

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PART I. Taxonomic review of the Family Coccidae (Hemiptera: Coccoidea) in the Korean Peninsula

Abstract

The family Coccidae is reviewed as 39 species of 19 genera in the Korean Peninsula, including seven new records, *Ceroplastes floridensis* Comstock, 1881, *Leptopulvinaria kawaii* Tanaka & Amano, *Parthenolecanium fletcheri* (Cockerell), *Pulvinaria hydrangeae* Steinweden, *P. idesiae* Kuwana, *P. photiniae* Kuwana, and *Saissetia Miranda* (Cockerell & Parrott).
Diagnosis and descriptions for all Korean species are redescribed with keys to subfamilies, tribes, genera, and species. Illustrations, photographs, and other ecological information are also provided.

Keywords: Coccidae, revision, new records, the Korean Peninsula

I. Introduction

1. General introduction of the Family Coccidae

The family Coccidae, also named soft scale insects, is the third largest family of Coccoidea, comprising 1,134 described species of 168 genera in all zoogeographical regions, especially most populated in tropics and subtropics (Hodgson, 1994; Ben-Dov *et al*., 2015). Taxonomy of this group is primarily based on adult females because of their distinct sexual dimorphism and high accessible to females with sedentary lifestyles (Gullan & Kosztarab, 1997). The female adults are characterized from other families by following characters: well-developed anal plates; deep anal cleft between anal lobes; eversible anal tube; anal ring consist of two sclerotized crescents; a structure of ventral microducts; tarsus without a campaniform sensilla (Hodgson, 1994). Many species are known as important pests in agricultural and ornamental products as well as inhibited pests in quranteen agency, however their faunal study have been poorly conducted. Previously, 32 species of 18 genera are recored in the family Coccidae from the Korean Peninsula (Paek *et al*., 2010). In addition to the previous species, seven new records, *Ceroplastes floridensis* Comstock, *Leptopulvinaria kawaii* Tanaka & Amano, *Parthenolecanium fletcheri* (Cockerell), *Pulvinaria hydrangeae* Steinweden, *P. idesiae* Kuwana, *P. photiniae* Kuwana, and *Saissetia Miranda* (Cockerell & Parrott), are newly reported to the Korean Peninsula, with taxonomical informations for all known species.

2. Morphology

The terminology of morphological characters is adapted from Hodgson (1994), Ben-Dov & Hodgson (1997) and Hodgson & Henderson (2000).

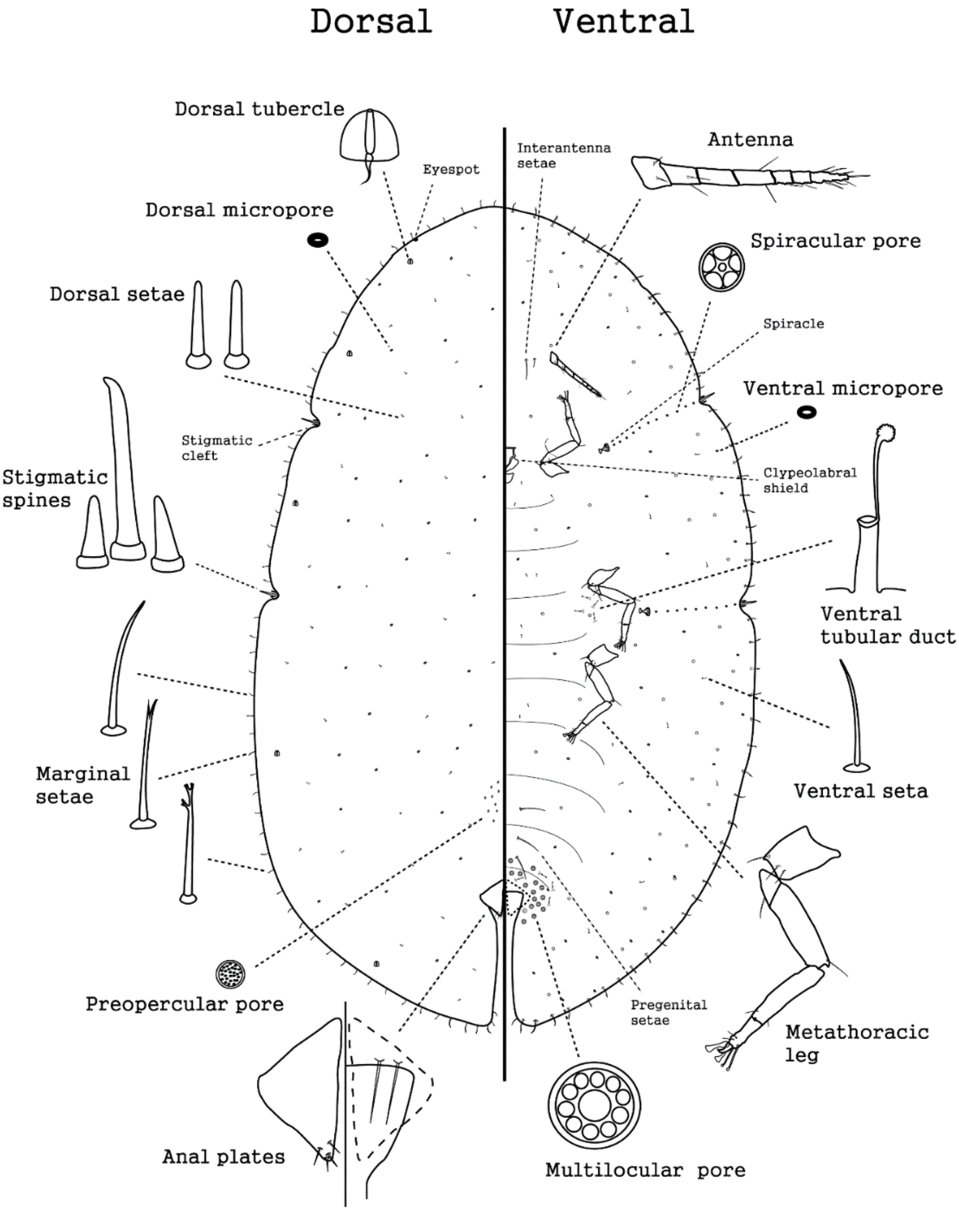

Fig. 1. Morphological structures of Coccidae

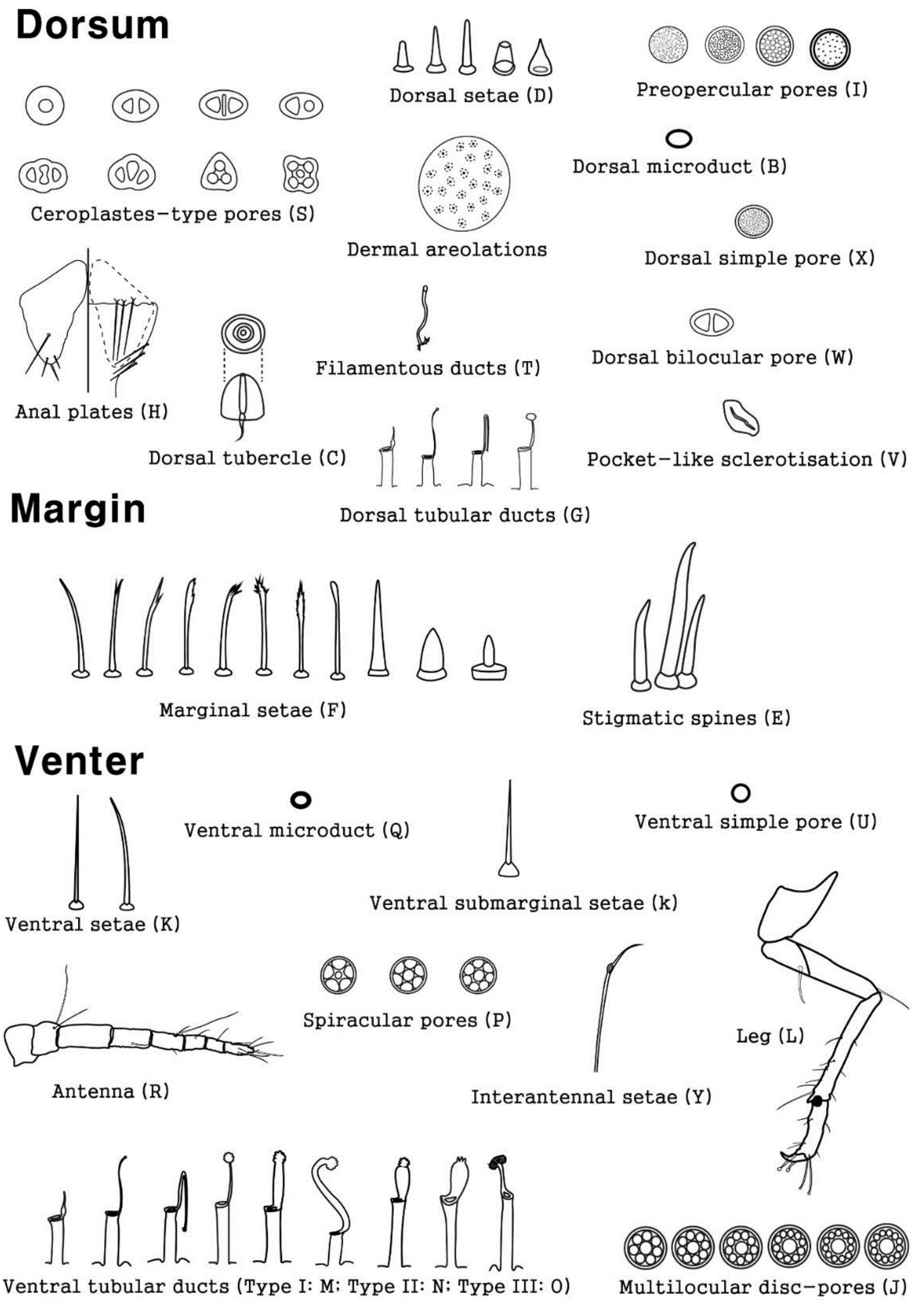

Fig. 2. Detail characters of Coccidae

3. Biology and life cycle

3.1. Biological characteristics

Sexual dimorphism. Male and female of soft scales have sexually dimorphic life cycles. The females have a sedentary lifestyle and neotenic development including two or three larval stages. Whereas, the males have developed similarly to holometabolism consisting prepupal and pupal stages after two instars. In addition, they have one pair of wings for flight.

Parthenogenesis. Although adult males have an ability to flight, they are fragile and can live for a short time due to lack of functional mouthparts (Gullan & Kosztarab, 1997). As a result, most species are able to reproduce offsprings as parthenogenesis which compensates a low possibility of mating (Hughes-Schrader, 1948). In fact, family Coccidae exhibits diverse types of parthenogenesis like most families of Coccoidea (Nur, 1971; Ross *et al*, 2010).

3.2. Life cycles of male and female

From 1st to 2nd instar of male & female

1st instar. The first-instar nymphs, also called ‘crawlers’, escape from brood chamber of adult females and play a major role in dispersal. Until this stage, both sexes do not have morphological sexual dimorphism. With well-developed legs, they move to other parts (e.g., branches, twigs and leaves) of existing host plant or try to find new one. After selecting the position, they insert stylet-like mouthparts into plant cells and feed nutrients from phloem (Hamon & Williams, 1984; Ben-Dov & Hodgson, 1997). During this phase, some species which belong to genus *Ceroplates* start to secrete soft wax on dorsum and have distinctive wax patterns.

2nd instar. A representative feature of the second-instar is showing sexual dimorphism. During the second-instar nymphs become adults, the differences, such as wax formations and morphological characters, are more remarkable.

From 2nd instar to adult of male

2nd instar male. The second-instar of males are elongate oval shaped and develop secretory organs, especially dorsal tubular ducts in marginal part of body. These organs secrete translucent wax cover and help to fix the nymph to host plant (Ben-Dov & Hodgson, 1997). The presence of dorsal tubular ducts is used for distinguishing males from females in this stage (Hamon & Williams, 1984; Hodgson & Henderson, 2000).

3rd instar male. The third-instar of males are called prepupa stage. During this stage, not only legs and antennae but also wing buds are being distinct. A penial sheath which is a unique character of the male develops at the end of the abdomen. Dorsal and ventral eyes are also present on heads, but they loss functional mouthparts. Therefore, they stop feeding activity after this stage (Ben-Dov & Hodgson, 1997; Hodgson & Henderson, 2000).

4th instar male. Although the forth-instar (i.e., pupa stage) of males have similar morphology to the third-instar, antennae and legs are more segmented and developed. The wing buds are more distinct and the penial sheath is more elongated (Hamon &

Williams, 1984; Ben-Dov & Hodgson, 1997).

Adult male. After last moulting, adult males leave host plants to find mating partners. One of the distinctive features of the adult male is having a pair of fore wings on the mesothorax (hind wings are either absent or reduced as hamulohalteres). Other appendages, such as legs and antennae, are completely developed. Also, they have two or four pair of simple eyes and a pair of ocelli on sclerotized head (Giliomee, 1967; Hodgson & Henderson, 2004).

From 2nd instar to adult of female

2nd and 3rd instar female. The second-instar of females with oval or circular body do not have tubular ducts on dorsum and conspicuous changes in morphology. They only have a change in body size. In case of annual species, the second-instar nymphs which settled on leaves at the first-instar stage move to woody parts of host plants. After resettling on the new places, they overwinter as the second-instar or immature adult stage.

Adult female. After two or three molting, nymphs become adults which have much more dorsal pores and ventral tubular ducts. Most soft scales (e.g., tribe Ceroplastini, Eulecaniini and Saissetiini) gradually make their body swelled and sclerotized. They lay eggs beneath the swelled bodies which act as brood chamber. Some groups (e.g., tribe Coccini) also have the same method like above groups, however their bodies are rather less convex and harden. In case of other groups (e.g., tribe Pulvinariini), they secrete white wax filaments from the ventral glands and lay eggs in the ovisac. Finally, the eggs emerge to crawlers and maintain their life cycles (Ben-Dov & Hodgson, 1997).

4. Historical review

4.1. Taxonomy and phylogeny of the Family Coccidae (Table 1).

Fallén in 1814 introduced the family Coccidae with the type genus *Coccus*. **Targioni Tozzetti (1868)** and **Signoret (1869)** subdivided the Coccidae (i.e. the Coccoidea of today). **Targioni Tozzetti (1868)** proposed four tribes in Coccidae: Orthezites (Orthezia and relatives), Coccites (the family Pseudococcidae of today), Diaspidites (Diaspididae), and Lecanites (Coccidae). Additionally, the Lecanites contained seven groups including four are related to soft scales which were the Eriophori demum folliculares (including *Filippia* and *Luzulaspis*), the Pulcinati (*Pulvinaria* and *Nidulari*), the Ceriferi (*Ceroplastes*, *Columnea* and *Ericerus*) and the nudi (*Lecanopsis* and *Lecanium*). **Signoret (1869)** presented a classification similar to **Targioni Tozzetti (1868)**, which are four groups: the Diaspides (now regarded as Diaspididae), the Coccides (Pseudococcidae), the Brachyscelides (Eriococcidae) and the Lecanides (Asterolecaniidae, Lecanodiaspididae, Coccidae, Aclerdidae and Tachardiidae)**.** Based on the classification of **Signoret (1869), Atkinson (1886)** subdivided the Lecanina (=Lecanides) into 5 groups: the Lecaniodiasparia, Signoretiaria (containing *Signoretia* (=*Luzulaspis*), *Eriopeltis* and *Philippia* (=*Filippia*)), Ceroplastaria (*Ceroplastes* and *Vinsonia*), Pulvinariaria (*Pulvinaria*) and Lecanaria (*Lecanium, Physokermes, Ericerus, Lecanopsis, Aclera* and *Carteria*). These groups are quite similar to the present classification, except for the last two groups. **Handlirsch (1903)** used the superfamily Coccoidea grouping all scale insects, whereas **Steinweden (1929)** restricted the meaning of the family Coccidae to the soft scale of today. Also, **Steinweden (1929)** proposed the generic level of classification studying the type species of 32 genera. This classification consisted of three groups: the *Coccus* (containing *Coccus*, *Eulecanium*, *Lecanium*, *Protopulvinaria*, *Pulvinaria* and *Saissetia* of today), the *Toumeyella* (*Neolecanium* and *Pseudophilippia*), and the *Exaeretopus* (*Exaeretopus*, *Parafairmairia*, *Philephedra* and *Luzulaspis*). The other 19 genera were not grouped, however most presented grouping is used today. **Bodenheimer (1953)** provided the subfamily groupings including the Ceroplatinae, Coccinae, Eriopeltinae and Filippinae, following the wax structures. Although **Borchsenius (1957)** agreed to the classification of Bodenheimer, he changed the positon of Eriopeltinae in the Filippiinae, so three groups were presented: Ceroplatinae (with a thick white wax covering the body of adult female), Coccinae (distinct wax absent or present beneath the abdomen of adult female), Filippinae (filamentous wax covering the adult female thoroughly). In addition, the Coccinae contained two tribes, Pulvinariini (wax secreted from beneath the abdomen, enclosing eggs) and Coccini (distinct wax absent and eggs stored under the body. Based on the adult males of 23 species in 19 genera, **Gilomee (1967)** proposed four genera in the family: the *Eulecanium*, the *Coccus*, the *Eriopeltis* and the *Inglisia*, This classification was quite different to previous grouping using characters of adult females. **Kosztarab & Kozar, 1988** elevated the three generic groups of Gilomee to the subfamilies which were Coccinae, Eulecaniinae, and Eriopeltinae. **Tang et al. (1990)** and **Tang (1991)** presented a complex grouping which was quite different to the classification of Giliomee. Based on the female adult, the family divided into four subfamilies: the Pseudopulvinariinae (including *Pseudopulvinaria* and *Mallococcus*) and the Filippiinae, Coccinae and

Ceroplastinae. Further, the Filippiinae was subdivided into the tribes Filippiini (consisting of Ceronemina, Ceroplastodina, Eripeltina and Filippiina) and Lecanopsiini (Lecanopsidini); the Coccinae into the tribes Coccini (Coccina and Eulecaniina) and the Pulvinariini (Pulvinariina and Takahashiina); and the Ceroplatinae into the tribes Ceroplastini and Ctenochitonini (Cardiococcina and Ctenochitonina). Most recently, **Hodgson (1994)** proposed a classification considering the characters of both adult males and females. The Coccidae was divided into 10 subfamilies, including the Coccinae subdivided into four tribes, Coccini, Paralecaniini, Pulvinariini, and Saissetiini.

4.2. History of Korean records (Table 2).

Until now, 32 species of Coccidae have been recored in Korea. In 1928, Machida and Aoyama firstly reported one species, *Takahashia japonica* (Cockerell), followed by *Ceroplastes ceriferus* (Fabricius), *C. japonicas* Green, *Nipponpulvinaria horii* (Kuwana), *Eulecanium kunoense* (Kuwana). Additionally, Satio (1931) reported *Ericerus pela* (Chavannes), and then Nakayama (1933) described six new records, *Coccus hesperidum* Linnaeus, *Eucalymnatus tessellatus* (Signoret), *Parasaissetia nigra* (Nietner), *Parthenolecanium corni* (Bouché), *Parthenolecanium persicae* (Fabricius), and *Saissetia coffeae* (Walker). After that, Kanda (1941) reported four species, *Eriopeltis festucae* (Fonscolombe), *Coccus pseudomagnoliarum* (Kuwana), *Eulecanium cerasorum* (Cockerell), and *Parthenolecanium glandi* (Kuwana), followed by *Pulvinaria nishigaharae* (Kuwana). In 1952, Shiraki reported *Ceroplastes rubens* Maskell and *Sphaerolecanium prunastri*. In addition, Borchsenius studied North Korean species and reported eight species, *Didesmococcus koreanus* Borchsenius, *Eulecanium kostylevi* Borchsenius, *E. secretum* Borchsenius, *Rhodococcus sariuoni* Borchsenius, *Eriopeltis sachalinensis* Borchsenius, *Luzulaspis bisetosa* Borchsenius, *Parthenolecanium orientale* (Borchsenius), *Psilococcus ruber* Borchsenius from 1955 to 1957. After 1958, Korean researchers reported five species until recently. Paik (1958) described *Metaceronema japonica* (Maskell), followed by *Pulvinaria torreyae* Takahashi, and *Eulecanium takachihoi* (Kuwana), and then *Pulvinaria nipponica* Lindinger and *P. floccifera* (Westwood) reported by Kwon *et al*. (2005).

Table 1. Historical review of classification of the family Coccidae

Steinweden, 1929	Bodenheimer, 1953	Borchsenius, 1957	Giliomee, 1967	Koteja, 1988	Tang et al., 1990	Hodgson, 1994
Coccidae	**Coccidae**	**Coccidae**	**Coccidae**	**Coccidae**	**Coccidae**	**Coccidae**
Coccus	Ceroplastinae	Ceroplastinae	*Coccus*	Coccinae	Coccinae	Coccinae
Toumeyella	Coccinae	Coccinae	*Eulecanium*	Eulecaniinae	- Coccini	- Coccini
Exaeretopus	Eriopeltinae	- Pulvinariini	*Eriopeltis*	Eriopeltinae	- Pulvinariini	- Pulvinariini
	Filippinae	- Coccini	*Inglisia*		Ceroplastinae	- Paralecaniini
		Filippinae			- Ceroplastini	- Saissetiini
					- Ctenochitonini	Ceroplastinae
					Pseudopulvinariinae	Eulecaniinae
					Filippiinae	Filippiinae
						Eiopeltinae
						Cardiococcinae
						Cissococcinae
						Cyphococcinae
						Myzolecaniinae
						Pseudopulvinariinae

Table 2. History of Korean records of the family Coccidae

No.	Author	Years	Recorded species	Korean name
1	Machida & Aoyama	1928	*Takahashia japonica* (Cockerell, 1896)	줄솜깍지벌레
2	Machida & Aoyama	1930	*Ceroplastes ceriferus* (Fabricius, 1798)	뿔밀깍지벌레
3			*Ceroplastes japonicus* Green, 1921	거북밀깍지벌레
4			*Nipponpulvinaria horii* (Kuwana, 1902)	단풍공깍지벌레
5			*Eulecanium kunoense* (Kuwana, 1907)	공깍지벌레
6	Saito	1931	*Ericerus pela* (Chavannes, 1848)	쥐똥밀깍지벌레
7	Nakayama	1933	*Coccus hesperidum* Linnaeus, 1758	무화과깍지벌레
8			*Eucalymnatus tessellatus* (Signoret, 1873)	남생이깍지벌레
9			*Parasaissetia nigra* (Nietner, 1861)	검은철모깍지벌레
10			*Parthenolecanium corni* (Bouché, 1844)	말채나무공깍지벌레
11			*Parthenolecanium persicae* (Fabricius, 1776)	복숭아공깍지벌레
12			*Saissetia coffeae* (Walker, 1852)	철모깍지벌레
13	Kanda	1941	*Eriopeltis festucae* (Fonscolombe, 1834)	사다리털깍지벌레
14			*Coccus pseudomagnoliarum* (Kuwana, 1914)	어리목련깍지벌레
15			*Eulecanium cerasorum* (Cockerell, 1900)	포도공깍지벌레
16			*Parthenolecanium glandi* (Kuwana, 1907)	큰공깍지벌레
17	Kanda	1943	*Pulvinaria nishigaharae* (Kuwana, 1907)	노랑솜깍지벌레
18	Shiraki	1952	*Ceroplastes rubens* Maskell, 1893	루비깍지벌레
19			*Sphaerolecanium prunastri* (Fonscolombe, 1834)	오얏공깍지벌레
20	Borchsenius	1955	*Didesmococcus koreanus* Borchsenius, 1955	진공깍지벌레
21			*Eulecanium kostylevi* Borchsenius, 1955	북쪽공깍지벌레
22			*Eulecanium secretum* Borchsenius, 1955	개야광공깍지벌레
23			*Rhodococcus sariuoni* Borchsenius, 1955	사리원깍지벌레
24	Borchsenius	1956	*Eriopeltis sachalinensis* Borchsenius, 1956	진사다리털깍지벌레
25	Borchsenius	1957	*Luzulaspis bisetosa* Borchsenius, 1952	쌍털깍지벌레
26			*Parthenolecanium orientale* (Borchsenius, 1957)	애기공깍지벌레
27			*Psilococcus ruber* Borchsenius, 1952	대륙털깍지벌레
28	Paik	1958	*Metaceronema japonica* (Maskell, 1897)	과자깍지벌레
29	Paik & Kim	1977	*Pulvinaria torreyae* Takahashi, 1956	주목솜깍지벌레
30	Paik	1978	*Eulecanium takachihoi* (Kuwana, 1902)	밤나무깍지벌레
31	Kwon *et al.*	2005	*Pulvinaria nipponica* Lindinger, 1933	무궁화솜깍지벌레
32			*Pulvinaria floccifera* (Westwood, 1870)	동백솜깍지벌레

II. Materials and Methods

Collection of soft scale insects.

Materials has been collected from all provinces of South Korea, including specimens of National Institute of Agricultural Sciences (NIAS). For taxonomic examinations of soft scale insects, using young adult females are higly recommended because mature adults have swelled and sclerotized bodies which can not be slide mounted. Therefore, it is important to know the periods of occurring young adults as well as their host plants. In the field, living samples would better to be collected together with leaves, stems or twigs of their host plants and transferred to laboratory. After photographing their living appearances, the samples put in 2.0ml tubes with 95% ETOH.

Slide mounted.

In order to exact identifications, the samples which are preserved in alcohol tubes should be slide mounted according to the modified method of Hodgson & Henderson (2000) as follows: Sample preserved in 95% ethy alcohol (ETOH) is transferred to 5ml tube containing 10% potassium-hydroxide (KOH) and then boied for 2-5 hours at 50-60℃ or leave in room temperature for about one or several days. After transferring decolorized specimen to distilled water, pumping the body to extract unnecessary substances using micro tools and leave for 5-10 minutes. Eliminate distilled water and add 1-2 drops of acid fuchsin stain for 50-60 minutes. For dehydration and cleaning the excess stain, move the specimen to 75% and 95% ETOH each for 5-10 minutes. After that, the sample is transferred into clove oil for over 10 minutes and mounted on a slide glass with Canada balsam.

Examinations.

The slide mounted specimens were studied under a microscope and the digital images were taken by a software (Active measure ver. 3.0.3, Mitani Co. Ltd, Japan) to measure and illustrate for each species. Terminology of morphological characters follows that of Hodgson (1994). All samples examined for the present study are deposited in SNU.

Abbreviations of localities and depositories are as follows:

GG, Gyeonggi-do; GW, Gangwon-do; CB, Chungcheongbuk-do; CN, Chungcheongnam-do; GB – Gyeongsangbuk-do; GN – Gyeongsangnam-do; JB, Jeollabuk-do; JN, Jeollanam-do; JJ, Jeju-do; NIAS, National Institute of Agricultural Sciences, Suwon, Korea; SNU, Seoul National University, Seoul, Korea.

III. Result

Systematic Accounts

Order Hemiptera 노린재목

Suborder Sternorrhyncha 진딧물아목

Superfamily Coccoidea 깍지벌레상과

Family Coccidae Fallén, 1814 밀깍지벌레과

Type genus: *Coccus* Linnaeus, 1758

Diagnosis. Well-developed and together quadrate anal plates on anus; a distinct anal cleft between anal lobes; an eversible anal tube to remove honeydew; an anal ring consist of two sclerotized crescents having setae and pores; a structure of ventral microducts; eyespots present on margin; tarsus without a campaniform sensilla (Hodgson, 1994).

Key to Korean subfamilies of Coccidae

1. *Ceroplastes*-type pores present on dorsum; a sclerotized caudal process present…...
………………………………………………………………………… Ceroplastinae

- *Ceroplastes*-type pores absent on dorsum; a sclerotized caudal process absent....... 2

2. Dorsum covered with a felted ovisac; dorsal tubercles and pocket-like sclerotisations absent; numerous long ventral setae usually present; two stigmatic

spines present in stigmatic area or absent…………………...………. Eriopeltinae

- Dorsum not covered with a felted ovisac; dorsal tubercles and pocket-like sclerotisations occasionally present; numerous long ventral setae absent; zero to three stigmatic spines in each stigmatic clefts………...............………. Filippiinae

3. Marginal setae only with simple pointed apices, never bifid or fimbriate; dorsal tubercles and pocket-like sclerotisations never present; each legs without a tibio-tarsal articulatory sclerosis……………………………………...… Eulecaniinae

- Marginal setae with simple pointed apices, also bifid or fimbriate tips present; dorsal tubercles and pocket-like sclerotisations occasionally present; legs usually with a tibio-tarsal articulatory sclerosis…..………...………………….…….……... Coccinae

Subfamily Ceroplastinae Atkinson, 1886 밀깍지벌레아과

Type genus: *Coccus* Linnaeus, 1758

Diagnosis. A thick wax usually covering entire body; *Ceroplastes*-type pores present on dorsum; a sclerotized caudal process for lifting anal plates to outside of thick wax; clear areas without pores; distinct characters of stigmatic areas; form of ventral microducts.

Genus *Ceroplastes* Gray, 1828 밀깍지벌레속

Type species: *Ceroplastes janeirensis* (Gray, 1828)

Diagnosis. Hemispherical body entirely covered by a thick wax cover; distinctive shape and color of wax; a sclerotized caudal process; only one type of stigmatic spine arranged in stigmatic clefts or margin (Gill, 1988; Hodgson, 1994; Hodgson & Henderson, 2000).

Key to Korean species of *Ceroplastes*

1. Body covered with reddish brown wax; *Ceroplates*-type pores present 3 types; ventral tubular duct absent; leg poorly developed………………..……… *C. rubens*

- Body covered with white wax; *Ceroplates*-type pores present 4 types; ventral tubular duct present; legs developed…………………….…………………….. 2

2. Body covered with thick white wax having a distinct horn; stigmatic spines conical in triangular shape composed of 5-6 rows……………….……………… *C. ceriferus*

- Body covered with turtle-shaped white wax without a distinct projecting horn; stigmatic spines conical, arranged in 2-3 rows………………..…………………… 3

3. Stigmatic spines almost continuously arranged and only 3-5 spinose setae scattered between anterior and posterior stigmatic clefts…………………….…... *C. japonicus*

- Stigmaitc spines distinctively separated by continuous 8-9 spinose setae between anterior and posterior stigmatic clefts……………………..………… *C. floridensis*

1. *Ceroplastes ceriferus* (Fabricius, 1798) 뿔밀깍지벌레

Coccus ceriferus Fabricius, 1798: 546.

Coccus chilensis Gray, 1828: 7.

Ceroplastes australiae Walker, 1852: 1087.

Ceroplastes vayssierei, Mahdihassan, 1933: 561.

Diagnosis. Body covered with thick white wax having a distinct horn; *Ceroplates*-type pores present 4 types; stigmatic spines conical in triangular shape composed of 5-6 rows; ventral tubular duct present 1 type; each leg without a tibio-tarsal articulation and an articulation sclerosis.

Living appearance. Body oval, completely covered by thick white wax with a distinct horn and powdery wax bands. Dorsum scarlet to dark red in color, heavily swelled and sclerotized during oviposition. Eggs reddish, deposited in ventral space (Fig. 11).

Slide-mounted material. Body oval to round, 1.2-3.8mm long, 0.9-3.6mm wide, with distinct stigmatic cleft; anal cleft short, present on immature adult but disappeared by caudal process (Fig. 34).

Dorsum. Derm membranous to heavily sclerotized. Dermal areolations absent. Dorsal tubercles absent. Dorsal setae cylindrical and stout with blunt apices, occasionally slightly pointed, each 5.4-10.0μm long, rather evenly present on dorsum. Dorsal tubular ducts absent. Filamentous ducts with small pores, each 1.5-1.8μm wide, distributed around margin. *Ceroplates*-type pores present 4 types: Monolocular pores each 4.0-6.0μm wide, rarely present over dorsum. Bilocular pores each 5.6-7.3μm wide, barred bilocular pores evenly scattered on entire dorsum, and irregular bilocular pores mainly distributed around submarginal areas. Trilocular pores each 6.0-8.2μm wide, usually detected over dorsum. Quadrilocular pores each 6.6-8.6μm wide, present throughout dorsum but some sparsely determined. Preopercular pore absent. Anal plates together elongated heart shape, each with rounded outer angles, 88.4-173.7μm long, 90.5-154.5μm wide. Each plate with 2 apical setae on dorsum (or venter) and 2 discal setae. Anal process elongated in old specimens. Clear areas present in submarginal area of body.

Margin. Marginal setae spinose, usually slightly curved, each 11.3-22.9μm long, with simple pointed apices, arranged around margin, except for spiracular areas, present about 2-4 laterally between stigmatic area. Stigmatic clefts moderately furrowed each with 40-44 stigmatic spines, conical, bullet-shaped, each 17.0-35.5μm long, arranged in triangular shape composed of 5-6 rows.

Venter. Derm membranous. Multilocular disc-pores 6.8-7.9μm wide, each with 10-12 loculi, mostly with 10 loculi, numerous around vulvar area, less frequently present on anterior area of abdomen and thorax. Spiracular pores 3.2-6.0μm wide, each with 5 loculi, in a band becoming wider from each spiracles and margin. Ventral tubular duct 28.7-39.6μm long, present 1 type with a moderately long outer ductule, a very thin and long inner dutule, occasionally entirely curved, and a quite small terminal gland, scattered around head and anal plates. Ventral microducts small, each 2.3-4.0μm wide, distributed over venter. Ventral submarginal setae sharply pointed, straight, each with a developed basal socket, each 11.3-22.9μm long. Ventral setae acute, straight, each with a rather wide basal socket, each 6.6-12.4μm long, evenly scattered on venter. Leg well developed, each without a tibio-tarsal articulation and a small articulation sclerosis, total length of metathoracic leg each 234.9-368.0μm long: each coxa 89.8-137.0μm long, trochanter+femer 127.7-183.9μm long, tibia+tarsus

146.0-213.0µm long, claw 11.8-20.1µm long. Tarsal digitules thinner and longer than claw digitules. Spiracles very developed, usually posterior peritreme broader than anterior: anterior peritremes each 23.3-90.5µm wide, posterior peritremes each 25.3-92.6µm wide. Antenna 6 segmented, each 130.1-211.9µm long. Clypeolabral shield 117.2-168.7µm wide.

Specimens examined. 5♀, Seoho-dong**,** Tongyeong-si, GN, 03.viii.2014, coll. J.Y. Choi, on *Camellia japonica* L. (Theaceae), Coll#. 140803-JY-05; 4♀, Jeodong-ri, Ulleung-eup, Ulleung-gun, GB, 08.viii. 2014, coll. J.Y. Choi, on *Camellia japonica* L. (Theaceae), Coll#. 140808-JY-01; 1♀, Bokgok-ri, Jipum-myeon, Yeongdeok-gun, GB, 20.x.1999, coll. G.M. Kwon, on *Diospyros kaki* THUNB. (Ebenaceae), Slide#. M1AV00328; 1♀, Nammunno, Sangdang-gu, Cheongju-si, CB, 21.iii.1997, coll. S.B. An, on *Diospyros kaki* THUNB. (Ebenaceae), Slide#. M1AV00311; 1♀, Goheung-eup, Goheung-gun, JN, 25.iii.1998, coll. M.L. Lee, on *Camellia japonica* L. (Theaceae), Slide#. M1AV00286; 1♀, Buchun-ri, Busan-myeon, Jangheung-gun, JN, 18.ix.2001, coll. G.M. Kwon, on *Diospyros kaki* THUNB. (Ebenaceae), Slide#. M1AV00347.

Host. Aceraceae: *Acer japonicus*; Amaranthaceae: *Amaranthus* sp.; Apocynaceae: *Thevetia peruviana*; Aquifoliaceae: *Ilex aquifolium*; *I. cornuta*; *I. crenata*; *I. japonicus*; *I. latifolia*; *I. opaca*; *I. serrata*; *I. vomitoria*; Araliaceae: *Fatsia japonica*; Berberidaceae: *Mahonia* sp.; Buxaceae: *Buxus sempervirens*; Celastraceae: *Euonymus europaeus*; *E. japonicus*; Cucurbitaceae: *Cucurbita moschata*; Ebenaceae: *Diospyros kaki*; Ericaceae: *Azalea* sp.; *Vaccinium arboreum*; Lythraceae: *Lagerstroemia indica,* Pinaceae*: Tsuga canadensis*; Pittosporaceae: *Pittosporum* sp.;

Podocarpaceae: *Podocarpus macrophyllus*; *P. nagi*; Rosaceae: *Crataegus* sp; *Pyracantha coccinea*; *Spiraea* sp.; Rutaceae: *Citrus* sp.; Sapindaceae: *Nephelium lappaceum*; Tamaricaceae: *Tamarix gallica*; Theaceae: *Camellia japonica*; *C. sinensis*; Ulmaceae: *Ulmus* sp.; Verbenaceae: *Callicarpa* sp. (Gimpel & Davidson, 1974).

Distribution. Cosmopolitan species: Korea, Japan, China, Taiwan, Thailand, Vietnam, Australia, USA, Europe, UK, South America, Africa.

Remarks. *Ceroplastes ceriferus* is similar to *C. pseudoceriferus* Green which had been misidentified in Korea (Lee *et al*., 2012). *C. ceriferus* is differentiated from *C. pseudoceriferus* by 15 marginal setae between anterior stigmatic clefts (about 40 in C. *pseudoceriferus*) and multilocular disc-pores absent around procoxa (Hodgson & Peronti, 2012). Although *C. pseudoceriferus* was not confimed in this study, it is possible to exist in Korea.

2. *Ceroplastes floridensis* Comstock, 1881

Ceroplastes floridensis Comstock, 1881: 331.

Diagnosis. Body covered with thick and bright white wax without a distinct projecting horn; *Ceroplates*-type pores present 4 types; stigmatic spines conical, arranged in 2-3 rows; ventral tubular duct present 1 type; each leg without a tibio-tarsal articulation and an articulation sclerosis.

Living appearance. Body oval, thoroughly coated with bright white wax with powdery wax bands on margin. Wax surface rather flat, without a distinct projecting horn. Dorsum reddish, highly swelled and sclerotized during oviposition. Eggs reddish, present under venter (Fig. 12)

Slide-mounted material. Body oval, 1.3-1.9mm long, 0.9-1.3mm wide, with distinct stigmatic cleft; anal cleft rather short, present on young adult, but disappeared by caudal process (Fig. 35).

Dorsum. Derm membranous to heavily sclerotized. Dermal areolations absent. Dorsal tubercles absent. Dorsal setae very short with bluntly pointed apices, each 3.4-4.3mm long, scarcely distributed over dorsum. Dorsal tubular ducts absent. Filamentous ducts not detected. C*eroplates*-type pores present 4 types: Monolocular pores each 2.8-4.0μm wide; Bilocular pores each 3.9-4.5μm wide, present 2 types, barred and irregular bilocular pores; Trilocular pores each 3.7-6.0μm; Quadrilocular pores each 3.4-4.0μm, most pores scattered on entire dorsum and intermixed with each pore. Preopercular pore absent. Anal plates each with rounded outer angles, 99.3-126.1μm long, 94.2-124.8μm wide. Each plate with 4 apical setae setae. Anal process not observed. Clear areas present in submarginal area of body.

Margin. Marginal setae spinose, mostly straight or slightly curved, each 16.8-20.0μm long, with simple pointed apices, arranged around margin, except for spiracular areas, about 41-44 anteriorly between anterior stigmatic areas. Stigmatic clefts moderately furrowed each with 30-44 stigmatic spines. Stigmatic spines conical, bullet-shaped, each with a narrow basal socket, each 9.9-14.1μm long, arranged in 2-3 rows, distinctively separated by continuous 8-9 spinose setae between anterior and posterior stigmatic clefts.

Venter. Derm membranous. Multilocular disc-pores 6.7-6.9μm wide, each with 10 loculi, frequently present around vulvar area, also sparsely scattered on anterior area of abdomen and thorax. Spiracular pores 3.4-3.9µm, each with 5 loculi in 3-4 pores wide between each spiracles and margin. Ventral tubular duct 18.9-21.3µm long, present 1 type with a developed outer ductule, rather broad inner ductule and a swelled terminal gland, usually present around submargin. Ventral microducts small, each 1.1-2.6µm wide, evenly distributed over venter. Ventral submarginal setae sharply spinose, each 6.8-8.1µm long. Ventral setae with 2 pairs of long and short setae between antennae and other setae acute, straight, each 5.0-8.4µm long, rarely present on entire venter. Leg well developed, each without a tibio-tarsal articulation and an articulation sclerosis, total length of metathoracic leg each 351.2-524.0µm long: each coxa 86.1-137.2µm long, trochanter+femer 118.0-173.2µm long, tibia+tarsus 130.2-199.7µm long, claw 11.1-14.5µm long. Tarsal digitules thinner and longer than claw digitules. Spiracles developed, mostly posterior peritreme broader than anterior: anterior peritremes each 20.3-39.3µm wide, posterior peritremes each 21.6-45.0µm wide. Antenna 6 segmented, each 201.3-275.3µm long. Clypeolabral shield 109.1-152.7µm wide.

Specimens examined. 2♀, Yanghwa-dong, Yeongdeungpo-gu, Seoul, 02.viii.2014, coll. J.Y. Choi, on Poaceae sp., Coll#. 140802-JY-06; 2♀, same locality, date and collector, on *Ternstroemia japonica* (Wight & Arn.) (Theaceae), Coll#. 140802-JY-09; 1♀, Seoho-dong, Tongyeong-si, 03.viii.2014, GN, coll. S.H. Lee, Coll#. 140803-JY-03; 1♀, Jeodong-ri, Ulleung-eup, Ulleung-gun, GB, 08.viii.2014, coll. Y.L. Lee, on *Machilus thunbergii* SIEB. *et* ZUCC. (Lauraceae), Coll#. 140808-JY-01; 1♀, Jang-dong, Dong-gu, Gwangju, 01.i.2016, coll. J.Y. Choi, on *Euonymus japonicus* Thunb. (Celastraceae), Coll#. 160108-JY-01.

Host. Anacardiaceae: *Mangifera indica*; *Schinus terebinthifolius*; Aquifoliaceae: *Ilex cornuta*; *I. crenata*; *I. vomitoria*; Araliaceae: *Aralia* sp.; *Hedera helix*; *Sciadophyllum* sp.; Burseraceae: *Bursera simaruba*; Celastraceae: *Euonymus japonicas*; Ebenaceae: *Diospyros kaki*; Ericaceae: *Pernettya* sp.; *Vaccinium* sp.; Lauraceae: *Lindera benzoin*, *Persea borbonia*; Myrtaceae: *Eugenia compacta*; *Eugenia jambolana*; *Psidium guajava*; *P. pomiferum*; Pinaceae: *Pinus elliotti*; *Tsuga canadensis*; Platanaceae: *Platanus* sp.; Poaceae sp.; Polygonaceae: *Coccoloba diversifolia*; Punicaceae: *Punica granatum*; Rosaceae: *Prunus persica*; *P. salicina*; *Pyrus communis*; *P. cydonia*; *P. malus*; Rubiaceae: *Gardenia jasminoides*; Serraceniaceae: *Serracenia minor* (Hall, 1922; Gimpel *et al.*, 1974; Hamon & Williams, 1984)

Distribution. Korea, Japan, China, Taiwan, Vietnam, Indonesia, Australia, USA, Canada, Europe, South America, Africa.

Remarks. Because of morphological similarities, *Ceroplastes floridensis* may have been overlooked as *C. japonicas* Green in Korea. However, both species are easily distinguished by arrangements of stigmatic spines (See above the key to species of *Ceroplastes*). In this study, *C. floridensis* is newly reported from Korea.

3. *Ceroplastes japonicus* Green, 1921 거북밀깍지벌레

Ceroplastes floridensis japonicus Green, 1921: 258.

Diagnosis. Body covered with turtle-shaped and yellowish white wax without a distinct projecting horn; *Ceroplates*-type pores present 4 types; stigmatic spines conical, arranged in 2-3 rows; ventral tubular duct present 1 type; each leg without a tibio-tarsal articulation and an articulation sclerosis.

Living appearance. Body oval, thoroughly coated with turtle-shaped white wax with powdery wax bands on margin. Wax surface flat or rough, without a distinct projecting horn. Dorsum reddish dark brown in color, strongly swelled and sclerotized during oviposition. Eggs reddish, stored under venter (Fig. 13).

Slide-mounted material. Body oval to circular, 1.7-3.5mm long, 1.1-3.1mm wide, with distinct stigmatic cleft; anal cleft very short, present on young adult but obscured by caudal process (Fig. 36).

Dorsum. Derm membranous to strongly sclerotized. Dermal areolations absent. Dorsal tubercles absent. Dorsal setae rather broad with bluntly pointed apices, each 5.1-8.3mm long, rarely scattered over dorsum. Dorsal tubular ducts absent. Filamentous ducts not detected. C*eroplates*-type pores present 4 types: Monolocular pores each 3.9-5.3μm wide; Bilocular pores each 4.1-5.3μm wide, present 2 types, barred and irregular bilocular pores; Trilocular pores each 4.0-7.0μm; Quadrilocular pores each 4.0-6.6μm, most pores present on entire dorsum and intermixed with each pore. Preopercular pore absent. Anal plates each with rounded outer angles, 138.6-160.4μm long, 109.9-137.0μm wide. Each plate with 4 apical setae. Anal process elongated in matured adult. Clear areas present in submarginal area of body.

Margin. Marginal setae spinose, mostly straight or slightly curved, each 12.2-30.3μm long, with simple pointed apices, distributed around margin, except for spiracular areas, about 38-40 anteriorly between anterior stigmatic areas. Stigmatic clefts moderately deep each with 98-123 stigmatic spines on each side. Stigmatic spines conical, bullet-shaped, each with a narrow basal socket, each 19.5-27.8μm long, arranged in 2-3 rows, continuously arranged between anterior and posterior stigmatic clefts. Only 3-5 spinose setae scattered between each stigmatic clefts.

Venter. Derm membranous. Multilocular disc-pores 5.3-7.8μm wide, each with 10 loculi, uncounted pores scattered around vulvar area, also rarely present on anterior area of abdomen and thorax. Spiracular pores 3.4-5.7μm, each with 5 loculi in a broad band between each spiracles and margin. Ventral tubular duct 21.2-41.4μm long, present 1 type with a developed outer ductule, a greatly or moderately broad inner ductule, and a swelled terminal gland, mainly distributed around submargin. Ventral microducts small, each 1.6-3.6μm wide, evenly present over venter. Ventral submarginal setae acute, straight or slightly curved, each 7.0-12.1μm long. Ventral setae with 2 pairs of long and short setae between antennae and other setae sharply pointed, straight, each 4.4-9.6μm long, scarcely scattered on entire venter, but frequently detected around anal plates. Leg well developed, each without a tibio-tarsal articulation and a small articulation sclerosis, total length of metathoracic leg each 543.2-635.7μm long: each coxa 131.3-160.2μm long, trochanter+femer 182.7-222.7μm long, tibia+tarsus 200.3-230.0μm long, claw 15.7-23.2μm long. Tarsal digitules thinner and longer than claw digitules. Spiracles well developed, mostly posterior peritreme broader than anterior: anterior peritremes each 41.9-53.4μm wide, posterior peritremes each 50.8-60.8μm wide. Antenna 6 segmented, each 285.3-327.7μm long. Clypeolabral shield 141.8-163.1μm wide.

Specimens examined. 2♀, Buksan-ri, Seoun-myeon, Anseong-si, GG**,** 29.iv.1999, coll. S.H. Lee, on *Diospyros kaki* THUNB. (Ebenaceae), Slide#**.** M1AV00078, M1AV00079**;** 1♀, Sangmaengbang-ri, Geundeok-myeon, Samcheok-si, GW**,** 29.v.1999, coll. J.Y. Choi, on *Diospyros kaki* THUNB. (Ebenaceae), Slide#**.** M1AV00082**;** 3♀, Cheonji-dong, Seogwipo-si, JJ, 14.ix.2014, coll. J.Y. Choi, on *Pittosporum tobira* (Thunb.) (Pittosporaceae), Coll#. 140914-JY-01**;** 1♀, Suwon-ri, Hallim-eup, Jeju-si, JJ, 17.ix.1996, coll. S.B. An, on same host plant, Slide#**.** M1AV00121**;** 3♀, same locality, 18.ix.1996, coll. and host data absent, Slide#**.** M1AV00186, M1AV00184, M1AV00185.

Host. Apocynaceae: *Nerium oleander*; *Trachelospermum asiaticum*; Aquifoliaceae: *Ilex integra*; Berberidaceae: *Berberis* sp.; *Epimedium colchicum*; Buxaceae: *Buxus sempervirens*; Celastraceae: *Euonymus japonicus*; Cornaceae: *Cornus mas*; *Svida* sp.; Cycadaceae: *Cycas revoluta*; Ebenaceae: *Diospyros kaki*; Ehretiaceae: *Ehretia acuminata*; Elaeagnaceae: *Elaeagnus pungens*; Elaeocarpaceae: *Elaeocarpus decipiens*; Lauraceae: *Laurus nobilis*; *Machilus thunbergii*; Magnoliaceae: *Magnolia grandiflora*; Moraceae: *Morus* sp.; *Myrtus communis*; Myrtaceae: *Feijoa sellowiana*; Pittosporaceae: *Pittosporum tobira*; Podocarpaceae: *Podocarpus nagi*; Rosaceae: *Cerasus avium*; *C. vulgaris*; *Crataegus* sp.; *Cydonia vulgaris*; *Eriobotrya japonica*; *Malus domestica*; *Persica vulgaris*; *Prunus laurocerasus*; *P. yedoensis*; *P. sinensis*; Rutaceae: *Citrus* sp.; *Poncirus trifoliata*; Salicaceae: *Salix glandulosa*; *S. saidaeana*; Theaceae: *Camellia japonica*; *Eurya japonica*; *Thea sinensis* (Tahakashi,1956; Borchsenius, 1957).

Distribution. Korea, Japan, China, Russia, Europe, UK.

4. *Ceroplastes rubens* Maskell, 1893 루비깍지벌레

Ceroplastes rubens Maskell, 1893: 214.

Ceroplastes rubensminor Maskell, 1897b: 309.

Diagnosis. Body covered with reddish brown wax without a distinct projecting horn; *Ceroplates*-type pores present 3 types; stigmatic clefts extremely deep, each with 22-26 stigmatic spines; ventral tubular duct absent; legs poorly developed.

Living appearance. Body oval, entirely concealed by moderately thick wax reddish brown wax with distinct curved wax bands on margin. Wax surface flat or roundly convex, without a distinct projecting horn. Dorsum dark red in color, considerably swelled and sclerotized during oviposition. Eggs reddish, laid in swollen venter (Fig. 14).

Slide-mounted material. Body oval to round, 1.7-3.8mm long, 1.3-3.2mm wide, with extremely furrowed stigmatic cleft; anal cleft rather short, present on young adult but shrunk by caudal process (Fig. 37).

Dorsum. Derm membranous to severely sclerotized. Dermal areolations absent. Dorsal tubercles absent. Dorsal setae stout and short each with a developed basal socket and a quite blunt apex, each 4.4-6.4mm long, evenly scattered over dorsum. Dorsal tubular ducts absent.

Filamentous ducts absent. *Ceroplates*-type pores present 3 types: Monolocular pores each 4.0-5.3μm wide; Bilocular pores each 4.8-7.2μm wide, barred bilocular pores, present 2 types, barred and irregular bilocular pores; Trilocular pores each 6.1-9.0μm wide, irregular trilocular pores, most pores present on entire dorsum and intermixed with each pore, but Quadrilocular pores absent. Preopercular pore absent. Anal plates each with rather rounded outer angles, 140.8-160.3μm long, 117.8-149.2μm wide. Each plate with 4 apical setae. Anal process proceeded slightly in matured adult. Clear areas about 10 present in submedian area of body.

Margin. Marginal setae similar to dorsal setae, but slightly longer and less blunt than the latter, each 4.5-7.6μm long, arranged around margin, except for spiracular areas, present about 2-4 laterally between stigmatic areas. Stigmatic clefts extremely deep each with 22-26 stigmatic spines: Median setae conical, mostly with blunt and slightly curved apices, each 39.9-66.6μm long. Lateral setae hemispherical with roundly convex apices, each 26.1-35.6μm long. The others similar to lateral setae, but much smaller than the latter, each 10.0-16.1μm long, present on ventral stigmatic clefts.

Venter. Derm membranous. Multilocular disc-pores 6.3-8.6μm wide, each with 10 loculi, many pores present around vulvar area, also rarely scattered on anterior area of abdomen and thorax. Spiracular pores 5.0-6.6μm wide, each with 5 or 6 loculi, usually with 5 loculi, arranged in a broad band between each spiracles and margin. Ventral tubular duct absent. Ventral microducts small, each 3.1-4.6μm wide, frequently scattered over venter. Ventral submarginal setae spinose, straight and rather stout, each 5.9-9.6μm long. Ventral setae with 2 pairs of long setae between antennae and other setae sharply pointed, usually straight, each 7.7-9.4μm long, frequently distributed on entire venter. Leg very short and poorly developed, total length of metathoracic leg each 156.2-212.8μm long: each coxa 56.2-71.9μm long, trochanter+femer 37.0-64.6μm long, tibia+tarsus 47.7-73.6μm long, claw 6.4-12.9μm long. Tarsal digitules longer than claw digitules. Spiracles well developed, posterior peritreme slightly broader than anterior: anterior peritremes each 55.6-70.6μm wide, posterior peritremes each 55.6-75.3μm wide. Antenna 6 segmented, each 155.9-199.4μm long. Clypeolabral shield 151.5-181.1μm wide.

Specimens examined. 2♀, Nohyeong-dong, Jeju-si, JJ, 13.ix.2014, coll. J.Y. Choi, on *Citrus* sp. (Rutaceae), Coll#. 140913-JY-09; 2♀, Gunnae-ri, Wando-eup, Wando-gun, JN, 04.vii.2014, same collector, on *Camellia japonica* L. (Theaceae), Coll#. 140704-JY-06; 2♀, Seogwipo-si, JJ, 18.i.1972, collector data absent, on *Euonymus alatus* (Thunb.) (Celastraceae), Slide#. M1AV00377, M1AV00378; 2♀, Topyeong-dong, Seogwipo-si, JJ, 5.ix.2001, coll. G.M. Kwon, on *Citrus unshiu* Marcovitch (Rutaceae), Slide#. M1AV00396, M1AV00399; 2♀, Donghong-dong, Seogwipo-si, JJ, 27.xi.1996, coll. K.S. Lee, on *Ligustrum obtusifolium* Sieb. & Zucc. (Oleaceae), Slide#. M1AV00408, M1AV00412.

Host. Acanthaceae: *Acer palmatum*; Apocynaceae: *Alyxia olivaeformis*; Aquifoliaceae: *Ilex cornuta*; *I. latifolia*; *I. oldhami*; *I. serrata*; Araceae: *Aglaonema pictum*; *Anthurium andraeanum*; Araliaceae: *Dizygotheca elegantissima*; *Hedera helix*; Araliceae: *Philodendron gigantium*; Aspleniaceae: *Asplenium nidum*; Asteraceae: *Helianthus* sp.; Buxaceae: *Buxus microphylla*; Caprifoliaceae: *Viburnum* sp.; Clusiaceae: *Calophyllum inophyllum*; Celastraceae: *Euonymus alatus*; Cycadaceae: *Cycas* sp.; Dicksoniaceae: *Cibotium* sp.; Ebenaceae: *Diospyros kaki*; Fabaceae: *Acacia* sp.; Lecythidaceae: *Barringtonia racemosa*; Loranthaceae:

Loranthus sp.; Magnoliaceae: *Magnolia salicifolia*; Moraceae: *Cudrania javanesis*; Myrtaceae: *Metrosideros collina*; *Psidium guajava*; *Rhodomyrtus tomentosa*; Oleaceae: *Ligustrum obtusifolium*; Orchidaceae: *Grammatophyllum* sp.; Pinaceae: *Pinus parviflora*; Polypodiaceae: *Polypodium* sp.; Rhizophoraceae: *Rhizophora* sp.; Rosaceae: *Chaenomeles* sp.; *Malus* sp.; Rubiaceae: *Gardenia jasminoides*; Rutaceae: *Citrus deliciosa*; *C. reticulata*; *C. unshiu*; Sapindaceae: *Litchi* sp.; Sapotaceae: *Calocarpum* sp.; Schisandraceae: *Kadsura japonica*; Sinopteridaceae: *Pellaea* sp.; Taxaceae: *Cephalotaxus* sp.; Theaceae: *Camellia japonica*; *C. rusticans, C. sasanqua*; Ulmaceae: *Celtis* sp.; Zingiberaceae: *Alpinia purpurata* (Gimpel & Davidson, 1974).

Distribution. Cosmopolitan species: Korea, Japan, China, Taiwan, Thailand, Vietnam, Indonesia, Australia, USA, Africa.

Remarks. *Ceroplastes rubens* is easily recognized by wax test of reddish brown.

Subfamily Coccinae Fallén, 1814 무화과깍지벌레아과

The subfamily Coccinae was divided into about 55 genera belonging to four tribes (Hodgson, 1994).

Key to Korean tribe of Coccinae

1. Body with white wooly ovisac under abdomen; three or four types (rarely two) of ventral tubular ducts present…………….………………...…………. Pulvinariini

- Body without white wooly ovisac under abdomen; one or two types of ventral tubular ducts present……………………………………………………….. 2

2. Ventral tubular ducts present on medial area of thorax or absent; multilocular disc pores only present around vulvar area, not on medial thorax and head......... Coccini

- Ventral tubular ducts present on submarginal area; multilocular disc pores present around vulvar area, also medial thorax……………………...………….. Saissetiini

Tribe Coccini Fallén, 1814 무화과깍지벌레족

Type genus: *Coccus* Linnaeus, 1758

Diagnosis. Ventral tubular ducts restricted to medial area of thorax or absent; absence of dorsal tubular duct except for some species in *Coccus*; dorsum without pocket-like sclerotizations; eyespots closely located on margin; differentiated stigmatic spines; unsclerotized stigmatic areas; multilocular disc pores only present around vulvar area, not on medial thorax and head (Hodgson, 1994).

Key to Korean genera of Coccini

1. Irregular polygonal plates present on dorsum……………..……..…. *Eucalymnatus*

- Irregular polygonal plates absent on dorsum…………………………….…….. *Coccus*

Genus *Coccus* Linnaeus, 1758 무화과깍지벌레속

Type species: *Coccus hesperidum* Linnaeus, 1758

Diagnosis. Ventral tubular ducts distributed on medial thorax, but not in submarginal area; legs with a tibio-tarsal articulation sclerosis; blunt or cylindrical dorsal setae; marginal setae with bifid or fimbriate apices; each triangular shaped anal plates with a few apical setae (Hodgson, 1994).

Key to Korean species of *Coccus*

1. Dorsal tubercles present; Marginal setae with bifid or fimbriate apices, occasionally with pointed tips; Antenna 7 segmented……….……... *C. hesperidum*

- Dorsal tubercles absent; Marginal setae with pointed apices; Antenna 8 Segmented……………………………………………...... *C. pseudomagnoliarum*

5. *Coccus hesperidum* Linnaeus, 1758 무화과깍지벌레

Coccus hesperidum Linnaeus, 1758: 455.

Calypticus laevis Costa, 1829: 11.

Coccus patellaeformis Curtis, 1843: 517.

Chermes lauri Boisduval, 1867: 340.

Lecanium angustatus Signoret, 1873b: 398.

Kermes aurantj Alfonso, 1875: 431.

Lecanium alienum Douglas, 1886: 77.

Lecanium minimum Newstead, 1892: 141.

Lecanium assimile amaryllids Cockerell, 1893b: 53.

Lecanium terminaliae Cockerell, 1893c: 254.

Lecanium ceratoniae Gennadius, 1895, cclxxvii.

Lecanium nanum Cockerell, 1896b.

Lecanium minimum pinicola Maskell, 1897b: 310.

Lecanium flaveolum Cockerell, 1897b: 52.

Lecanium ventrale Ehrhorn, 1898: 245.

Lecanium (*Calymnatus*) *hesperidum pacificum* Kuwana, 1902a: 30.

Lecanium signiferum Green, 1904: 197.

Coccus hemisphaerides Lindinger, 1929: 109-110.

Coccus jungi Chen, 1936: 218.

Diagnosis. Dorsal tubercles present; dorsal setae cylindrical and stout, with blunt apices; dorsal tubular ducts present or not; marginal setae with pointed, bifid or fimbriate apices; multilocular disc-pores each with 10 loculi; leg each with a tibio-tarsal articulatory sclerosis; antenna 7 segmented.

Living appearance. Body elongate oval to round, occasionally diverse asymmetrical shapes depend on host plants, and relatively flat or moderately convex during oviposition. Dorsum greenish or yellowish brown in color, usually with irregular black or brown spots (Fig. 15).

Slide-mounted material. Body elongate oval to circular, 2.0-3.8mm long, 1.6-2.8mm wide, with rather distinct stigmatic cleft; anal cleft approximately 1/6-1/7 of body length (Fig. 38).

Dorsum. Derm membranous. Dermal s developed and small, each with a microductule. Dorsal tubercles convex, each with an inner filamentous ductule, present on submarginal area, 4-6 in total on each side: 1 or 2 between apex of head and anterior stigmatic cleft, 1 between anterior and posterior stigmatic clefts and 2 or 3 between posterior stigmatic cleft and anal cleft. Dorsal setae cylindrical and stout with blunt apices, each 5.5-9.4μm long, evenly scattered on dorsum. Dorsal tubular ducts not detected. Preopercular pore round to oval, distributed in a dense group in front of anal plates. Anal plates each triangular in shape, 135.2-175.4μm long, 110.9-152.7μm wide, mostly posterolateral margin rather longer than anterolateral margin: anterolateral margin 86.2-109.7μm long, posterolateral margin 91.7-122.5μm long. Each plate with 2 inner margin setae, 1 outer margin setae, and 1 apical setae on dorsum (or venter).

Margin. Marginal setae spinose, straight or slighly curved, each 18.5-36.6μm long, usually with bifid or fimbriate apices, also simple pointed tips frequently detected according to specimens, present about 8-10 laterally between stigmatic areas. Stigmatic clefts rather distinct each with 3 stigmatic spines, median spine slightly curved, and more or less 2 times as long as lateral spine: medians 38.2-73.8μm long, laterals 4.9-44.2μm long.

Venter. Derm membranous. Pregential disc-pores 3.2-4.7μm wide, mostly each with 10 loculi, relatively a small number present around vulvar area. Spiracular pores 3.6-4.5μm wide, each with 5 loculi, in a narrow or single band between each spiracles and margin. Ventral tubular duct present 1 type with a moderately narrow inner ductule and a developed flower-head-like terminal gland, present around each coxa of legs and anal plates. Ventral microducts quite small, rarely distributed over entire venter. Ventral setae with 3 pairs of long pregenital setae present, also about 2 pairs of long setae between antennae and other setae sharply spinose, scarcely present on entire venter. Leg well developed, each with a tibio-tarsal articulation and a small articulation sclerosis, total length of metathoracic leg each 273.8-548.6μm long: each coxa 89.8-137.0μm long, trochanter+femer 127.7-183.9μm long, tibia+tarsus 146.0-213.0μm long, claw 11.8-20.1μm long. Tarsal digitules thinner and longer than claw digitules. Spiracles normally developed, mostly posterior peritreme broader than anterior: anterior peritremes each 22.4-36.1μm wide, posterior peritremes each 28.0-49.2μm wide. Antenna 7 segmented, each 237.8-329.1μm long. Clypeolabral shield 102.2-142.5μm wide.

Specimens examined. 2♀, Punggok-ri, Gochon-eup, Gimpo-si, GG, 20.v.1998, coll. G.M. Kwon, on *Ficus benjamina* L. (Moraceae), Slide#. M1AV00453, M1AV00456; 2♀, Neunggok-dong, Siheung-si, GG, 20.V.1998, same collector and host, Slide#. M1AV00449, M1AV00452; 2♀, Sucheong-dong, Osan-si, GG, 06.vi.2015, coll. J.Y. Choi, on *Schefflera actinophylla* (Endl.) (Araliaceae), Coll#. 150601-JY-04; 2♀, Cungjeongno, Jung-gu, Seoul, 25.iii.2015, same collector, on *Dracaena* sp. (Asparagaceae), Coll#. 150325-JY-01; 2♀, Cheolli-dong, Andong-si, GB, 07.vi.2015, same collector, on *Schefflera* sp. (Araliaceae), Coll#. 150607-JY-06; 2♀, Cheonjeon-ri, Sinbuk-eup, Chuncheon-si, GW, 31.v.2015, same collector, on *Heteropanax* sp. (Araliaceae), Coll#. 150531-JY-01; 2♀, Sincheon-dong, Dong-gu, Daegu, 06.vi.2015, same collector and host, Coll#. 150606-JY-12; 2♀, Gayang-dong, Dong-gu, Daejeon, 06.vi.2015, same collector and host, Coll#. 150606-JY-03; 1♀, Sacheon-ri, Deoksan-myeon, Yesan-gun, CN, 01.vi.2015, same collector, on *Schefflera actinophylla* (Endl.) (Araliaceae), Coll#. 150424-JY-01; 1♀, Yeon-dong, Jeju-si, JJ, 17.iv.2003, coll. G.M. Kwon, on *Schefflera* sp. (Araliaceae), Slide#. M1AV00429; 1♀, Sinhyo-dong, Seogwipo-si, JJ, 14.ix.2014, coll. J.Y. Choi, on *Asplenium antiquum* Makino (Aspleniaceae), Coll#. 140914-JY-05; 1♀, Geumam-dong, Jeonju-si, Deokjin-gu, JB, 06.vi.2015, coll. same collector, on *Anthurium* sp. (Araceae), Coll#. 150606-JY-06.

Host. Araliaceae: *Heteropanax* sp.; *Pseudopanax crassifolius*; *P. lessonii*; *Schefflera actinophylla*, *S.* sp.; Asparagaceae: *Dracaena* sp. Aspleniaceae: *Asplenium antiquum*; Asteraceae: *Brachyglottis bellidioides*; *B. repanda*; *Olearia nummularifolia*; *Senecio* sp.; Bignoniaceae: *Tecomanthe speciosa*; Blechnaceae: *Blechnum fraseri*; Cyatheaceae: *Cyathea* sp.; Escalloniaceae: *Corokia* sp.; Fabaceae: *Carmichaelia* sp.; *Chordospartium stevensonii*; Lauraceae: *Beilschmiedia tawa*; Lobeliaceae: *Pratia physaloides*; Moraceae: *Ficus* benjamina; Myoporaceae: *Myoporum laetum*; Pittosporaceae: *Pittosporum* sp.; Rubiaceae: *Coprosma* sp.; Solanaceae: *Solanum aviculare*; Thymelaeaceae: *Pimelea* sp.; Verbenaceae: *Vitex lucens* (Hodgson & Henderson, 2000).

Distribution. Cosmopolitan species: Korea, Japan, China, Russia, Taiwan, Thailand, Vietnam, Indonesia, Australia, USA, Canada, Europe, South America, Africa.

Remarks. *Coccus hesperidum* is cosmopolitan species and higly polyphagous (having host plants belonging to about 133 families). Also, this species have morphological variations which are not only superficial appearances, body shapes and color, but also micro structures, positions of dorsal or ventral tubular ducts, sizes of a tibio-tarsal sclerosis, and shapes of anal plates (Hodgson, 1994; Ben-Dov et al., 2015).

6. *Coccus pseudomagnoliarum* (Kuwana, 1914) 어리목련깍지벌레

Lecanium (*Eulecanium*) *pseudomagnoliarum* Kuwana, 1914: 7.

Coccus citricola Campbell, 1914: 222.

Coccus aegaeus De Lotto, 1973: 291.

Diagnosis. Dorsal tubercles absent; dorsal setae short and stout, with pointed apices; dorsal tubular ducts absent; marginal setae with pointed apices; multilocular disc-pores each with 6-10 loculi, usually 7 or 8 loculi; each leg without a tibio-tarsal articulatory sclerosis; antenna 8 segmented.

Living appearance. Body elongate oval, moderately convex. Dorsum green or grey in color, with numerous yellow and dark spots. Eggs orange, stored beneath venter (Fig. 16).

Slide-mounted material. Body elongate oval, 4.2-4.5mm long, 3.5-3.6mm wide, almost without stigmatic cleft; anal clefts about 1/6-1/7 of body length (Fig. 39).

Dorsum. Derm membranous. Dermal areolations well developed. Dorsal tubercles absent. Dorsal setae sharply spinose, short and stout, evenly present on entire dorsum, especially rather frequently present around anal plates. Dorsal tubular ducts absent. Preopercular pore round, 4.7-5.2µm wide, scattered in a dense group of about 10 in front of anal plates. Anal plates quadrate, 157.2-168.4µm long, 179.1-185.8µm wide, usually anterolateral margin rather longer than posterolateral margin: anterolateral margin 109.9-119.9µm long, posterolateral margin 105.4-108.6µm long. Each plate with 4 apical setae.

Margin. Marginal setae spinose, straight or slighly curved, each 27.7-30.1µm long, usually with simple pointed apices, occasionally with spatulate tips, present 23-26 laterally between stigmatic areas. Stigmatic clefts not distinct, each with 3 stigmatic spines, median spine slightly curved, and over 2 times as long as lateral spine: medians 67.9-75.5μm long, laterals 25.1-35.7μm long.

Venter. Derm membranous. Multilocular disc-pores 5.7-6.5μm wide, each with a variable number of loculi, 6-10 loculi, usually 7 and 8, frequently present around or under vulvar area, also scarcely scattered on anterior abdomen. Spiracular pores 4.4-4.5μm wide, each with 5 loculi, in a narrow band 1-2 pores wide between each spiracles and margin. Ventral tubular duct present according to Gill, 1988, but not detected in the examined specimens. Ventral microducts small, evenly present over venter. Ventral setae with 3 pairs of long pregenital setae present, also about 4 pairs of long and short setae between antennae and other setae sharply spinose, each 10.6-13.6μm long, evenly distributed on entire venter. Leg well developed, each with a tibio-tarsal articulation, but an articulation sclerosis absent, total length of metathoracic leg each 551.7-588.8μm long: each coxa 140.6-144.0μm long, trochanter+femer 177.5-196.1μm long, tibia+tarsus 212.1-222.7μm long, claw 21.6-25.9μm long. Tarsal digitules thinner and longer than claw digitules. Spiracles normally developed, usually posterior peritreme broader than anterior: anterior peritremes each 47.7-56.6μm wide, posterior peritremes each 61.8-71.7μm wide. Antenna 8 segmented, each 341.4-346.6μm long. Clypeolabral shield 162.8-368.5μm wide.

Specimens examined. 2♀, Seogwipo-si, JJ, 10.v.1972, collector data absent, on *Celtis* sp. (Ulmaceae), Slide#. 7197-A(1), 7197-A(2); 7♀, Sujeong-dong, Yeosu-si, JN, coll. J.Y. Choi, same host, Coll#: 150527-JY-01, 150527-JY-06, 150527-JY-09.

Host. Lauraceae: *Laurus nobilis*; Rutaceae: *Citrus aurantium*; C. deliciosa; *Citrus limon*; *Evodia rutaecarpa*; Ulmaceae: *Celtis australis*; *Zelkova serrata* (Takahashi, 1955c; Marotta, 1987; Marotta & Tranfaglia, 1990).

Distribution. Korea, Japan, Russia, Australia, USA, Europe.

Genus *Eucalymnatus* Cockerell, 1901 남생이깍지벌레속

Type species: *Lecanium tessellatum* Signoret, 1873

Diagnosis. Irregular polygonal plates on dorsum; long setae present on anterior margin of ano-genital fold set (Gill, 1989; Hodgson, 1994)

7. *Eucalymnatus tessellatus* (Signoret, 1873) 남생이깍지벌레

Lecanium tessellatum Signoret, 1873b: 401.

Lecanium perforatum Newstead, 1894: 233.

Lecanium tessellatum swainsonae Cockerell, 1897a: 109.

Lecanium subtessellatum Green, 1904: 206.

Lecanium tessellatum obsoletum Green, 1922: 1024.

Diagnosis. Polygonal plates irregularly present around margin; dorsal tubercles present; dorsal tubular ducts absent; marginal setae with acute, bifid or fimbriate apices; Multilocular disc-pores with 6 or 7 loculi; ventral tubular duct absent; leg each with a tibio-tarsal articulation and articulation sclerosis; antenna 7 or 8 segmented, usually 8.

Living appearance. Body oval, asymmetrical, rather flat. Dorsum dark red brown in color with sclerotized polygonal plates.

Slide-mounted material. Body pyriform to oval or asymmetrical, with distinct stigmatic cleft; anal cleft about 1/4 of body length.

Dorsum. Derm membranous to sclerotized. Polygonal plates irregular shaped, and relatively larger ones present around margin. Dermal areolations present, but small. Dorsal tubercles normal, convex, distributed in a cleft between polygonal plates submarginally, 8-11 in total on body: 0-2 pairs between apex of head and anterior stigmatic clefts, 0 or 1 pairs between anterior and posterior stigmatic clefts and 0-3 pairs between posterior stigmatic clefts and anal cleft. Dorsal setae bluntly spinose, short, curved, rarely scattered throughout dorsum. Dorsal tubular ducts absent. Dorsal pore small, scarcely present on dorsum. Preopercular pore present or absent, if present, in a small group of about 5-10 in front of anal plates. Anal plates each triangular in shape. Each plate with 4 apical setae present along to posterior margin.

Margin. Marginal setae spinose, straight or curved, usually with acute, bifid or fimbriate apices, present about 13-15 setae on each side between anterior and posterior stigmatic clefts. Stigmatic clefts apparent each with 3 stigmatic spines, bluntly spinose, median spine more about 2 times as long as lateral spine.

Venter. Derm membranous. Pregenital disc-pores mostly each with 6 or 7 loculi, frequently scattered around vulvar area, less number present on anterior area of abdomen and thorax. Spiracular pores each with 5 loculi, in a narrow band between each spiracles and margin. Ventral tubular duct absent. Ventral microducts quite small, rarely scattered on entire venter. Ventral setae sharply spinose, scarcely scattered over venter. Leg well developed, each with a tibio-tarsal articulation and articulation sclerosis. Tarsal digitules thinner and longer than claw digitules. Spiracles small, usually posterior peritreme slighly broader than anterior. Antenna 7 or 8 segmented, usually 8. Clypeolabral shield present.

Host. Anacardiaceae: *Schinus terebinthifolius*; Apocynaceae: *Nerium oleander*; *Plumeria rubra*; Araceae: *Scindapsus aureus*; Araliaceae: *Meryta angustifolia*; Arecaceae: *Elaeis guineensis*; Asclepiadaceae: *Calotropis gigantea*; Asteraceae: *Fitchia* sp.; Caricaceae: *Carica papaya*; Flagellariaceae: *Flagellaria* sp.; Gnetaceae: *Gnetum gnemon*; Heliconiaceae: *Heliconia* sp.; Hippocrateaceae: *Salacia* sp.; Lauraceae: *Cinnamomum elegans*; Lecythidaceae: *Barringtonia asiatica*; Malvaceae: *Lagunaria patersonii*; Moraceae: *Ficus tinctoria*; Musaceae: *Musa paradisiaca*; *M. sapientum*; Myrtaceae: *Eugenia malaccensis*; Oleaceae: *Olea verrucosa*; Orchidaceae: *Calanthe* sp.; *Vanilla* sp.; Pandanaceae: *Pandanus* sp.; Pittosporaceae: *Pittosporum bracteolatum*; Rubiaceae: *Morinda citrifolia*; *Randia tahitensis*; *Timonius sp*.; Rutaceae: *Citrus aurantifolia*; *C. limon*; *C. paradisi*; *C. reticulata*; *Evodia* sp.; Sapindaceae: *Dodonaea viscosa*; Sterculiaceae: *Theobroma cacao*; Verbenaceae: *Premna* sp.; Zingiberaceae: *Alpinia purpurata*; *Elettaria cardamomum* (Williams & Watson, 1990).

Distribution. Korea, Japan, China, Russia, Taiwan, Thailand, Vietnam, Indonesia, Australia, USA, Europe, South America, Africa.

Remarks. Any specimens of *Eucalymnatus tessellatus* could not be examined in this study. Above diagnosis and description was written according to Hamon & Williams, 1984; Hodgson, 1994.

Tribe Pulvinariini Targioni-Tozzetti, 1868 솜깍지벌레족

Type genus: *Pulvinaria* Targioni-Tozzetti, 1867

Diagnosis. Long or short white ovisac produced from beneath abdomen, usually making body strongly lifted; three or four types (scarcely two) of ventral tubular ducts; dorsum slightly covered with wax secretion or absent woolly wax cover; dorsal tubular ducts absent, or if present, one type with a filamentous inner ductule and short outer ductule; legs with a tibio-tarsal articulatory sclerosis; eyespots present on margin; slightly furrowed and unsclerotized stigmatic clefts (Hodgson, 1994).

Key to Korean genera of Pulvinariini

1. Ventral tubular ducts only present 2 types; Long ventral setae arranged medially between anal plates and mouthparts…………………...…..……... *Leptopulvinaria*

- Ventral tubular ducts present 3 types; Long ventral setae restricted to anterior area of anal plates…….…………………………………………………………….. 2

2. Dorsal tubular ducts usually present; Legs each with a tibio-tarsal articulatory sclerosis…………….………………………………………………….…. *Pulvinaria*

- Dorsal tubular ducts absent; Each leg without a tibio-tarsal articulatory sclerosis...…………………………………………….....…….. *Nipponpulvinaria*

Genus *Leptopulvinaria* Kanda, 1960

Type species: *Leptopulvinaria elaeocarpi* Kanda, 1960

Diagnosis. Convex dorsal tubercles around submarginal area of body; only two types of ventral tubular ducts; rather long ventral setae arranged medially between anterior to anal plates and near to mouthparts (Hodgson, 1994; Tanaka & Amano, 2008).

Remarks. *Leptopulvinaria* consists of 2 species, *L. elaeocarpi* Kanda, 1960 and *L. kawaii* Tanaka & Amano, 2008, which were only described from Japan. In this paper, *Leptopulvinaria* is reported for the first time from Korean peninsula with one species, *L. kawaii.*

8. *Leptopulvinaria kawaii* Tanaka & Amano, 2008

Leptopuvinaria kawaii Tanaka & Amano, 2008: 225.

Diagnosis. Dermal areolations well-developed; dorsal tubercles present; dorsal tubular ducts present; marginal setae each with a simple pointed apex; multilocular disc-pores usually each with 10 loculi; ventral tubular duct present 2 types; antenna 8 segmented; legs each with a tibio-tarsal articulatory sclerosis.

Living appearance. Body elongate oval, slightly convex. Dorsum dark or light brown, usually with irregular pattern of black stripes before oviposition and covered by thin coiled wax. Ovisac made by secretion of white wax and moderately long, one or three times length of body. Eggs light yellow or orange in color (Fig. 17).

Slide-mounted material. Body oval to elongate oval, 3.2-4.3mm long and 2.3-3.2mm wide; anal cleft approximately 1/6 of body length (Fig. 40).

Dorsum. Derm membranous. Dermal areolations well-developed. Dorsal tubercles convex, each with an inner filamentous ductule around submargins, 11-14 in total on each side: 4-5 between apex of head and anterior stigmatic cleft, 2-3 between anterior and posterior stigmatic clefts and 5-6 between posterior stigmatic cleft and anal cleft. Dorsal setae spinose and pointed, each 5.4-10.2μm long, frequently scattered on dorsum, evenly present throughout dorsum. Dorsal tubular ducts each with a moderately long outer ductule and a quite thin inner ductule with a small terminal gland. Dorsal microducts frequently scattered on entire dorsum. Preopercular pore round to oval, small, 3.39-6.46μm wide, present in a loose group of 1-9 in front of anal plates. Anal plates each triangular in shape, 121.6-145.1μm long, 119.9-151.1μm wide, usually anterolateral margin having similar length to posterolateral margin; anterolateral margin 79.8-100.9μm long, posterolateral margin 82.0-102.8μm long. Each plate with 4 apical or subapical setae.

Margin. Marginal setae sharply spinose, straight or slightly curved, with simple pointed apices, each 24.1-41.7μm long, present 16-17 setae between anterior and posterior stigmatic clefts. Stigmatic cleft slightly furrowed, each with 3 stigmatic spines, median spine about less 2 times as long as lateral spine: median 32.0-53.8μm long, laterals 17.1-30.9μm long. Eyespots located near margin.

Venter. Derm membranous. Multilocular disc-pores 5.0-8.2μm wide, usually each with 10 loculi, mainly scattered around vulvar area, less frequently present on anterior area of abdomen and thorax, especially some groups present laterad of meta-, meso-, and procoxa. Spiracular pores 5.0-8.2μm wide, each with 5 loculi, in a narrow band 2-3 pores wide extending from each spiracles to stigmatic clefts. Ventral tubular duct 10.1-19.1μm long, present 2 types: Type I with a moderately narrow inner ductule and a developed flower-head-like terminal gland, present on submargin and median areas of abdomen, thorax and head. Type II with a short outer ductule, a filamentous inner ductule, and a very small terminal gland, frequently present on submargin of posterior abdomen and rarely scattered on rest areas of venter. Ventral microducts distributed on entire venter, especially frequent on submargin. Ventral setae with about 8 pairs of long setae present between anal plates and mouthparts, also about 5 pairs of long setae between antennae and other setae sharply spinose, each 10.1-19.1μm long, evenly distributed on entire venter. Leg well-developed, each with a tibio-tarsal articulation and an articulatory sclerosis, total length of metathoracic leg each 703.3-879.7μm long: each coxa 144.2-209.5μm long, trochanter+femer 214.9-291.4μm long, tibia+tarsus 304.4-366.2μm, claw 29.7-39.4μm long. Tarsal digitules thinner and longer than claw digitules. Spiracles normally developed, anterior peritreme mostly smaller than posterior: anterior peritremes each 32.3-49.3μm wide, posterior peritremes each 36.6-54.0μm wide. Antenna 8 segmented, each 398.3-481.0μm long. Clypeolabral shield 142.5-183.5μm wide.

Material examined. 10♀, Daemun-ri, Gunoe-myeon, Wando-gun, JN, Korea, 04. v. 2014, same collector, on *Eurya* sp. (Theaceae), Coll#: 140504-JY-05; 8♀, Buhwang-ri, Bogil-myeon, Wando-gun, JN, Korea, 11. iv. 2015, coll. J.Y. Choi, on *Ilex cornuta* Lindl. (Aquifoliaceae), Coll# 150411-JY-22.

Host. Aquifoliaceae: *Ilex cornuta*; *I. integra*; *I. latifolia*; *I. pedunculosa*; Pentaphylacaceae:

Cleyera japonica; *Eurya japonica*; *Ternstroemia gymnanthera*; Symplocaceae: *Symplocos myrtaceae* (Tanaka & Amano, 2008).

Distribution. Korea, Japan.

Remarks. *Leptopuvinaria kawaii* is differentiated from *Nipponpulvinaria* and *Pulvinaria* species by only two types of ventral tubular ducts and rather long ventral setae arranged between anterior to anal plates and near to mouthparts, while the species of other genera have 3 types of ventral tubular ducts and only 3 pairs of long pregenital setae. In this study, *L. kawaii* is newly reported from Korea.

Genus *Nipponpulvinaria* Tanaka, 2008

Type species: *Pulvinaria horii* Kuwana, 1902

Diagnosis. A complete and broad submarginal band of large ventral tubular ducts; absence of dorsal tubular ducts; legs without a tibio-tarsal articulatory sclerosis (Tanaka, 2008).

Remarks. *Nipponpulvinaria* was newly erected as a monotypic genus of Pulvinariini based on absence of a tibio-tarsal articulatory sclerosis and different distributions of each type of ventral tubular ducts from other genera of Pulvinariini (Tanaka, 2008).

9. *Nipponpulvinaria horii* Kuwana, 1902 단풍공깍지벌레

Pulvinaria horii Kuwana, 1902b: 59.

Lecanium lichenoides Green, 1921: 257.

Diagnosis. Dermal areolations well-developed; dorsal tubercles absent; dorsal tubular ducts absent; marginal setae each with a simple pointed apex; multilocular disc-pores usually each with 10 loculi; ventral tubular duct present 3 types; antenna 8 or 9 segmented; each leg without a tibio-tarsal articulatory sclerosis.

Living appearance. Body oval to round, moderately convex. Dorsum whitish or yellowish, with a white longitudinal band surrounded by black mottling and other spots irregularly scattered on entire dorsum. Ovisac short, 1/2-1 times length of body, and abundantly secreted from abdomen, making body extremely lifted except for an anterior end. Eggs red or orange in color and concealed by white ovisac (Fig. 18).

Slide-mounted material. Body oval to circular, 4.3-8.4mm long, 4.0-8.2 mm wide, with slightly furrowed stigmatic cleft; anal cleft about 1/4-1/5 of body length (Fig. 41).

Dorsum. Derm membranous or slightly sclerotized. Dermal areolations well-developed, each with a micropore 2.6-3.6μm wide. Dorsal tubercles absent. Dorsal setae bluntly spinose, stout, slightly curved near to apices, present 2 sized: long sized setae, each 7.95-10.34μm long; small sized setae, each 15.32-19.59μm long, both types of setae sparsely distributed over dorsum. Dorsal tubular ducts not detected. Dorsal microducts frequently scattered entire dorsum. Preopercular pore round, 5.3-7.3μm wide, extensively present on dorsal area between anal plates and near to mouthparts. Anal plates together quadrate, each with rounded outer angles, 200.6-247.1μm long, 164.6-276.2μm wide. Each plate with 4 apical setae.

Margin. Marginal setae spinose, stout, each 24.8-42.5μm long, usually with simple pointed apices, present about 15-19 laterally between anterior and posterior stigmatic clefts. Stigmatic clefts slightly deep, each with 3 stigmatic spines, bluntly spinose, median spine approximately 2 times as long as lateral spine: medians 77.2-122.2μm long, laterals 27.2-65.7μm long. Eyespots located near margin.

Venter. Derm membranous. Multilocular disc-pores 8.2-9.5μm wide, each with 9 or 10 loculi, mostly with 10, mainly scattered around vulvar area, less frequently present on anterior area of abdomen and thorax, especially some groups present laterad of meta- and mesocoxa. Spiracular pores 5.3-7.0μm wide, each with 5 loculi, in a narrow band 2-3 pores wide between each spiracles and margin. Ventral tubular duct 34.0-49.4μm long, present 3 types: Type I with a developed outer ductule, a broad and slightly curved inner ductule and a large flower-head-like terminal gland, frequently present and intermixed with Type III in submarginal band. Type II with a narrow inner ductule and a developed flower-head-like terminal gland**,** mainly scattered on posterior abdomen. Type III with a filamentous inner ductule and shorter outer ductule, primarily distributed on submarginal area. Ventral microducts small, each 2.4-3.6μm long, evenly scattered on entire venter. Ventral setae with 3 pairs of long pregenital setae present, also about 4 pairs of long setae between antennae and other setae sharply spinose, slender, each 12.3-18.9μm long, scarcely distributed on entire venter. Each leg normally developed, without a tibio-tarsal articulation and an articulatory sclerosis, total length of metathoracic leg each 604.0-946.0μm long: each coxa 129.4-166.9μm long, trochanter+femer 166.2-207.5μm long, tibia+tarsus 225.4-262.7μm long, claw 22.4-32.7μm long. Tarsal digitules relatively thin. Spiracles normally developed, usually posterior peritreme much broader than anterior: anterior peritremes each 66.0-113.1μm wide, posterior peritremes each 77.9-142.2μm wide. Antenna 8 or 9 segmented, each 420.0-485.9μm long. Clypeolabral shield 225.4-316.3μm wide.

Specimens examined. 5♀, Daehak-dong, Gwanak-gu, Seoul, 17.iv.2014, coll. J.Y. Choi, on *Acer palmatum* Thunb. (Sapindaceae), Coll#. 140417-JY-01; 5♀, same locality, collector and host, 23.v.2014, Coll#. 140523-JY-03.

Host. Aceraceae: *Acer trifidum*; Fagaceae: *Shiia sieboldii*; Hippocastanaceae: *Aesculus hippocastanum*; *A. turbinata*; Moraceae: *Ficus carica*; Rosaceae: *Pyrus simonii*; Sapindaceae: *Koelreuteria paniculata*; Ulmaceae: *Zelkova serrata* (Kuwana, 1902b; Kuwana, 1907; Takahashi, 1955b; Takahashi, 1956; Canard, 1994).

Distribution. Korea, Japan, Europe, UK.

Genus *Pulvinaria* Tarioni-Tozzetti, 1867 솜깍지벌레속

Type species: *Coccus vitis* Linnaeus, 1758

Diagnosis. Elongate white ovisac secreted from body; many ventral tubular ducts distributed in submarginal band or median area of body; less frequent number of ventral tubular ducts present on head; few dorsal tubular ducts (Gill, 1988; Hodgson, 1994).

Remarks. *Pulvinaria* is comprised of about 146 species occurring in all of the zoogeographical regions (Ben-Dov *et al*., 2015).

Key to Korean species of *Pulvinaria*

1. Dorsal tubercles well-developed…………………………………………………… 2

- Dorsal tubercles absent…………………………...…………………………….. 3

2. Spatulated marginal setae present; Dermal areolations well-developed; Dorsal tubular ducts present……………………………………...…………… *P. torreyae*

- Spatulated marginal setae absent; Dermal areolations absent; Dorsal tubular ducts absent…………………………….…………………………….……..... *P. floccifera*

3. Marginal setae each with a blunt apex……………..…………..….. *P. nishigaharae*

- Marginal setae each with a simple pointed or bifid apex………………………….. 4

4. Ventral tubular ducts (Type I) with a broad inner ductule, usually present on submarginal area…………………………………………………….….. *P. nipponica*

- Ventral tubular ducts (Type I) with a broad inner ductule, usually present on medial area of head, thorax, and abdomen, and in inner submarginal band……….….…... 5

5. Dorsal tubular ducts frequently distributed on dorsum……….……...... *P. photiniae*

- Dorsal tubular ducts scarcely distributed on dorsum……………...…. *P. hydrangeae*

10. *Pulvinaria floccifera* (Westwood, 1870) 동백솜깍지벌레

Coccus flocciferus Westwood, 1870: 308.

Pulvinaria camelicola Signoret, 1873a: 32.

Pulvinaria linearis Targioni Tozzetti, 1884: 398.

Pulvinaria brassiae Cockerell, 1895a: 135.

Pulvinaria theae Froggatt, 1915: 418.

Diagnosis. Dermal areolations absent; dorsal tubercles present; dorsal tubular ducts absent; marginal setae each with a simple pointed, bifid or fimbriate apex; pregential disc-pores with 7 loculi; ventral tubular duct present 3 type; antenna 8 segmented; leg each with a tibio-tarsal articulatatory sclerosis.

Living appearance. Body elongate oval, slightly convex. Dorsum cream to tan colored, mottled with brown. Ovisac elongate, secreted from abdomen.

Slide-mounted material. Body elongate oval, with shallow stigmatic cleft; anal cleft about 1/6 of body length.

Dorsum. Derm membranous. Dermal areolations present, but not distinct on mature adult. Dorsal tubercles small, present on submarginal area, 4-14 in total on body, but occasionally absent. Dorsal setae spinose, short, abundantly distributed on entire dorsum. Dorsal tubular ducts each with a normal outer ductule and a filamentous inner ductule, and a small terminal gland, frequently present over dorsum. Bilocular pores and simple disc pores present on dorsum. Preopercular pore quite small, slightly sclerotized, present in a small group of 7-25 in front of anal plates. Anal plates each triangular in shape. Each plate with 4 apical setae.

Margin. Marginal setae spinose, long and slightly curved, usually present about 15-27 laterally between stigmatic areas. Stigmatic clefts slightly furrowed, each with 3 stigmatic spines, blunt and stout, median spine about over 2 or 3 times as long as lateral spine.

Venter. Derm membranous. Pregential disc-pores usually each with 7 loculi, mainly scattered around vulvar area, less frequently present on anterior area of abdomen and thorax, occasionally small groups also present laterad of metacoxa and mesocoxa. Spiracular pores each with 5 loculi, in a broad band 3-4 pores wide between each spiracles and margin. Ventral tubular duct present 3 type: Type I with a developed outer ductule, a rather stout inner ductule, and a developed flower-head-like terminal gland, usually present on head, thorax and abdomen. Type II with a narrow inner ductule, and a large flower-head-like terminal gland, mainly scattered medial area of posterior abdomen. Type III with a filamentous inner ductule and a quite small terminal gland, frequently scattered in wide submarginal bands between antennae and anal lobes. Ventral microducts small, especially present in submarginal band, also rarely distributed over venter. Ventral setae sharply pointed, slender, present on entire venter. Leg well developed, each with a tibio-tarsal articulation and an articulation sclerosis. Tarsal digitules thinner and longer than claw digitules. Spiracles normally developed, usually posterior peritreme much broader than anterior. Antenna 8 segmented. Clypeolabral shield normal.

Host. Agavaceae: *Dracaena* sp.; Amaranthaceae: *Achyranthes* sp.; Apocynaceae: *Nerium* sp.; Asteraceae: *Chrysanthenum* sp.; Celastraceae: *Euonymus radicans*; Euphorbiaceae: *Chamaesyce* sp.; *Euphorbia* sp.; Magnoliaceae: *Magnolia japonica*; Malvaceae: *Hibiscus* sp.; Moraceae: *Ficus* sp.; Myrsinaceae: *Ardisia crispa*; Myrtaceae: *Pimenta* sp.; Orchidaceae: *Odontoglossum* sp.; Polygonaceae: *Altigonon* sp.; *Coccoloba* sp.; Taxaceae: *Taxus baccata*; Theaceae: *Camellia* sp.; *C. sinensis*; *Cleyera ochnacea*; Pentaphylacaceae: *Eurya japonica*; *Ternstroemia japonica*; Umbelliferae: *Foeniculum* sp. (Takahashi, 1955d; Takahashi, 1956; Hamon & Williams, 1984; Hodgson & Hilburn, 1900; Hodgson & Hilburn, 1991; Hodgson &

Henderson, 2000).

Distribution. Korea, Japan, China, Australia, USA, Canada, Europe, UK, South America, Africa.

Remarks. *Pulvinaria floccifera* was firstly reported by Kown *et al*., 2005, however taxonomical information was not provided. In this study, any specimens of the specimens of this species could not be examined. Above diagnosis and description was written according to Hodgson & Henderson, 2000; Williams & Kosztarab, 1972; Tanaka & Amano, 2007. In Tanaka & Amano, 2007, the dermal areolations and dorsal tubular ducts are described as absent characters in dorsum.

11. *Pulvinaria hydrangeae* Steinweden, 1946

Pulvinaria hydrangeae Steinweden, 1946: 7.

Diagnosis. Dorsal areolations present; dorsal tubercles absent; dorsal tubular ducts present; marginal setae each with a simple pointed apex, occasionally with a bifid or fimbriate tip; Multilocular disc-pores usually each with 7 loculi; ventral tubular duct present 3 types; antenna 8 segmented; legs each with a tibio-tarsal articulatory sclerosis.

Living appearance. Body elongate oval, slightly convex. Young adult female not observed. Dorsum of mature adult female yellowish or light brownish, slightly covered with white coiled wax. Body extremely lifted by white ovisac secreted from abdomen. Ovisac about 2 or 3 times as long as body. Eggs reddish yellow in color and stored in ovisac (Fig. 20).

Slide-mounted material. Body elongate oval, 2.0-3.4mm long, 1.6-2.9mm wide, with moderately deep stigmatic cleft; anal cleft about 1/5-1/7 of body length (Fig. 43).

Dorsum. Derm membranous. Dermal areolations well-developed. Dorsal tubercles absent. Dorsal setae spinose, acute, each 8.7-13.0μm long, evenly distributed on entire dorsum. Dorsal tubular ducts each with a short outer ductule and a filamentous inner ductule and a very small terminal gland, rarely present on entire dorsum. Preopercular pore round, 3.6-5.4μm wide, present in a small group of 10-14 in front of anal plates. Anal plates each triangular in shape, 133.7-155.0μm long, 138.6-172.8 wide, mostly posterolateral margin slightly longer than anterolateral margin: anterolateral margin 89.0-111.2μm long, posterolateral margin 98.4-120.0μm long. Each plate with 4 apical setae. Eyespots located near margin.

Margin. Marginal setae spinose, slender, slightly curved, each 29.0-54.4μm long, usually with simple pointed apices, occasionally with bifid or fimbriate tips, present about 9-15 laterally between stigmatic areas. Stigmatic clefts moderately furrowed, each with 3 stigmatic spines, blunt, stout, median spine about over 2 times as long as lateral spine: medians 71.4-83.7μm long, laterals 27.8-59.5μm long.

Venter. Derm membranous. Multilocular disc-pores 6.5-7.9μm wide, usually each with 7 loculi, numerous pores scattered around vulvar area, less frequently present on anterior area of abdomen and thorax, especially small group also present laterad of metacoxa and mesocoxa. Spiracular pores 4.2-6.0μm wide, each with 5 loculi, in a narrow band 2-3 pores wide between each spiracles and margin. Ventral tubular duct 27.0-38.5μm long, present 3 types: Type I with a developed outer ductule, a rather broad inner ductule and a developed flower-head-like terminal gland, mainly present on head and thorax, occasionally detected on abdomen. Type II with a slender inner ductule and a relatively large flower-head-like terminal gland, usually distributed around abdomen and medial submargin. Type III with a filamentous inner ductule, slightly or entirely curved and a quite small terminal gland, frequently scattered in submarginal area and making submarginal band, less number present on anterior area of venter. Ventral microducts small, each 1.9-3.2μm long, frequently scattered on entire venter, especially on submargin. Ventral setae with 3 pairs of long pregenital setae present, also about 5 pairs of long setae between antennae and other setae sharply spinose, slender, each 7.6-14.8μm long, evenly distributed on entire venter. Leg normally developed, each with a tibio-tarsal articulation and an articulatory sclerosis, total length of metathoracic leg each 796.4-922.1μm long: each coxa 195.2-245.7μm long, trochanter+femer 281.4-334.3μm long, tibia+tarsus 269.9-325.9μm long, claw 27.6-35.9μm long. Tarsal digitules thinner and longer than claw digitules. Spiracles normally developed, usually posterior peritreme slightly broader than anterior: anterior peritremes each 46.6-60.2μm wide, posterior peritremes each 54.4-68.2μm wide. Antenna 8 segmented, each 408.4-497.4μm long. Clypeolabral shield 158.0-190.8μm wide.

Specimens examined. 10♀, Han-gye-ri, Buk-myeon, Inje-gun, GW, 13.vi.2015, coll. Y.R. Lee & H.S. Lee, on *Weigela* sp. (Caprifoliaceae), Coll#. 150613-JY-01.

Host. Aceraceae: *Acer campestris*; *A. monspessulanum*; *A. pseudoplatanus*; Caprifoliaceae: *Weigela* sp. Cornaceae: *Cornus sanguinea*; Ebenaceae: *Diospyros kaki*; Hydrangeaceae: *Hydrangea* sp.; *H. hortensis*; Moraceae: *Ficus* sp.; *Morus alba*; Platanaceae: *Platanus acerifolia*; Rosaceae: *Crataegus* sp.; *Prunus avium*; *P.*

serrulata; Taxaceae: *Tilia platyphyllos*; *T. vulgaris*; Ulmaceae: *Celtis australis* (Canard, 1965; Hodgson & Henderson, 2000; Ben-Dov, 2013).

Distribution. Korea, Japan, Australia, USA, Europe, UK.

Remarks. *Pulvinaria hydrangeae* is distinguished from *P. photiniae* by frequency of ventral tubular ducts. The ventral tubular ducts of *P. hydrangeae* scarcely distributed on entire dorsum and less than the number of dorsal microductules, whereas those of *P. photiniae* are frequently distributed. In this study, *Pulvinaria hydrangeae* is firstly reported from Korea.

12. *Pulvinaria idesiae* Kuwana, 1914

Pulvinaria idesidae Kuwana, 1914: 6.

Diagnosis. Dermal areolations present; dorsal tubercles absent; dorsal tubular ducts absent; marginal setae each with a simple pointed apex; pregential disc-pores with 8 loculi; ventral tubular duct present 3 type; antenna 8 segmented; legs each with a tibio-tarsal articulatatory sclerosis.

Living appearance. Body oval, slightly convex. Dorsum greenish light brown with yellow spots on dorsum, especially stigmatic furrows and an anal cleft. Ovisac moderately long, one or two times length of body, and produced mainly from beneath abdomen, making body strongly lifted. Eggs light orange in color (Fig. 21).

Slide-mounted material. Body oval to round, 3.7-5.8mm long and 3.2-5.0mm wide; anal cleft about 1/5-1/6 of body length (Fig. 44).

Dorsum. Derm membranous, slightly sclerotized. Dermal areolations well developed.

Dorsal tubercles absent. Dorsal setae spinose with a pointed apex, each 6.3-9.9μm long, frequently distributed over entire dorsum. Dorsal tubular ducts absent. Dorsal microducts evenly present on entire dorsum. Preopercular pore round to oval, small, 4.5-6.0μm wide, rarely scattered in a small group of 2-3 in front of anal plates. Anal plates each triangular in shape, posterolateral margin much longer than anterolateral margin: anterolateral 104.6-142.9μm long, posterolateral 124.7-173.3μm long. Each plate with 4 apical setae.

Margin. Marginal setae spinose, straight or curved, with simple, pointed apices, each 34.8-47.9μm long, present 14-17 setae between anterior and posterior stigmatic clefts. Stigmatic cleft shallow each with 3 stigmatic spines, median spine about more 2 times as long as lateral spine: median 80.4-108.0μm long, laterals 34.1-50.0μm long.

Venter: Derm membranous. Pregenital disc-pore 6.3-7.9μm wide, mostly with 8 loculi, mostly distributed around vulvar area, also relatively small number present on abdomen and thorax. Spiracular pores 4.2-5.3μm wide, each with 5 loculi, present in a narrow band extending from each spiracles to stigmatic clefts. Ventral tubular duct 23.3-36.7μm long, present 3 types: Type I with a broad inner ductule and a well-developed flower-haed-like terminal gland, frequently scattered on medial abdomen and thorax. Type II with a moderately narrow inner ductule and a developed flower-head-like terminal gland, maily present on submarginal area, also scarcely scattered on medial area of abdomen and thorax. Type III with a quite sort or long outer ductule, a very thin and long inner ductule, usually entirely curved, and a quite small terminal gland, primarily present on submargin and rarely scattered on rest areas of venter. Ventral microducts evenly present on entire venter, especially frequent on submargin.

Ventral setae with about 8 pairs of long setae present between anal plates and mouthparts, also about 6 pairs of long setae between antennae and other setae sharply spinose, each 12.0-20.5μm long, evenly distributed on entire venter. Leg well developed, each with a small tibio-tarsal sclerosis, total length of metathoracic leg each 880.7-1390.0μm long: each coxa 204.5-356.4μm long, trochanter+femer 280.91-478.5μm long, tibia+tarsus 280.9-508.7μm, claw 34.8-48.2μm long. Tarsal digitules thinner and longer than claw digitules. Spiracles normally developed: anterior peritremes each 56.4-70.9μm wide, posterior peritremes each 49.9-91.6μm wide. Antenna 8 segmented, each 399.1-625.6μm long. Clypeolabral shield 180.3-204.5μm wide.

Specimens examined. 8♀, Sillim-dong, Gwanak-gu, Seoul, Korea, 22.v.2014, coll. J.Y. Choi, on *Acer* sp. (Aceraceae), Coll#. 140522-JY-02.

Host. Betulaceae: *Alnus hirsuta*; Cornaceae: *Cornus* sp.; Ebenaceae: *Diospyros kaki*; Flacourtiaceae: *Idesia polycarpa*; Hippocastanaceae: *Aesculus turbinata*; Salicaceae: *Salix glandulosa* (Takahashi, 1956).

Distribution. Korea, Japan.

Remarks. This species is newly reported from Korea. *Pulvinaria idesiae* is close to *P. regalis* Canard, however distinct characters which could distinguish both species are absent in current taxonomy. To clarify this problem, further examination for both speices is highly needed.

13. *Pulvinaria nipponica* Lindinger, 1933 무궁화솜깍지벌레

Pulvinaria nipponica Lindinger, 1933: 50

Diagnosis. Dermal areolations present; dorsal tubercles absent; dorsal tubular ducts present; marginal setae each with a simple pointed apex; Multilocular disc-pores usually each with 6-8 loculi, mostly 8; ventral tubular duct present 3 types; antenna 8 or 9 segmented; legs each with a tibio-tarsal articulatory sclerosis.

Living appearance. Body oval to round, moderately convex. Dorsum whitish or yellowish, with a white longitudinal band surrounded by black mottling and other spots irregularly scattered on entire dorsum. Ovisac short, 1/2-1 times length of body, and abundantly secreted from abdomen, making body extremely lifted except for an anterior end. Eggs red or orange in color and concealed by white ovisac (Fig. 19).

Slide-mounted material. Body elongate oval, 2.8-4.4mm long, 2.1-3.6mm wide, with shallow stigmatic cleft; anal cleft approximately 1/8 of body length (Fig. 42).

Dorsum. Derm membranous. Dermal areolations well-developed. Dorsal tubercles absent. Dorsal setae spinose, stout, slightly pointed, each 6.1-10.2μm long, evenly scattered on entire dorsum. Dorsal tubular ducts 16.5-24.3μm long, each with a moderately developed outer ductule and a very narrow inner ductule with a quite small terminal gland, evenly present on dorsum. Dorsal simple pores 3.2-5.0μm wide and bilocular pores about 5.3μm wide, distributed throughout dorsum. Preopercular pore not detected. Anal plates together quadrate, 113.4-145.4μm long, 124.3-164.4μm wide, usually posterolateral margin rather longer than anterolateral margin: anterolateral margin 71.0-100.6μm long, posterolateral margin 91.3-113.8μm long. Each plate with 4 apical setae.

Margin. Marginal setae spinose, slender, straight or slightly curved, each 24.2-48.5μm long, usually with acute apices, present about 14-17 laterally between stigmatic areas. Stigmatic clefts slightly furrowed, each with 3 stigmatic spines, bluntly spinose, stout, median spine about more 2 times as long as lateral spine: medians 69.3-89.0μm long, laterals 20.8-37.0μm long. Eyespots located near margin.

Venter. Derm membranous. Multilocular disc-pores 6.0-7.9μm wide, each with 6-8 loculi, mostly 8, mainly scattered around vulvar area, less frequently present on anterior area of abdomen. Spiracular pores 4.9-6.6μm wide, each with 5 loculi, in a moderately broad band 3-4 pores wide between each spiracles and margin. Ventral tubular duct 19.9-28.3μm long, present 3 types: Type I with a normal outer ductule, a broad inner ductule and a developed flower-head-like terminal gland, mainly present on submarginal area, especially anterior thorax and head. Type II with similar to Type I, but inner ductule much slender than Type I, usually distributed on medial abdomen, thorax and head, also present on anterior submargin. Type III with a filamentous inner ductule and a shorter outer ductule, usually scattered on submargin, especially frequent on either side of abdomen. Ventral microducts small, each 11.1-24.3μm long, frequently scattered over venter, especially on submargin. Ventral setae with 3 pairs of long pregenital setae present, also about 4 pairs of long setae between antennae, especially interantennal setae with a bulbous expansion near to tip and other setae sharply spinose, slender, each 8.4-13.9μm long, evenly distributed on entire venter. Each leg normally developed, without a tibio-tarsal articulation, but having a small articulatory sclerosis, total length of metathoracic leg each 794.4-868.0μm long: each coxa 206.7-232.9μm long, trochanter+femer 283.2-310.5μm long, tibia+tarsus

269.9-285.4μm long, claw 29.8-39.2μm long. Tarsal digitules thinner and longer than claw digitules. Spiracles normally developed, usually posterior peritreme slightly broader than anterior: anterior peritremes each 42.2-61.0μm wide, posterior peritremes each 52.7-69.2μm wide. Antenna 8 or 9 segmented, usually 8, each 353.8-424.8μm long. Clypeolabral shield 158.8-188.2μm wide.

Specimens examined. 6♀, Yeouido-dong, Yeongdeungpo-gu, Seoul, 16.v.2015, coll. J.Y. Choi, on *Hibiscus syriacus* L. (Malcaceae), Coll#. 150516-JY-09; 1♀, Sedong-ri, Gogeum-myeon, Wando-gun, JN, 6.viii.1977, coll. S. Kawai, same host, Slide#. 8417.

Host. Ebenaceae: *Diospyros kaki*; Malvaceae: *Hibiscus syriacus*; Rosaceae: *Pyracantha coccinea*; Rutaceae: *Citrus* sp.; Ulmaceae: *Zelkova serrata* (Sasscer, 1915; Steinweden, 1946; Takahashi & Tachikawa, 1956; Williams & Kosztarab, 1972; Gill, 1988).

Distribution. Korea, Japan, China, USA.

Remarks. *Pulvinaria nipponica* was newly recorded by Kown *et al*., 2005, however taxonomical information was not provided. In this study, taxonomical description of this species is firstly described with the morphological illustration and photographs of living appearances.

14. *Pulvinaria nishigaharae* (Kuwana, 1907) 노랑솜깍지벌레

Lecanium nishigaharae Kuwana, 1907: 192.

Diagnosis. Dermal areolations present; dorsal tubercles absent; dorsal setae frequently distributed on entire dorsum; dorsal tubular ducts absent; preopercular pores 0-9 present in front of anal plates; marginal setae variable length, each with a blunt or simple pointed apex; Multilocular disc-pores usually each with 7-15 loculi, usually 10; ventral tubular ducts present 3 types; antenna 6-8 segmented, usually 8; legs each with a tibio-tarsal articulatory sclerosis.

Living appearance. Body elongate oval. Dorsum dark yellowish brown in color, with small pale areas (Fig. 22).

Slide-mounted material.

Dorsum. Derm membranous. Dermal areolations not described. Dorsal tubercles absent. Dorsal setae normally spinose, rarely distributed on dorsum. Dorsal tubular ducts not described. Preopercular pore present in a small group of about 7 in front of anal plates. Anal plates each triangular in shape, posterolateral margin slightly longer than anterolateral margin. Each plate with 3 or 4 apical setae.

Margin. Marginal setae spinose, slender and slightly curved, usually with blunt apecies and variable length, present about 20-24 laterally between stigmatic areas. Larger marginal setae quite long, occasionally with bifid tips and similar to length of median stigmatic spine, present at intervals of 1-3 smaller ones. Stigmatic clefts each with 3 stigmatic spines, median spine about over 2 times as long as lateral spine, and curved at tips.

Venter. Derm membranous. Pregential disc-pores frequently scattered around posterior abdomen, also about 10 present behind procoxa, and some groups present laterad of metacoxa and mesocoxa. Spiracular pores each with 5 loculi, in a moderately broad band 3-4 pores wide between each spiracles and margin. Ventral tubular ducts: Type I with a rather stout inner ductule, mainly present on submarginal area and making a broad submarginal band, but not detected in medial area of venter. Type II with a slender inner ductule, scattered on outer part of submarginal band. Ventral microducts not described. Ventral submarginal setae shorter than marginal setae, arranged in a row. Ventral setae 2-4 long setae present between antennae. Legs normal. Antenna normal.

Host. Aceraceae: *Acer buergerianum*; Cornaceae: *Cornus florida*; *Cornus controversa*; Moraceae: *Morus* sp.; Ulmaceae: *Aphananthe aspera*; *Zelkova serrata* (Kuwana, 1907; Takahashi, 1956; Kawai, 1980; Tanaka & Amano, 2006; Tanaka, 2015).

Distribution. Korea, Japan.

Remarks. Samples of *Pulvinaria nishigaharae* could not be slide-mounted because of swollen and sclerotized body. Therefore, living appearances is only provided in this study. Above diagnosis and description was written according to Takahashi, 1955d and Tanaka, 2015.

15. *Pulvinaria photiniae* Kuwana, 1914

Pulvinaria photiniae Kuwana, 1914: 4.

Diagnosis. Dermal areolations well-developed; dorsal tubercles absent; dorsal tubular ducts present; marginal setae each with a simple pointed apex; Multilocular disc-pores usually each with 7 or 8 loculi, mainly 8; ventral tubular duct present 3 types; antenna 8 segmented; legs each with a tibio-tarsal articulatatory sclerosis.

Living appearance. Body elongate oval, moderately convex. Body dark brown in color, distinctively with a dusky yellow longitudinal stripe on center of dorsum. Dorsum slightly covered with white wax secretion, especially on marginal area. Ovisac white, about 1 or 2 times as long as body. Body heavily elevated by ovisac. Eggs pale white in color and covered in ovisac (Fig. 23).

Slide-mounted material. Body elongate oval, 2.5-3.7mm long and 1.8-3.0mm wide, without distinct stigmatic cleft; anal cleft approximately 1/7-1/8 of body length (Fig. 45).

Dorsum. Derm membranous. Dermal areolations well-developed. Dorsal tubercles absent. Dorsal setae sharply spinose, each 6.1-9.1μm long, present evenly throughout dorsum. Dorsal tubular ducts each with a developed outer ductule and a filamentous inner ductule, and a very small terminal gland, frequently present on entire dorsum. Preopercular pore round to oval, small, 3.6-4.5μm wide, distributed in a loose group of about 10 in front of anal plates. Anal plates together quadrate, each with roundish edges, mostly posterolateral margin slightly longer than anterolateral margin: anterolateral margin 63.9-97.6μm long, posterolateral margin 82.4-104.5μm long. Each plate with 4 apical setae.

Margin. Marginal setae finely spinose, mostly with simple pointed apices, but occasionally some bifid or fimbriate, each 30.8-55.2μm long, present 10-12 setae between anterior and posterior stigmatic clefts. Stigmatic cleft shallow each with 3 stigmatic spines, median spine about more 2 times as long as lateral spine: median 55.9-88.8μm long, laterals 21.7-38.6μm long. Eyespots located near margin.

Venter. Derm membranous. Multilocular disc-pores 5.3-7.1μm wide, with 7-8 loculi, mainly 8, mainly present around vulvar area, less frequently scattered on anterior area of abdomen and thorax, especially small group also present laterad of metacoxa and mesocoxa. Spiracular pores 4.1-6.2μm wide, each with 5 loculi, arranged in a narrow band 2-3 pores wide between each spiracles and margin. Ventral tubular duct 20.6-31.2μm long, present 3 types: Type I with a developed outer ductule, a rather broad inner ductule and a developed flower-head-like terminal gland, mainly distributed on medial abdomen, thorax and head, also present on submarigin. Type II with a moderately narrow inner ductule and a well- developed flower-head-like terminal gland, usually scattered on posterior abdomen and submargin. Type III with a short outer ductule, a filamentous inner ductule and a quite small terminal gland, frequently present on submarginal area and making submarginal band. Ventral setae with 3 pairs of long pregenital setae present, also about 3 pairs of long setae present on thorax or anterior abdomen, about 4 pairs of long setae between antennae and other setae sharply spinose, each 9.1-17.7, evenly distributed on entire venter. Leg well-developed, each with a distinct tibio-tarsal sclerosis, total length of metathoracic leg each 680.6-820.9μm long: trochanter+femer 241.4-293.4μm long, tibia+tarsus 230.0-289.3μm, claw 23.2-35.6μm long. Tarsal digitules thinner and longer than claw digitules. Spiracles normally developed: anterior peritremes each 48.2-65.6μm wide, posterior peritremes each 56.3-71.8μm wide. Antenna 8 segmented, each 319.4-395.5μm long. Clypeolabral shield 138.6-187.3μm wide.

Specimens examined. : 9♀, Garwol-ri, Sinbuk-myeon, Pocheon-si, GG, Korea, 16.v.2015, coll. J.Y. Choi, on *Styrax obass*ia Siebold *et* Zucc. (Styracaceae), Coll#:

150516-JY-12.

Host plants. Cannabaceae: *Celtis sinensis*; Rosaceae: *Photinia villosa*; Styracaceae: *Styrax obassia* (Kuwana, 1914; Sasscer, 1915).

Distribution. Korea, Japan, China.

Remarks. In this study, *Pulvinaria photiniae* is firstly reported from Korea.

16. *Pulvinaria* sp.

Pulvinaria torreyae Takahashi, 1956: 29. Misidentification.

Diagnosis. Dermal areolations well developed; dorsal tubercles present; dorsal tubular ducts present; marginal setae each with a pointed, bifid, spatulate and slightly frayed apex; pregential disc-pores with 7 loculi; ventral tubular duct present 3 type; antenna 8 segmented; legs with a tibio-tarsal articulatatory sclerosis.

Living appearance. Not seen.

Slide-mounted material. Body elongate oval, 5.4-6.3mm long, 4.3-4.4mm wide with slightly furrowed stigmatic cleft; anal cleft approximately 1/8 of body length (Fig. 46).

Dorsum. Derm membranous. Dermal areolations well developed. Dorsal tubercles not detached. Dorsal setae spinose, stout, rather pointed, each 9.2-12.1μm long, evenly scattered on entire dorsum. Dorsal tubular ducts 27.8-28.5μm long, each with a moderately developed outer ductule and a quite narrow and long inner ductule with a very small terminal gland, evenly present on dorsum. Dorsal micropores 3.2-3.6μm wide, frequently distributed on dorsum. Preopercular pores 5.7-7.0μm wide, present in a large group of 17-22 between anal plates and metacoxa. Anal plates together quadrate, 203.9-210.3µm long, 182.3-192.7µm wide, usually posterolateral margin much longer than anterolateral margin: anterolateral margin 108.5-124.3µm long, posterolateral margin 161.4-166.3µm long. Each plate with 4 apical setae.

Margin. Marginal setae spinose, straight or slightly curved, each 54.6-61.4µm long, usually with pointed and spatulate apices, occasionally having very few bifid tips, present about 17-20 laterally between stigmatic area. Stigmatic clefts shallow, each with 3 stigmatic spines, bluntly spinose, stout, median spine about more 2 times as long as lateral spine: medians 86.7-97.0µm long, laterals 31.6-41.4µm long. Eye spots located near margin.

Venter. Derm membranous. Pregential disc-pores 6.6-8.2µm wide, each with 10 or 11 loculi, mostly with 10, mainly scattered around vulvar area, less frequently present on anterior area of abdomen and thorax, especially small group also present laterad of metacoxa, mesocoxa and procoxa. Spiracular pores 5.3-6.0µm wide, each with 5 loculi, in a narrow band 2-3 pores wide between each spiracles and margin. Ventral tubular duct present 3 type: Type I with a normal outer ductule and a broad inner ductule with a large flower-head-like terminal gland, usually present on medianal area of thorax. Type II with similar to Type I, but inner ductule much narrow and slender than Type I, mainly scattered around submarginal area and median abdomen. Type III with a filamentous inner ductule and a shorter outer ductule, frequently distributed in a submarginal band especially near to margin. Ventral microducts small, each 3.6-3.9µm long, frequently scattered over entire venter. Ventral setae with 3 pairs of long pregenital setae present, also about 5 or 6 pairs of long setae between antennae and other setae sharply spinose, each 21.0-23.8μm long, evenly distributed on entire venter. Leg normally developed, each without a tibio-tarsal articulation, but having a small articulation sclerosis, total length of metathoracic leg each 1209.7-1415.4μm long: each coxa 328.9-331.8μm long, trochanter+femer 363.5-407.1μm long, tibia+tarsus 449.7-480.2μm long, claw 30.9-34.2μm long. Tarsal digitules thinner and longer than claw digitules. Spiracles normally developed, usually posterior peritreme much broader than anterior: anterior peritremes each 69.4μm wide, posterior peritremes each 77.6-85.0μm wide. Antenna 8 segmented, each 430.0-597.4μm long. Clypeolabral shield 196.0-198.9μm wide.

Specimens examined. 2♀, Maetan-dong, Yeongtong-gu, Suwon-si, GG, 19.vi.2003, coll. G.M. Kwon, on *Taxus cuspidata* Siebold & Zucc. (Taxaceae), Slide#. M1AV00964, M1AV00966.

Host. Taxaceae: *Taxus cuspidata.*

Distribution. Korea, Japan.

Remarks. The examined samples which were used for reporting *P. torreyae* have different characters (a complete submarginal band of ventral tubular ducts and multilocular disc-pores with 10 loculi) from true *P. torreyae.* We concluded that is a report of misidentification and this species is a new species or other Palearctic continental one. After further taxonomic works for this species, *P. torreyae* should be excluded from Korean fauna and reported as another species which were exactly identified.

Tribe Saissetiini Hodgson, 1994

Type genus: *Saissetia* Déplanche, 1859

Diagnosis. One or two types of ventral tubular ducts making a broad submarginal band; lack of dorsal tubular ducts; dorsal tubercles and pocket-like sclerotizations usually present on dorsum, occasionally both not appeared; multilocular disc pores mostly with 10 loculi, scattered around vulvar area, also medial thorax; eyespots located on margin; slightly deep and unsclerotized stigmatic clefts (Hodgson, 1994)

Key to Korean genera of Saissetiini

1. Many polygonal reticulations present on dorsum; Dorsal setae with cylindrical apices...………………...…………………………………………. *Parasaissetia*

- Many polygonal reticulations absent on dorsum; Dorsal setae without cylindrical apices…………………….……………………………………………………. 2

2. Distinctive H pattern of ridges present on dorsum; Dorsal setae with 1 size…….. …………………………………………………………………………… *Saissetia*

- Distinctive H pattern of ridges absent on dorsum; Dorsal setae with 2 sizes………. ………………………………………………………………. *Parthenolecanium*

Genus *Parasaissetia* Takahashi, 1955 검은철모깍지벌레속

Type species: *Lecanium nigrum* Nietner, 1861

Diagnosis. A dark and highly sclerotized dorsum with many polygonal reticulations;

submarginal band consisting of ventral tubular ducts; cylindrical dorsal setae; absence of H pattern on dorsum; legs without tibio-tarsal articulation sclerosis (Gill, 1988; Hodgson, 1994).

17. *Parasaissetia nigra* (Nietner, 1861) 검은철모깍지벌레

Lecanium nigrum Nietner, 1861: 9.

Lecanium depressum Targioni Tozzetti, 1867: 29.

Lecanium depressum simulans Douglas, 1887: 28.

Lecanium begoniae Douglas, 1892: 209.

Lecanium caudatum Green, 1896: 10.

Lecanium (*Saissetia*) *pseudonigrum* Kuwana, 1909b: 162.

Lecanium (*Saissetia*) *siderxylum* Kuwana, 1909b: 162.

Saissetia cuneiformis Leonardi, 1913: 33.

Lecanium (*Saissetia*) *signatum* Newstead, 1917: 363.

Lecanium (*Saissetia*) *nigrum nitidum* Newstead, 1920: 191.

Saissetia perseae Brain, 1920: 11.

Lecanium nigrumnitidum, Newstead, 1920: 191.

Lecanium (*Saissetia*) *crassum* Green, 1930: 287.

Coccus asiaticus Lindinger, 1932: 201.

Diagnosis. Dorsum with many polygonal areas; dorsal tubercles present; pocket-like sclerotisations usually present on submargin; dorsal setae usually with clavate apices;

dorsal tubular ducts absent; marginal setae with variable shaped apices; multilocular disc-pores usually each with 10 loculi; ventral tubular duct present 1 type; each leg without a tibio-tarsal articulatory sclerosis; antenna usually 8 segmented.

Living appearance. Body elongate oval, flat to moderately convex. Dorsum of young adult female yellowish sometimes with brown or red spots. Mature adult female dark purple brown or black in color, soft, and usually with a single series of wax plates around margin.

Slide-mounted material. Body circle to elongate oval, with slightly furrowed stigmatic cleft; anal cleft approximately 1/7-1/8 of body length.

Dorsum. Derm membranous with many polygonal areas excluding margin of body. Dermal areolations present in each polygon medially. Dorsal tubercles convex, rather small, scattered on submarginal area, 1-26 in total on body: 0-3 pairs between apex of head and anterior stigmatic clefts, 0-2 pairs between anterior and posterior stigmatic clefts and 0-7 pairs between posterior stigmatic clefts and anal cleft. Pocket-like sclerotisations usually present on submargin, and closely appeared with dorsal tubercles, total 0-17 on whole dorsum. Dorsal setae mainly with clavate apices, less frequently fimbriate, blunt or flat, commonly distributed on entire dorsum. Dorsal tubular ducts absent. Dorsal microducts small, distributed in each dorsal areolation. Preopercular pore circular, quite convex and sclerotized, present in a less dense group of about 4-13 in front of anal plates. Anal plates each triangular in shape, mostly posterolateral margin slightly longer than anterolateral margin. Each plate with 4 apical setae.

Margin. Marginal setae with variable shaped apices, such as broad, flat and fimbriate tips, present about 11-19 setae on each side between anterior and posterior stigmatic clefts. Stigmatic clefts slightly deep each with 3 stigmatic spines, bluntly spinose, median spine about 2-4 times as long as lateral spine.

Venter. Derm membranous. Pregenital disc-pores usually each with 10 loculi, frequently scattered around vulvar area, less number present on anterior area of abdomen. Spiracular pores each with 5 loculi, in a narrow band between each spiracles and margin. Ventral tubular duct present 1 type with a long and developed outer ductule, a moderately narrow inner ductule, and a large flower-head-like terminal gland, distributed in each side of submarginal bands. Ventral microducts frequently scattered on entire venter. Ventral submarginal setae arranged in a single row. Ventral setae abundant on median thorax and head. Leg well developed, each with a tibio-tarsal articulation, but articulation sclerosis absent. Tarsal digitules thinner and longer than claw digitules. Spiracles normally developed, usually posterior peritreme slighly broader than anterior. Antenna 7 or 8 segmented, usually 8. Clypeolabral shield present.

Host. Aquifoliaceae: *Ilex* sp.; Iridaceae: *Iris germanica*; Myrtaceae: *Feijoa sellowiana*; Rosaceae: *Prunus armeniaca*; Thymelaeaceae: *Daphne* sp. (Hodgson & Henderson. 2000).

Distribution. Korea, Japan, China, Indonesia, Australia, Taiwan, Thailand, Vietnam, Laos, USA, Canada, Europe, UK, South America, Africa.

Remarks. Although tree slide specimens of *Parasaissetia nigra* were confirmed in National Institute of Agricultural Sciences (NIAS), taxonomical examinations could not be performed because of sample conditions. Above diagnosis and description was written according to Hodgson, 1994.

Genus *Parthenolecanium* Šulc, 1908 애기공깍지벌레속

Type species: *Lecanium corni* Bouché, 1844

Diagnosis. Distinct submarginal band including ventral tubular ducts; ventral tubular ducts less frequently present on medial venter (Gill, 1988)

Key to Korean species of *Parthenolecanium*

1. Shapes of stigmatic spines similar to marginal setae……………….…….. *P. glandi*

- Shapes of stigmatic spines distinct and different to marginal setae………..……… 2

2. Dorsal tubercles absent; ventral tubular ducts present 1 type…………... *P. fletcheri*

- Dorsal tubercles present; ventral tubular ducts present 3 types…………….…….. 3

3. Antenna 6 or 7 segmented…………………..……………………………… *P. corni*

- Antenna 8 segmented…………………...……………………...……….. *P. persicae*

18. *Parthenolecanium corni* (Bouché, 1844) 말채나무공깍지벌레

Lecanium corni Bouché, 1844: 298.

Lecanium vini Bouché, 1851: 112.

Coccus tiliae Fitch, 1851: 69.

Lecanium ribis Fitch, 1857a: 427.

Lecanium cynosbati Fitch, 1857b: 436.

Lecanium juglandifex Fitch, 1857d: 463.

Lecanium corylifex Fitch, 1857d: 473.

Lecanium fitchii Signoret, 1873b: 404.

Lecanium rugosum Signoret, 1873b: 429.

Lecanium tarsalis Signoret, 1873b: 430.

Lecanium wistariae Signoret, 1873b: 433.

Lecanium robiniarum Douglas, 1890: 318.

Lecanium armeniacum Craw, 1891: 12.

Lecanium assimile Newstead, 1892: 141.

Lecanium lintneri Cockerell and Bennett in Cockerell, 1895b: 381.

Lecanium caryae canadense Cockerell, 1895c: 253.

Lecanium crawii Ehrhorn, 1898: 247.

Lecanium (*Eulecanium*) *caryarum* Cockerell, 1898b: 293.

Lecanium (*Eulecanium*) *maclurarum* Cockerell, 1898b: 294.

Lecanium (*Eulecanium*) *kingii* Cockerell, 1898a: 322.

Lecanium maclurae Hunter, 1899: 67.

Lecanium kansasense Hunter, 1899: 69.

Lecanium (*Eulecanium*) *aurantiacum* Hunter, 1900: 107.

Lecanium (*Eulecanium*) *vini*: King and Reh, 1901: 6.

Lecanium rehi King in King and Reh, 1901: 61.

Lecanium websteri Cockerell and King in King, 1901a: 106.

Eulecanium guignardi King, 1901b: 334.

Eulecanium rosae King, 1901b: 336.

Eulecanium fraxini King, 1902: 158.

Lecanium obtusum Thro, 1903: 191.

Lecanium folsomi King, 1903: 193.

Lecanium corni robiniarum Marchal, 1908: 278.

Lecanium persicae crudum Green, 1917: 202.

Diagnosis. Dermal areolations absent; dorsal tubercles present; pocket-like sclerotisations present on submargin; dorsal setae present 2 sizes; dorsal tubular ducts absent; marginal setae usually with blunt apices; multilocular disc pores with 10 loculi; ventral tubular duct present 3 type; legs each with a tibio-tarsal articulatory sclerosis; antenna 6 or 7 segmented.

Living appearance. Body oval to round, variable shaped and colored, moderately or highly convex. Dorsum yellowish to dark brown in color, rough surfaced, sometimes with black stripes and spots. Eggs usually whitish or yellowish, stored in swollen venter (Fig. 25).

Slide-mounted material. Body oval to circular, 2.9-6.0mm long, 2.4-5.4mm wide, without distinct stigmatic cleft; anal cleft about 1/6 of body length (Fig. 47).

Dorsum. Derm membranous to heavily sclerotized. Dermal areolations absent. Dorsal tubercles normal and convex, each 12.1-21.3μm wide, each with an inner filamentous ductule, present on submarginal area, 5-9 in total on each side: 2 or 3 between apex of head and anterior stigmatic cleft, 1 or 2 between anterior and posterior stigmatic clefts and 2-4 between posterior stigmatic cleft and anal cleft. Pocket-like sclerotisations irregular shaped, 7.1-19.7μm wide, rarely distributed on submargin, total 0-3 on each side. Dorsal setae spinose, stout with blunt apices, present 2 sizes: large sized setae, each 7.4-13.9μm long, arranged in 2 longitudinal rows medially between anterior anal plates and head; small sized setae, each 3.4-7.8μm long, sparsely scattered on both sides of dorsum, except for the median area. Dorsal tubular ducts each with a normal outer ductule, a narrow inner ductule, usually entirely curved, and a small terminal gland, evenly distributed on dorsum. Dorsal microducts evenly scattered on entire dorsum. Preopercular pore round, variable sized, 4.9-9.7μm wide, distributed in a dense group of 13-23 in front of anal plates. Anal plates each triangular in shape, 96.5-153.3μm long, 106.4-160.0μm wide, usually posterolateral margin rather longer than anterolateral margin: anterolateral margin 53.2-104.0μm long, posterolateral margin 69.7-112.5μm long. Each plate with 4 apical setae.

Margin. Marginal setae spinose, stout, straight or slighly curved, each 17.4-26.1μm long, usually with blunt apices, present about 10-16 laterally between stigmatic. Stigmatic clefts not furrowed each with 3 stigmatic spines, bluntly spinose, stout, median spine approximately 1.5-2 times as long as lateral spine: medians 47.8-54.1μm long, laterals 19.9-31.6μm long.

Venter. Derm membranous to sclerotized. Pregential disc-pores 6.3-7.9μm wide, mostly each with 10 loculi, many pores scattered around vulvar area, less frequently present on anterior area of abdomen and thorax. Spiracular pores 4.4-5.7μm wide, each with 5 loculi, in a moderately broad band 2-3 pores wide between each spiracles and margin. Ventral tubular duct 25.1-39.0μm long, present 3 type: Type I with a moderately narrow inner ductule, a developed flower-head-like terminal gland, and outer ductule relatively longer than inner ductule, primarily present submarginally around body. Type II with similar to Type I, but outer ductule rather shorter than inner ductule, mainly intermixed with Type I, less numbers scattered on medial area of body. Type III with a filamentous inner ductule and a short outer ductule, distributed between antennae and nearly end of anterior body. Ventral microducts small, each 2.1-3.7μm wide, frequently present over venter, especially on submargin. Ventral submarginal setae spinose, straight and rather stout, each 10.0-17.9μm long. Ventral setae sharply pointed, slender, scarcely scattered on entire venter. Leg normally developed, each with a tibio-tarsal articulation and a small articulation sclerosis, total length of metathoracic leg each 374.9-554.9μm long: each coxa 107.8-133.7μm long, trochanter+femer 149.1-184.6μm long, tibia+tarsus 189.3-224.7μm long, claw 20.3-25.1μm long. Tarsal digitules thinner and longer than claw digitules. Spiracles normally developed, usually posterior peritreme much broader than anterior: anterior peritremes each 26.1-55.2μm wide, posterior peritremes each 33.4-69.3μm wide. Antenna 6 or 7 segmented, each 242.6-289.7μm long. Clypeolabral shield 126.4-180.2μm wide.

Specimens examined. 1♀, Maam-ri, Dunnae-myeon, Hoengseong-gun, GW, 30.viii.2000, coll. G.M. Kwon, on Leguminosae sp., Slide#. M1AV00724; 1♀, Dangu-dong, Wonju-si, GW, 9.Viii.1998, same collector, on *Helianthus annuus* L. (Asteraceae), Slide#. M1AV00766; 1♀, Maetan-dong, Yeongtong-gu, Suwon-si, GG, 19.iv.2001, same collector, on *Zelkova serrata* (Thunb.) (Ulmaceae), Slide#. M1AV00739; 2♀, Yeouido-dong, Yeongdeungpo-gu, Seoul, 17.v.2015, coll. J.Y. Choi, on *Prunus* sp. (Rosaceae), Coll#. 150517-JY-03; 1♀, Songmyeon-ri, Cheongcheon-myeon, Goesan-gun, CB, 29.iv.1999, same collector, host data absent, Slide#. M1AV00745; 1♀, Hwaseo-myeon, Sangju-si, GB, 8.v.2001, same collector, on *Chaenomeles sinensis* (Thouin) (Rosaceae), Slide#. M1AV00774; 1♀, Sanje-ri, Sanpo-myeon, Naju-si, JN, 25.v.2001, coll. same collector, on *Diospyros kaki* L. (Ebenaceae), Slide#. M1AV00821; 2♀, Handong-ri, Pungyang-myeon, Goheung-gun, JN, 24.v.2001, same collector, on *Diospyros kaki* L., Slide#. M1AV00824, M1AV00825.

Host. Asteraceae: *Helianthus annuus*; Ebenaceae: *Diospyros kaki*; Fagaceae: *Quercus nigra*; Hamamelidaceae: *Liquidambar styraciflua*; Myricaceae: *Myrica cerifera*; Pinaceae: *Pinus* sp.; Rosaceae: *Chaenomeles sinensis*, *Prunus* sp.; Ulmaceae*: Zelkova serrata* (Hamon & Williams, 1984).

Distribution. Korea, Japan, China, Russia, New Zealand, USA, Canada, Europe, UK, South America.

Remarks. *Parthenolecanium corni* has highly variable chracters, such as color, size or shape of the body (Stepaniuk & Lagowska, 2006). For that reason, molecular analyses are also necessary for confirming identification based on morphology.

19. *Parthenolecanium fletcheri* (Cockerell, 1893)

Lecanium fletcheri Cockerell, 1893d: 221.

Lecanium (*Eulecanium*) *fletcheri*, Cockerell, 1896a: 332.

Lecanium arion Lindinger, 1912: 323.

Diagnosis. Dermal areolations well developed; dorsal tubercles and pocket-like sclerotisations absent; dorsal setae present 2 sizes; dorsal tubular ducts absent; marginal setae usually with blunt apices; multilocular disc pores with 10 loculi; ventral tubular duct present 1 type; each leg without a tibio-tarsal articulatory sclerosis; antenna 8 segmented.

Living appearance. Body oval, heavily convex or hemispherical. Dorsum dark brownish, distinctively with a pale yellow or white longitudinal stripe on medial dorsum and many irregular spots. Eggs usually translucent white, stored in swollen venter (Fig. 26).

Slide-mounted material. Body oval, 2.3-3.3mm long, 1.8-2.9mm wide with quite shallow stigmatic cleft; anal cleft about 1/8-1/10 of body length (Fig. 48).

Dorsum. Derm membranous to slightly sclerotized. Dermal areolations well developed, but relatively small. Dorsal tubercles and Pocket-like sclerotisations not detected. Dorsal setae bluntly spinose, stout, present 2 sizes: large sized setae, each 18.2-26.9μm long, arranged in 2 irregular longitudinal rows medially between anterior anal plates and near to mouthparts; small sized setae, each 5.6-10.9μm long, scarcely scattered on both sides of dorsum, except for the median area. Dorsal tubular ducts absent. Dorsal microducts 2.3-3.2μm wide, frequently distributed on dorsum. Preopercular pores 4.1-7.4μm wide, present in a small group of 9 or 10 between anal plates and metacoxa. Anal plates together quadrate, mostly width much longer than length: 111.9-127.7μm long, 127.3-169.0μm wide. Anterolateral margin usually much longer than posterolateral margin: anterolateral margin 85.8-105.7μm long, posterolateral margin 76.8-94.1μm long. Each plate with each 4 apical setae.

Margin. Marginal setae spinose, stout and straight, each 14.7-22.1μm long, usually with blunt apices, about 6-10 laterally between stigmatic areas. Stigmatic clefts slightly deep, each with 3 stigmatic spines, bluntly spinose, stout, median spine about less 2 times as long as lateral spine: medians 26.2-45.8μm long, laterals 13.6-26.7μm long. Eye spots present near to margin.

Venter. Derm membranous. Pregential disc-pores 5.7-8.9μm wide, each with 10 loculi, frequently scattered around vulvar area, also evenly present on anterior area of abdomen and thorax, especially small group present laterad of metacoxa, mesocoxa and procoxa. Spiracular pores 4.7-6.3μm wide, each with 5 loculi, in a rather narrow band 1-2 pores wide between each spiracles and margin. Ventral tubular duct present 1 type with a long and normally developed outer ductule and a narrow and slender inner ducutule with a very large flower-head-like terminal gland, usually present submarginally and consisting of a submarginal band. Ventral microducts present on entire dorsum, especially on submargin. Ventral submarginal setae sharply spinose, slender, 10.8-17.6μm long. Ventral setae with 3 pairs of long pregenital setae present, also 2 pairs of long setae between antennae and other setae sharply spinose, each 7.4-11.9μm long, evenly distributed on entire venter. Leg normally developed, each with a tibio-tarsal articulation, but an articulation sclerosis absent, total length of metathoracic leg each 414.5-455.8μm long: each coxa 106.7-118.6μm long, trochanter+femer 130.0-144.1μm long, tibia+tarsus 153.7-179.5μm long, claw 12.7-23.1μm long. Tarsal digitules thinner and longer than claw digitules. Spiracles normally developed, usually posterior peritreme much broader than anterior: anterior peritremes each 34.9-48.1μm wide, posterior peritremes each 44.9-56.1μm wide. Antenna 8 segmented, each 129.5-265.6μm long. Clypeolabral shield 146.6-

180.4μm wide.

Specimens examined. 10♀, Daemun-ri, Baekgok-myeon, Jincheon-gun, CB, 16.v.2015, coll. Y.R. Lee, on *Thuja orientalis* L. (Curpressaceae), Coll#. 150516-JY-13.

Host. Curpressaceae: *Thuja occidentalis*; *T. orientalis;* Taxaceae: *Taxus* sp. **(**Kozár, 1980; Gill, 1988).

Distribution. Korea, Russia, USA, Canada, Europe, UK.

Remarks. *Parthenolecanium fletcheri* is rather monophagous, which has host plants belonging to Cupressaceae. This species is newly reported from Korea.

20. *Parthenolecanium glandi* (Kuwana, 1907) 큰공깍지벌레

Lecanium glandi Kuwana, 1907: 191.

Diagnosis. Dorsum shiny dark brown in color, with small sunken spots, slightly covered with wax secretion; antenna 7 segmented; marginal setae conical; stigmatic spines similar to marginal setae; anal plates with 4 apical setae.

Host. Rosaceae: *Malus sylvestris*; *Pyrus communis*; Ulmaceae: *Zelkova serrata* (Kuwana, 1907; Takahashia, 1955b).

Distribution. Korea, Japan, China.

Remarks. Any specimens of *Parthenolecanium glandi* could not be examined in this study. Above diagnosis was written according to Paik, 2000.

21. *Parthenolecanium orientale* (Borchsenius, 1957) 애기공깍지벌레

Parthenolecanium corni orientalis Borchsenius, 1957: 369.

Host. Fabaceae: *Wisteria chinensis*; Grossulariaceae: *Ribes* sp.; Rosaceae: *Prunus* sp.; Salicaceae: *Salix* sp. (Borchsenius, 1957; Borchsenius, 1960).

Distribution. Korea, China.

Remarks. *Parthenolecanium orientale* was only recorded in North Korea (Borchsenius, 1957). Any specimens of this species could not be collected in South Korea. Also, any description could not be taken in this study because proper references are absent in current taxonomy.

22. *Parthenolecanium persicae* (Fabricius, 1776) 복숭아공깍지벌레

Chermes persicae Fabricius, 1776: 304.

Coccus persicorum Sulzer, 1776: 112.

Coccus clematitis Goeze, 1778: 344.

Coccus costatus Schrank, 1781: 296.

Coccus clematidis Gmelin, 1790: 2220.

Coccus berberidis Schrank, 1801: 146.

Lecanium elongatum Signoret, 1873b: 404.

Lecanium genistae Signoret, 1873b: 405.

Lecanium mori Signoret, 1873b: 407.

Lecanium sarothamni Douglas, 1891: 65.

Coccus spini Heyden, 1894.

Eulecanium magnoliarum hortensiae Cockerell, 1903: 19.

Eulecanium cecconi Leonardi, 1908: 178.

Lecanium (*Eulecanium*) *spinosum* Brittin, 1940: 420.

Parthenolecanium thymi Danzig, 1967: 152.

Diagnosis. Dermal areolations absent; dorsal tubercles present; pocket-like sclerotisations present or absent; dorsal setae present 2 sizes; marginal setae with pointed apices; multilocular disc pores with 10 loculi; ventral tubular duct present 3 type; legs each with a tibio-tarsal articulatory sclerosis; antenna 8 segmented.

Living appearance. Body elongate oval, moderately or strongly convex. Dorsum of immature adult female greenish or yellowish usually with a transversal band between each side of anterior and posterior spiracles and other black or brown spots present on entire dorsum. Old adult female becoming dark brown in color and sclerotized with a rather distinct longitudinal ridge medially (Fig. 27).

Slide-mounted material. Body elongate oval 2.2-8.1mm long, 1.1-6.4mm wide, with slightly deep stigmatic cleft; anal cleft approximately 1/7 of body length (Fig. 49).

Dorsum. Derm membranous to strongly sclerotized. Dermal areolations absent. Dorsal tubercles normal and convex, each 22.7-28.6μm wide, each with an inner filamentous ductule, distributed on submarginal area, 11-18 in total on each side: 4 or 5 between apex of head and anterior stigmatic cleft, 2 or 3 between anterior and posterior stigmatic clefts and 5-10 between posterior stigmatic cleft and anal cleft.

Pocket-like sclerotisations present or absent, detected on only few specimens, if present, irregular shaped, 11.4µm wide, scarcely scattered on submargin. Dorsal setae bluntly spinose, stout, present 2 sizes: large sized setae, each 9.7-16.1µm long, arranged in 2 longitudinal rows medially between anterior anal plates and near to anterior end of body; small sized setae, each 6.8-8.6µm long, rarely scattered on both sides of dorsum, except for the median area. Dorsal tubular ducts absent. Dorsal microducts and bilocular pores small, frequently scattered on entire dorsum. Preopercular pore round, variable sized, 6.1-9.5µm wide, present in a dense group of about 20-21 in front of anal plates. Anal plates together quadrate, 142.7-174.8µm long, 123.1-178.6µm wide, mostly posterolateral margin rather longer than anterolateral margin: anterolateral margin 104.5-110.7µm long, posterolateral margin 114.4-129.7µm long. Each plate with 4 apical setae.

Margin. Marginal setae spinose, long, stout or slender, curved, each 41.6-62.3µm long, primarily with pointed apices, about 9-12 laterally between stigmatic areas. Stigmatic clefts slightly furrowed each with 3 stigmatic spines, bluntly spinose, stout, median spine less 1.5 times as long as lateral spine: medians 45.7-61.7µm long, laterals 31.3-51.2µm long.

Venter. Derm membranous to sclerotized. Pregential disc-pores 5.2-7.8µm wide, usually each with 10 loculi, many pores scattered around vulvar area, less frequently present on anterior area of abdomen and thorax, also some pores appeared around each coxa. Spiracular pores 3.1-5.2µm wide, each with 5 loculi, in a broad band 3-4 pores wide between each spiracles and margin. Ventral tubular duct 23.0-33.3µm long, present 3 type: Type I with a developed outer ductule, a very broad inner ductule, and a large terminal gland, mainly distributed in a submarginal band. Type II with a moderately narrow inner ductule and a large flower-head-like terminal gland, primarily present submarginally around body, rarely present on medial thorax and abdomen and intermixed with Type I. Type III with a filamentous inner ductule and a short outer ductule, scattered between antennae and nearly end of anterior body. Ventral microducts small, each 2.3-3.6μm wide, frequently distributed on entire venter, especially on submarginal area. Ventral submarginal setae sharply spinose, straight, each 10.6-18.5μm long, arranged in 2 rows. Ventral setae sharply pointed, relatively stout, sparsely scattered over venter. Leg normally developed, each with a tibio-tarsal articulation and an articulation sclerosis, total length of metathoracic leg each 645.2-795.7μm long: each coxa 144.5-177.1μm long, trochanter+femer 221.8-258.1μm long, tibia+tarsus 243.3-337.3μm long, claw 19.2-29.6μm long. Tarsal digitules thinner and longer than claw digitules. Spiracles normally developed, usually posterior peritreme much broader than anterior: anterior peritremes each 54.9-86.1μm wide, posterior peritremes each 69.6-93.1μm wide. Antenna 8 segmented, each 404.8-521.8μm long. Clypeolabral shield 161.1-189.6μm wide.

Specimens examined. 7♀, Maetan-dong, Yeongtong-gu, Suwon-si, GG, 26.iv.2015, coll. J.Y. Choi, on *Magnolia Kobus* DC. (Magnoliaceae), Coll#. 150426-JY-03; 1♀, same locality and host, 9.vi.1998, coll. G.M. Kwon, Slide#. M1AV00961; 1♀, Juchon-myeon, Gimhae-si, GN, 27.vi.2001, same collector, *Poncirus trifoliate* (L.) (Rutaceae), Slide#. M1AV00963.

Host. Berberidaceae: *Berberis vulgaris*; Ebenaceae: *Diospyros kaki*; *Diospyros lotus*; Elaeagnaceae: *Elaeagnus* sp.; Fabaceae: *Sophora* sp.; *Wisteria sinensis*;

Hydrangeaceae: *Hydrangea hortensis*; Magnoliaceae: *Magnolia Kobus*; Menispermaceae: *Menispermum canadense*; Moraceae: *Ficus carica*; *Morus alba*; *M. nigra*; Oleaceae: *Fraxinus excelsior*; Rosaceae: *Armeniaca vulgaris*; *Prunus armeniaca*; *P. domestica*; *P. laurocerasus*; *P. persica*; *Rosa* sp.; Rutaceae: *Citrus aurantium*; *Poncirus trifoliate* (Marotta, 1987).

Distribution. Korea, Japan, China, Australia, USA, Canada, Europe, UK, South America, Africa.

Genus *Saissetia* Deplanche, 1859 철모깍지벌레속

Type species: *Lecanium coffeae* Walker, 1852

Diagnosis. Extremely convex or hemispherical shape of body; distinctive H pattern of ridges on dorsum; distinct ventral submarginal band consisting of ventral tubular ducts; large median stigmatic spine; conical or spinose dorsal setae (Gill, 1988).

Key to Korean species of *Saissetia*

1. Dorsal setae spinose and short; Ventral tubular ducts with 3 types............. *S. coffeae*

- Dorsal setae conical and long; Ventral tubular ducts with 2 types……….. *S. miranda*

23. *Saissetia coffeae* (Walker, 1852, 1852) 철모깍지벌레

Lecanium coffeae Walker, 1852: 1079.

Lecanium hemisphaericum Targioni Tozzetti, 1867: 26.

Chermes anthurii Boisduval, 1867: 328.

Chermes filicum Boisduval, 1867: 335.

Chermes hibernaculorum Boisduval, 1867: 337.

Lecanium beaumontiae Douglas, 1887: 95.

Lecanium clypeatum Douglas, 1888: 59.

Diagnosis. Dermal areolations well developed; dorsal tubercles present; dorsal tubular ducts absent; marginal setae usually with bifid or fimbriate apices; multilocular disc pores mostly with 10 loculi; ventral tubular duct present 3 types; legs each with a tibio-tarsal articulatory sclerosis; antenna 8 segmented.

Living appearance. Body oval, considerably convex, helmet-shaped. Dorsum pale yellow to dark brown in color, without distinct stripes and spots. White silky wax mainly secreted from beneath abdomen, and slightly protruding around margin. Eggs light purple in color (Fig. 28).

Slide-mounted material. Body oval, 2.0-3.1mm long, 1.7-2.9mm wide, with slightly furrowed stigmatic cleft; anal cleft about 1/5-1/6 of body length (Fig. 50).

Dorsum. Derm membranous. Dermal areolations well developed, each with a simple pores 1.8-3.2μm wide. Dorsal tubercles convex, each with an inner filamentous ductule, present on submarginal area, 5-8 in total on each side: 1 or 2 between apex of head and anterior stigmatic cleft, 1 or 2 between anterior and posterior stigmatic clefts and 3 or 4 between posterior sitgmatic cleft and anal cleft. Dorsal setae spinose and stout, each 5.6-8.9μm long, rarely distributed over dorsum. Dorsal tubular ducts absent. Preopercular pore round to oval, 3.7-5.7μm wide, present in a group of approximately 11 in front of anal plates. Anal plates together quadrate, 135.1-158.6μm long, 145.8-197.8μm wide, usually posterolateral margin slighly longer than anterolateral margin: anterolateral margin 84.1-106.7μm long, posterolateral margin 86.4-129.2μm long. Each plate with 3 apical setae and 1 discal seta.

Margin. Marginal setae, variable sized and shaped, each 31.2-64.5μm long, mostly with bifid or fimbriate apices, also bluntly pointed and curved tips, 11-15 laterally between stigmatic areas. Stigmatic clefts slightly deep each with 3 stigmatic spines, median spine slightly curved, and more or less 2-3 times as long as lateral spine: medians 61.9-82.6μm long, laterals 14.2-36.2μm long.

Venter. Derm membranous. Pregential disc-pores 5.5-7.5μm wide, each with 9 or 10 loculi, mostly with 10 loculi, numerous pores primarily present around vulvar area, also less numbers scattered on anterior area of abdomen and thorax. Spiracular pores 3.7-5.3μm wide, each with 5 or 6 loculi, usually with 5 loculi, present in a narrow band 2-3 pores wide between each spiracles and margin. Ventral tubular duct 19.4-38.0μm long, present 3 types: Type I with a broad inner ductule and a developed flower-head-like terminal gland, frequently present around submargin. Type II with a short outer ductule, a filamentous inner ductule, and a quite small terminal gland, and Type III with a narrow inner ductule and a developed flower-head-like terminal gland, rarely scattered in submarginal band. Ventral microducts 1.9-2.9 μm wide, evenly present on entire dorsum, especially around submargin. Ventral setae acute, straight, each 6.9-13.2μm long, evenly scattered on entire venter. Leg well developed, each with a tibio-tarsal articulation and an articulation sclerosis, total length of metathoracic leg each 674.4-749.2μm long: each coxa 169.8-210.3μm long, trochanter+femer 221.8-246.1μm long, tibia+tarsus 226.2-273.8μm long, claw 18.7-31.2μm long. Tarsal digitules thinner and longer than claw digitules. Spiracles normally developed, posterior peritreme slightly broader than anterior: anterior peritremes each 36.8-56.3μm wide, posterior peritremes each 44.7-59.5μm wide. Antenna 8 segmented, each 343.0-382.6μm long. Clypeolabral shield 154.4-190.2μm wide.

Specimens examined. 1♀, Suwon-si, GG, 15.ii.1972, collector data absent, on *Cycas revolute* Thunb. (Cycadaceae), Slide#. M1AV00700; 1♀, Seoul, 22.ii.1972, collector data absent, on an alpine plant, Slide#. M1AV00702; 1♀, same locality, date and collector, on *Cycas revolute* Thunb. (Cycadaceae), Slide#. M1AV00703; 1♀, same locality, date and collector, on *Euonymus japonica* Thunb. (Celastraceae), Slide#. M1AV00705; 1♀, Dongnae-gu, Busan, 14.xi.1976, collector data absent, on *Nerium indicum* L. (Apocynaceae), Slide#. M1AV00710; 1♀, same locality, date and collector, *Coffea arabica* L. (Rubiaceae), Slide#. M1AV00712; 1♀, same locality, date and collector, *Ardisia crenata* Sims (Primulaceae), Slide#. M1AV00713; 4♀, Sagye-ri, Andeok-myeon, Seogwipo-si, JJ, 14.ix.2014, coll. J.Y. Choi, on *Cycas revolute* Thunb. (Cycadaceae), Coll#. 140914-JY-09.

Host. Araceae: *Anthurium* sp.; *Monstera deliciosa*; Apocynaceae: *Nerium indicum*; Araliaceae: Aralia sp.; *Aralia elegantissima*; *A. laciniata*; Aristolochiaceae: *Aristolochia pistolachia*; Begoniaceae: *Begonia* sp.; Brexiaceae: *Brexia madagascariensis*; Celastraceae: *Euonymus* sp.; *E. japonica*; Cycadaceae: *Cycas revolute*; Euphorbiaceae: *Croton* sp.; Liliaceae: *Asparagus* sp.; *Cordyline australis*; Nymphaceae: *Nuphar lutea*; Oleaceae: *Ligustrum* sp.; Oleandraceae: *Nephrolepis* *exaltata*; Piperaceae: *Piper* sp.; *Pittosporum tobira*; Polygonaceae: *Muehlenbeckia platyclada*; *Platycerium* sp.; *Platycerium alcicorne*; Primulaceae: *Ardisia crenata*; Pteridaceae: *Adiantum capillus-veneris*; Rubiaceae: *Chlorophytum comosum*; *Coffea Arabica*; *Gardenia jasminoides*; *Rondeletia odorata*; Theaceae: *Camellia* sp.; Verbenaceae: *Duranta integrifolia* (Marotta, 1987).

Distribution. Korea, Japan, China, Russia, Taiwan, Thailand, Vietnam, Indonesia, Australia, USA, Europe, Canada, South America, Africa.

24. *Saissetia miranda* (Cockerell & Parrott in Cockerell, 1899)

Lecanium oleaemirandum, Cockerell & Parrott in Cockerell 1899: 12.

Diagnosis. Dermal areolations well developed; dorsal tubercles present; dorsal tubular ducts absent; marginal setae usually with bifid or fimbriate apices; multilocular disc pores mostly with 10 loculi; ventral tubular duct present 2 types; legs each with a tibio-tarsal articulatory sclerosis; antenna 8 segmented.

Living appearance. Body round, heavily convex, hemispherical. Dorsum of young adult light brown in color, with distinct shape of ridges. Mature adult becoming darker, with rough surface (Fig. 29).

Slide-mounted material. Body round to slightly oval, 1.8-2.9mm long, 1.4-2.5mm wide, with shallow stigmatic cleft; anal cleft about 1/5-1/6 of body length (Fig. 51).

Dorsum. Derm membranous. Dermal areolations well developed, each with a simple pore about 2.4μm wide. Dorsal tubercles convex, each with an inner filamentous ductule, present on submarginal area, 9-10 in total on each side: 2 between apex of head and anterior stigmatic cleft, 2 between anterior and posterior stigmatic clefts and 3 or 4 between posterior sitgmatic cleft and anal cleft. Dorsal setae conical, long and stout, each 13.5-18.7m long, scarcely scattered over dorsum. Dorsal tubular ducts absent. Dorsal microducts evenly distributed on dorsum. Preopercular pore round, 4.9-7.8μm wide, present in a group of about 8 in front of anal plates. Anal plates each triangular in shape, 175.6-184.2μm long, 179.0-194.1μm wide, usually posterolateral margin much longer than anterolateral margin: anterolateral margin 105.5-111.2μm long, posterolateral margin 136.6-137.0μm long. Each plate with 3 apical setae and 1 discal seta.

Margin. Marginal setae, each 54.1-55.6μm long, usually with bifid and fimbriate apices, occasionally simple pointed tips, present 63-67 anteriorly between anterior stigmatic areas, 20-23 laterally between stigmatic areas and 46-48 on each side of abdomen. Stigmatic clefts slightly furrowed each with 3 stigmatic spines, median spine more than 2 times as long as lateral spine: medians 57.2-61.6μm long, laterals 27.5-29.1μm long.

Venter. Derm membranous. Multilocular disc-pores 8.0-8.2μm wide, each with 10 loculi, usually distributed around vulvar area. Spiracular pores 3.7-5.2μm wide, each with 5 loculi, present in a narrow band 2-3 pores wide between each spiracles and margin. Ventral tubular duct 24.6-34.1μm long, present 2 types: Type I with a normal outer ductule, a narrow inner ductule and a developed flower-head-like terminal gland, moderately scattered on submarginal area. Type II with a filamentous inner ductule, and a quite small terminal gland, intermixed with Type I. Ventral microducts 1.6-2.3μm wide, evenly present on entire dorsum. Ventral setae with 3 pairs of long pregenital setae present, also 5 pairs of long or short setae between antennae and other setae scarcely distributed on dorum. Leg well developed, each with a tibio-tarsal articulation and an articulation sclerosis, total length of metathoracic leg each 627.6-784.1μm long: each coxa 130.8-148.2μm long, trochanter+femer 198.4-211.4μm long, tibia+tarsus 243.2-268.2μm long, claw 17.3-24.5μm long. Tarsal slightly thinner and longer than claw digitules. Spiracles normally developed, posterior peritreme slightly broader than anterior: anterior peritremes each 42.3-49.0μm wide, posterior peritremes each 47.6-54.5μm wide. Antenna 8 segmented, each 297.0-361.3μm long. Clypeolabral shield 168.6-169.7μm wide.

Specimens examined. 2♀, Bangbae 1-dong, Seocho-gu, Seoul, 07.vii.2015, coll. J.Y. Choi, on *Ficus benjamina* L. (Cycadaceae), Coll#. 150707-JY-02.

Host. Arecaceae: *Cocos nucifera*; Euphorbiaceae: *Acalypha tricolor*; Fabaceae: *Crotalaria usaramoensis*; Heliconiaceae: *Heliconia* sp.; Malvaceae: *Abutilon graveolens*; Rubiaceae: *Morinda citrifolia*; *Timonius* sp.; Moraceae: *Ficus benjamina*; Rutaceae: *Citrus paradisi*; Tiliaceae: *Grewia crenata* (Williams & Watson, 1990).

Distribution. Korea, Japan, Indonesia, Taiwan, Laos, Europe, USA, Africa, South America.

Remarks. In this study, *Saissetia miranda* is newly reported from Korea.

Subfamily Eriopeltinae Šulc, 1941 사다리털깍지벌레아과

Type genus: *Eriopeltis* Signoret, 1872

Diagnosis. Rather elongate body; a felted ovisac covering entire or part of dorsum; large dorsal tubular ducts similar to ventral tubular ducts on submarginal area; membranous dorsum, not sclerotized; anal plates with one or two inner margin setae; multilocular disc pores each with 7-10 loculi; generally two types of ventral tubular ducts; lack of stigmatic clefts; absent or two stigmatic spines present in stigmatic area; absence of dorsal tubercles and pocket-like sclerotisations; normally developed legs and antennae (Hodgson, 1994).

Key to Korean genera of Eriopeltinae

1. Dorsal setae truncate cone shaped; Legs poorly developed……….…….. *Eriopeltis*
- Dorsal setae not truncate cone shaped; Legs normally developed…...…………… 2
2. Stigmatic spines distinguished from marginal setae; anterior margin of anal plates present……….………………………………………………… *Luzulaspis*
- Stigmatic spines not distinguished from marginal setae; anterior margin of anal plates obscure or absent…………………………………...… *Psilococcus*

Genus *Eriopeltis* Signoret, 1872 사다리털깍지벌레속

Type species: *Coccus festucae* Fonscolombe, 1834

Diagnosis. Distinctive truncate cone shaped dorsal setae present on entire dorsum; poorly developed and distort legs; lack of stigmatic spines; scarcely present ventral setae (Gill, 1988; Hodgson, 1994).

Key to Korean species of *Eriopeltis*

1. Marginal setae arranged in a single row…………………..……………. *E. festucae*

- Marginal setae arranged in two or three rows.………...…………… *E. sachalinensis*

25. *Eriopeltis festucae* (Fonscolombe, 1834) 사다리털깍지벌레

Coccus festucae Fonscolombe, 1834: 216.

Eriopeltis agropyri Borchsenius, 1956: 399.

Eriopeltis araxis Borchsenius, 1956: 401.

Eriopeltis caucasicus Borchsenius, 1956: 402.

Eriopeltis desertus Borchsenius, 1956: 403.

Eriopeltis eversmanni Borchsenius, 1956: 403.

Eriopeltis ferganensis Borchsenius, 1956: 404.

Eriopeltis hamberdiensis Borchsenius, 1956: 405.

Eriopeltis maximus Borchsenius, 1956: 408.

Eriopeltis phragmitidis Borchsenius, 1956: 408.

Eriopeltis pratensis Borchsenius, 1956: 411.

Eriopeltis rasinae Borchsenius, 1956: 411.

Eriopeltis zolotarevae Borchsenius, 1956: 416.

Diagnosis. Dorsal tubercles absent; dorsal setae truncated cone-shaped; dorsal tubular ducts absent; dorsal simple and bilocular pore present; marginal setae with blunt pointed apices; multilocular disc-pores with 6 to 11 loculi; ventral tubular duct present 3 types; ventral setae absent; Leg poorly developed; antenna 6 segmented.

Living appearance. Body elongate oval, convex, tapered at anterior and posterior end of the body. Dorsum pale pink in color, thoroughly covered with white filamentous wax (Patch, 1905; Borchsenius, 1957).

Slide-mounted material. Body longish and elongate oval, 3.4-4.5mm long, 1.8-2.6mm wide, without distinct stigmatic clefts; anal cleft relatively short, approximately 1/13-1/14 of body length (Fig. 52).

Dorsum. Derm membranous. Dermal areolations not detected. Dorsal tubercles absent. Dorsal setae basically truncated cone shaped, each 16.2-37.4μm long, densely scattered over dorsum except for a long vertical band extending anal plates to nearly anterior end of body; stout and broad shaped setae at the middle area, but rather pointed and long shaped setae at each end of body, especially the posterior end. Dorsal tubular ducts with a large outer ductule, a moderately narrow inner ductule, and a developed flower-head-like terminal gland, frequently distributed over dorsum. Dorsal simple pore small 2.5-3.4μm wide, and bilocular pore 4.0-5.8μm wide, evenly present on entire dorsum. Preopercular pore 5.3-7.3μm wide, frequently distributed on the long vertical band of middle of body. Anal plates each triangular in shape, 140-190.3μm long, 133.4-244.6μm wide, mostly posterolateral margin much longer than anterolateral margin: anterolateral margin 86.7-128.7μm long, posterolateral margin 97.0-167.9μm long. Each plate with 4-5 apical setae.

Margin. Marginal setae spinose, short, stout, with blunt pointed apices, 9.8-16.8μm long. Stigmatic clefts not distinct and nearly flat, without stigmatic spines.

Venter. Derm membranous. Pregential disc-pores 5.7-7.9µm wide, with variable numbers of loculi, each 6 to 11, abundant pores mainly scattered around vulvar area, also less numbers scattered on anterior area of abdomen and thorax. Spiracular pores 4.7-7.4µm wide, each with 5 to 7 loculi, usually with 5 loculi, arranged in a narrow band between each spiracles and margin. Ventral microducts not detected. Ventral tubular duct 29.1-45.1µm long, present 2 types: Type I with a moderately narrow inner ductule, usually curved, and a developed flower-head-like terminal gland, frequently present over venter. Type II with slender and long inner ductule and a not distinct terminal gland, evenly distributed on venter. Ventral submarginal setae spinose, straight or slightly curved, each 15.5-29.5µm long. Ventral setae absent. Leg quite short and poorly developed, total length of metathoracic leg each 86.2-252.3µm long: each coxa 34.0-65.3µm long, trochanter+femer 27.4-63.0µm long, tibia+tarsus 27.5-106.1µm long, claw 10.8-26.0µm long. Tarsal digitules thinner and longer than claw digitules. Spiracles normally developed, usually posterior peritreme broader than anterior: anterior peritremes each 52.8-72.1µm wide, posterior peritremes each 56.8-75.0µm wide. Antenna 6 segmented, each 113.1-156.4µm long. Clypeolabral shield 129.1-190.1µm wide.

Specimens examined. 6♀, Daehyeon-ri, Bukhu-myeon, Andong-si, GB, 1.vii.1999, coll. G.M. Kwon, on Poaceae sp., Slide#. M1AV00621, M1AV00622, M1AV00625, M1AV00627, M1AV00628, M1AV00631; 2♀, Suwon-si, GG, 20.vi.1977, collector data absent, on Poaceae sp., Slide#. M1AV00616, M1AV00617.

Host. Poaceae: *Brachypodium pinnatum*; *B. silvaticum*; *Bromus* sp.; *Festuca* sp.; *F. ovina* (Marotta, 1987).

Distribution. Korea, China, Russia, USA, Canada, Europe, UK.

Remarks. Ecological appearances of *Eriopeltis festucae* was not observed in this study.

26. *Eriopeltis sachalinensis* Borchsenius, 1956 진사다리털깍지벌레

Eriopeltis sachalinensis Borchsenius, 1956: 413.

Eriopeltis koreanus Borchsenius, 1956: 406.

Eriopeltis strelkovi Borchsenius, 1956: 414.

Eriopeltis japonensis Takahashi, 1957: 65.

Diagnosis. Body oval; dorsum pink or yellow in color; antenna 6 or 7 segmented, but segmentation not clear; legs quite short, and stout; marginal setae arranged in two or three rows; dorsal pores 3 to 5 present around each base of marginal setae.

Host. Poaceae: *Calamagrostis purpurea*; *Festuca* sp. (Borchsenius, 1956; Takahashi, 1957)

Distribution. Korea, Japan, China, Russia.

Remarks. *Eriopeltis sachalinensis* was only reported in North Korea (Borchsenius, 1956). In this study, any specimens could not be examined. Above diagnosis was written according to Danzig, 1986.

Genus *Luzulaspis* Cockerell, 1902 쌍털깍지벌레속

Type species: *Aspidiotus luzulae* Dufour, 1864

Diagnosis. 2 stigmatic spines in stigmatic area; almost 30 setae present between antennae; many dorsal and ventral tubular ducts (Gill, 1988; Hodgson, 1994).

27. *Luzulaspis bisetosa* Borchsenius, 1952 쌍털깍지벌레

Luzulaspis bisetosa Borchsenius, 1952: 277.

Luzulaspis amabilis Kanda, 1960: 116.

Diagnosis. Dorsum of young adult female with two longitudinal bands; antenna 8 segmented; spiracular pores present in a narrow band 2-3 pores wide between each spiracles and margin; stigmatic spines stout, curved, and bifid, 2 present on each stigmatic areas; marginal setae slender, similar length to stigmatic spines, arranged in a single row; dorsal setae slender, occasionally a group of rather stout setae distributed on head.

Host. Cyperaceae: *Carex* sp.; *C. nanella*; *C. rugata*; Juncaceae: *Luzula* sp. (Koteja, 1979; Danzig, 1980).

Distribution. Korea, Japan, Russia.

Remarks. *Luzulaspis bisetosa* was only recorded in North Korea (Borchsenius, 1957). Any specimens of this species could not be examined in this study. Above diagnosis was written according to Danzig, 1986.

Genus *Psilococcus* Borchsenius, 1952 대륙털깍지벌레속

Type species: *Psilococcus ruber* Borchsenius, 1952

Diagnosis. Wide band of disc pores present around marginal area of venter; distinctive anal plates without or obscure anterior margin.

28. *Psilococcus ruber* Borchsenius, 1952 대륙털깍지벌레

Psilococcus ruber Borchsenius, 1952: 270.

Psilococcus parvus Borchsenius, 1957: 115.

Diagnosis. Dorsal tubercles absent; dorsal tubular ducts present; marginal setae with blunt apices; multilocular disc-pores with 7-9 loculi; spiracular pores with 4 to 6 loculi; ventral tubular duct present 1 types; each legs without a tibio-tarsal articulatory sclerosis; antenna 6 segmented.

Living appearance. Body elongate oval. Dorsum yellowish red in color. Eggs covered with small ovisac.

Slide-mounted material. Body quite elongate oval, without stigmatic clefts; anal cleft slightly deep, approximately 1/10 of body length.

Dorsum. Derm membranous. Dermal areolations not described. Dorsal tubercles absent. Dorsal setae spinose, acute, rarely scattered on entire dorsum. Dorsal tubular ducts each with a large and developed outer ductule, a filamentous and long inner ductule and a small terminal gland, frequently distributed on submarginal area, especially around posterior abdomen. Dorsal simple pore evenly present on entire dorsum. Preopercular pores round and convex, abundantly present in a dense group in front of anal plates. Anal plates each triangular in shape, without distinct anterior margins. Each plate with 4 apical setae.

Margin. Marginal setae spinose, slender, with blunt apices, present about 4 or 5 setae on each side between anterior and posterior stigmatic clefts. Stigmatic clefts absent, without distinct stigmatic spines.

Venter. Derm membranous. Pregential disc-pores with variable numbers of loculi, each 7-9, frequently scattered around vulvar area, also less numbers present on anterior area of abdomen and thorax. Spiracular pores each with 4 to 6 loculi, usually with 5 loculi, arranged in a broad band between each spiracle and margin. Ventral microducts usually limited to median areas of body. Ventral tubular duct present 1 types similar to dorsal tubular duct, frequently present posterior median and margin of abdomen. Ventral setae scarcely scattered on venter. Leg small and normally developed, each with a tibio-tarsal articulation, but articulation sclerosis absent. Tarsal digitules thinner and longer than claw digitules. Spiracles small, usually posterior peritreme moderately broader than anterior. Antenna 6 segmented. Clypeolabral shield present.

Host. Cyperaceae: *Carex* sp.; *C. brizoides*; *C. campylorhina*; *C. canescens*; *C. dispalata*; *C. divulsa*; *C. duriuscula*; *C. humilis*; *C. pallescens* (Koteja, 1969a; Koteja, 1969b; Danzig,1980).

Distribution. Korea, Russia, Europe.

Remarks. *Psilococcus ruber* was only reported in North Korea (Borchsenius, 1957). Any specimens of this species could not be examined in this study. Above diagnosis was written according to Kosztarab & Kozár, 1988; Hodgson, 1994.

Subfamily Eulecaniinae Koteja, 1988

Type genus: *Eulecanium* Cockerell, 1893

Diagnosis. Multilocular disc pore each with 10 loculi, broadly scattered on median abdomen and thorax, also on head; simple pointed marginal setae, not bifid or fimbriate; lack of dorsal tubercles and pocket-like sclerotisations; a complete submarginal band including ventral tubular ducts; legs with rather slender claw digitules; without a tibio-tarsal articulation sclerosis (Hodgson, 1994)

Key to Korean genera of Eulecaniinae

1. Dorsal tubular ducts present……………………………….……..…….…….. 2

- Dorsal tubular ducts absent…………………………………….…………..… 3

2. Stigmatic spines almost 6 present in stigmatic clefts; Marginal setae present 1 type.. ……………………………………………………………………… *Ericerus*

- Stigmatic spines 2 or 3 present in stigmatic clefts; Marginal setae present 2 types……..……..…….. *Eulecanium*

3. Preopercular disc-pores absent……………..……………………….. *Rhodococcus*

- Preopercular disc-pores present……………………...………………………..… 4

4. Preopercular pores and long vetral setae separated to two groups present near to each anterior end of body; Multilocular disc-pores with 10 loculi.. *Didesmococcus*

- Preopercular pores and long vetral setae distributed in a wide band between anal plates and anterior head; Multilocular disc-pores with 7 loculi…. *Sphaerolecanium*

Genus *Didesmococcus* Borchsenius, 1953, 진공깍지벌레속

Type species: *Didesmococcus megriensis* Borchsenius, 1953

Diagnosis. This genus is distinguished by two groups of preopercular pores; distinctive distribution of long ventral setae present near to anterior end of body; relatively large dorsal microducts; spiracular disc-pores with multiloculi (Hodgson, 1994)

29. *Didesmococcus koreanus* Borchsenius, 1955 진공깍지벌레

Didesmococcus koreanus Borchsenius, 1955a: 288.

Diagnosis. Body round and hemispherical. Dorsum of mature adult female dark brownish and heavily sclerotized. Antenna 6 segmented, with long third segment.

Living appearance. (Fig. 30)

Host. Rosaceae: *Prunus* sp. (Borchsenius, 1960).

Distribution. Korea, China.

Remarks. In this study, *Didesmococcus koreanus* which was only recorded in North Korea was also collected from South Korea (Borchsenius, 1955a). However, taxonomical examinations with slide-mounted materials could not be performed because of sample conditions. Above diagnosis was written according to Paik, 2000.

Genus *Ericerus* Guérin-Meneville, 1858 쥐똥밀깍지벌레속

Type species: *Coccus ceriferus* Fabricius (as a misidentification of *Coccus pela* Chavannes, 1848)

Diagnosis. This genus is recognized by almost 6 stigmatic spines in stigmatic clefts; abundant dorsal tubular ducts except for area of preopercular pores (Hodgson, 1994).

30. *Ericerus pela* (Chavannes, 1848) 쥐똥밀깍지벌레

Coccus pela Chavannes, 1848: 144.

Coccus sinensis Walker, 1852: 1087.

Coccus sinensis Westwood, 1853: 95.

Eulecanium potanini Borchenius, 1955: 297.

Diagnosis. Dorsal tubercles absent; dorsal tubular ducts with a completely reduced inner ductule; marginal setae usually with blunt apices; stigmatic clefts each with 4-6 stigmatic spines; multilocular disc pores with 10 loculi; ventral tubular duct present 2 type; each legs without a tibio-tarsal articulatory sclerosis; antenna 6 or 7 segmented.

Living appearance. Body slightly oval to round, extremely convex or spherical. Dorsum of young adult female pale brownish usually with many irregular shaped and sized spots and coiled wax filaments on entire dorsum. Mature adult female becoming darker brown in color, and having swelled and sclerotized dorsum with small pits making rough surface. Abundant mass of white wax covering twigs of host plant and containing crowded larvae of males (Fig. 31).

Slide-mounted material. Body slightly oval to circular, 4.0-5.3mm long, 3.5-5.0mm wide, occasionally width of body is longer than length, with slightly furrowed stigmatic clefts; anal cleft about 1/6 of body length (Fig. 53).

Dorsum. Derm membranous to heavily sclerotized. Dermal areolations present. Dorsal tubercles absent. Dorsal setae bluntly spinose, stout, each 7.4-11.0μm long, rarely scattered on dorsum. Dorsal tubular ducts 26.0-39.8μm long, each with a moderately developed outer ductule and an inner ductule and terminal gland completely reduced or absent. Dorsal microducts small, 1.7-3.4μm wide, frequently distributed throughout dorsum. Preopercular pore round, present in a dense group between anterior anal plates and median thorax. Anal plates together quadrate, each with rounded outer angles, 160.9-208.4μm long, 149.0-193.0μm wide. Each plate with 3 or 4 apical setae.

Margin. Marginal setae spinose, stout, straight or slightly curved, each 27.5-42.2μm long, mostly with blunt apices and well developed basal sockets, about 23-30 laterally between stigmatic areas. Stigmatic clefts slightly deep each with 4-6 stigmatic spines, much blunt and stout than marginal setae: the longest one 31.8-59.7μm long, other laterals 29.5-46.7μm long.

Venter. Derm membranous to sclerotized. Pregential disc-pores 8.1-11.2μm wide, usually each with 10 loculi, frequently scattered around vulvar area, less frequently present on anterior area of abdomen and thorax. Spiracular pores 5.3-6.5μm wide, each with 5 loculi, in a moderately broad band 2-3 pores wide between each spiracles and margin, especially quite broader groups 5-6 pores wide present at each ends of band. Ventral tubular duct 26.0-39.8μm long, present 2 type: Type I with a long outer ductule, and a narrow and short inner ductule with a large flower-head-like terminal gland, mainly distributed in submarginal area. Type II with an outer ductule much broader than Type I and an inner ductule similar to Type I, rarely scattered on median thorax and abdomen, especially anterior area of anal plates. Ventral microducts small, each 1.1-3.4, frequently present over venter. Ventral submarginal setae spinose, straight or slightly curved, similar to ventral setae, each 10.0-19.0μm long. Ventral setae sharply spinose, slender, evenly present on entire venter. Leg normally developed, but small, each with a tibio-tarsal articulation, but an articulation sclerosis absent, total length of metathoracic leg each 360.7-642.4μm long: each coxa 96.8-119.4μm long, trochanter+femer 108.4-144.6μm long, tibia+tarsus 132.7-155.6μm long, claw 13.6-24.9μm long. Tarsal digitules relatively thin. Spiracles normally developed, quite large: anterior peritremes each 162.2-195.1μm wide, posterior peritremes each 162.1-218.2μm wide. Antenna 6 or 7 segmented, each 181.9-242.2μm long. Clypeolabral shield 200.3-257.0μm wide.

Specimens examined. 1♀, Gangwon National Univ., Hyoja 2-dong, Chuncheon-si, GW, 02.iv.2015, coll. J.Y. Choi, on *Ligustrum obtusifolium* Siebold & Zucc. (Oleaceae), Coll#. 150425-JY-02; 9♀, Ilsandong-gu, Goyang-si, GG, 28.iii.1998, coll. J.C. Jung, same host, Slide#. M1AV00602, M1AV00603, M1AV00604, M1AV00605, M1AV00606, M1AV00607, M1AV00608, M1AV00609, M1AV00610.

Host. Oleaceae: *Chionanthus retusens*; *Ligustrum* obtusifolium; *Fraxinus bungeana*; *F. longicuspis*; *Ligustrum medium*; *Syringa amurensis* (Kuwana, 1923; Danzig, 1967).

Distribution. Korea, Japan, China, Russia, South America.

Genus *Eulecanium* Cockerell, 1893 공깍지벌레속

Type species: *Coccus tiliae* Linnaeus, 1758

Diagnosis. Spinose dorsal setae, stigmatic spines and marginal setae; dorsum with dorsal tubular ducts; two types of ventral tubular ducts: Type I in a broad submarginal band; Type II rarely scattered on thoracic and abdominal areas; ventral microducts limitedly distributed in a distinct band relating to submarginal band of ventral tubular ducts; multilocular disc pores widely present on median abdomen and thorax, occasionally on head; anal plates with more than one inner marginal setae; legs without a tibio-tarsal articulation sclerosis claws present at right angles to tarsus; claw digitules having rather small apical dilations (Hodgson, 1994).

Key to Korean species of *Eulecanium*

1. Marginal setae only slender…………………………..………………. *E. kostylevi*

- Marginal setae conical and stout or slender…...…………..………………………. 2

2. Marginal setae conical and stout……….………………………………………… 3

- Marginal setae conical and slender…………………………………...…………… 4

3. Dorsum with distinct white or yellow spots when mature adult........... *E. cerasorum*

- Dorsum without distinct white or yellow spots when mature adult........ *E. takachihoi*

4. Dorsum with 7 or 8 dark transverse stripes when immature adult…… *E. kunoense*

- Dorsum without 7 or 8 dark transverse stripes when immature adult…… *E. secretum*

31. *Eulecanium cerasorum* (Cockerell, 1900) 포도공깍지벌레

Lecanium cerasorum Cockerell, 1900: 71.

Diagnosis. Body highly convex, hemispherical; dorsum with irregular pattern of whitish or yellowish spots; antenna 7 segmented; marginal setae stout and conical; stigmatic spines similar to marginal setae and shorter than ones; ventral tubular ducts present 1 type; spiracular pores with 5 loculi; multilocular disc-pores 10 loculi; anal plates with 5 to 7 apical setae.

Living appearance. (Fig. 32).

Host. Aceraceae: *Acer* sp.; Betulaceae: *Carpinus* sp.; Fabaceae: *Wisteria* sp.; Hamamelidaceae: *Liquidamber* sp.; Magnoliaceae: *Magnolia* sp.; Rosaceae: *Prunus* sp.; *Pyracantha* sp.; Ulmaceae: *Celtis* sp.; *Zelkova* sp. (Kosztarab, 1996).

Distribution. Korea, Japan, China, USA.

Remarks. Any slide specimens of *Eulecanium cerasorum* could not be examined because of heavily sclerotized individuls. However, photographs of living appearances is provided and above diagnosis was written according to Gill, 1988; Paik, 2000.

32. *Eulecanium kostylevi* Borchsenius, 1955 북쪽공깍지벌레

Eulecanium kostylevi Borchsenius, 1955a: 295.

Diagnosis. Body brownish, convex and hemispherical at mature adult female, with winkled surface; Dorsum of immature female light orange in color, with a brown longitudinal band medially, and one pair of spotted bands laterally; antenna 7 segmented; marginal setae slender, with simple pointed apices, present about 15 laterally between stigmatic areas; stigmatic spines quite short and thin; dorsal pores and cylindrical dorsal tubular ducts scarcely scattered on dorsum.

Host. Corylaceae: *Corylus heterophylla*; Fabaceae: *Maackia amurensis*; Juglandaceae: *Juglans mandshurica*; Rosaceae: *Rosa dahurica*; Ulmaceae: *Ulmus propinqua* (Danzig, 1967).

Distribution. Korea, China, Russia.

Remarks. *Eulecanium kostylevi* was only recored in North Korea (Borchsenius, 1955). Any specimens of this species could not be examined in this study. Above diagnosis was written according to Danzig, 1986.

33. *Eulecanium secretum* Borchsenium, 1955 개야광공깍지벌레

Eulecanium secretum Borchsenius, 1955a: 299.

Diagnosis. Body dark brown, heavily convex, and hemispherical at old adult female; dorsum of young females yellow to brown in color, with longitudinal and transverse stripes; antenna 7 or 8 segmented; marginal setae conical and slender, with simple pointed apices, but absent between stigmatic areas; stigmatic spines cylindrical, with blunt apices; dorsal pores frequent present on dorsum.

Host. Rosaceae: *Cotoneaster lucida*; *Dasiphora dahurica*; *D. fruticosa* (Danzig, 1980).

Distribution. Korea, Russia.

Remarks. *Eulecanium secretum* was only reported in North Korea (Borchsenius, 1955). Any specimens of this species could not be examined in this study. Above diagnosis was written according to Danzig, 1986.

34. *Eulecanium takachihoi* (Kuwana, 1902) 밤나무공깍지벌레

Lecanium (*Eulecanium*) *takachihoi* Kuwana, 1902b: 63.

Diagnosis. Body oval, highly convex, and posterior part lower than anterior; dorsum drown in color, with depressed regions on margin; antenna 7 segmented; marginal setae rather stout, with simple pointed apices; stigmatic spines 2 or 3, usually shorter and thicker than marginal setae.

Host. Fagaceae: *Castanea* sp.; *Quercus mongolica* (Kuwana, 1902a; Danzig, 1980).

Distribution. Korea, Japan, Russia.

Remarks. Although one slide specimen of *Eulecanium takachihoi* was confirmed in National Institute of Agricultural Sciences (NIAS), taxonomical examinations could not be performed because of sample conditions. Above diagnosis was written according to Danzig, 1986.

35. *Eulecanium kunoense* Kuwana, 1907 공깍지벌레

Lecanium kunoensis Kuwana, 1907: 191.

Diagnosis. Dorsum yellow in color, with 7 or 8 dark brown transverse stripe, but changing to bluish brown after oviposition; antenna 6 or 7 segmented; marginal setae 2 types present: very long and slender setae on upper and under margins; conical and stout setae on lateral margins; stigmatic spines with length similar to marginal setae or slightly stouter; ventral tubular duct present 1 type; spiracular pores with 5 loculi; multilocular disc-pores 10 loculi; anal plates with 3 or 4 apical setae.

Host. Grossulariaceae: *Grossularia* sp.; *Ribes* sp.; Hippocastanaceae: *Aesculus* sp.; Juglandaceae: *Juglans regia*; Rhamnaceae: *Rhamnus japonicus*; Rosaceae: *Amygdalus communis*; *Cerasus vulgaris*; *Crataegus* sp.; *Cydonia oblonga*; *Malus sylvestris*; *Prunus mume*; *Pyracantha* sp.; *Pyrus baccata* (Husseiny & Madsen, 1962).

Distribution. Korea, Japan, China, USA.

Remarks. Although five slide specimens of *Eulecanium kunoense* were confirmed in National Institute of Agricultural Sciences (NIAS), taxonomical examinations could not be performed because of sample conditions. Above diagnosis was written according to Gill, 1988; Paik, 2000.

Genus *Rhodococcus* Borchsenius, 1955 사리원깍지벌레속

Type species: *Rhodococcus rosaeluteae* Borchsenius, 1953

Diagnosis. Absence of dorsal tubular ducts and preopercular pores; sharply spinose marginal setae; stigmatic spines much shorter than marginal setae; an anal ring without both setae and pores (Hodgson, 1994).

36. *Rhodococcus sariuoni* Borchsenius, 1955 사리원깍지벌레

Rhodococcus sariuoni Borchsenius, 1955a: 302.

Diagnosis. Body hemispherical or spherical; dorsal setae very scarcely present; antenna 6 segmented, with long third segment; marginal setae present about 10 laterally between stigmatic areas; multilocular disc-pores and ventral tubular ducts present.

Host. Rosaceae: *Cerasus* sp.; *Malus* sp.; *Spiraea* sp. (Borchsenius, 1955b).

Distribution. Korea, China.

Remarks. *Rhodococcus sariuoni* was only recorded in North Korea (Borchsenius, 1955). Any specimens of this species could not be examined in this study. Above diagnosis was written according to Danzig, 1986; Paik, 2000.

Genus *Sphaerolecanium* Šulc, 1908 오얏공깍지벌레속

Type species: *Chermes emerici* Planchon, 1864

Diagnosis. Dorsum with a wide band consisting of highly sclerotized preopercular pores and long dorsal setae between anal plates and near to anterior head; multilocular disc pores usually each with 7 loculi (Hodgson, 1994).

37. *Sphaerolecanium prunastri* (Fonscolombe, 1834) 오얏공깍지벌레

Coccus prunastri Fonscolombe, 1834: 211.

Eulecanium piligerum Leonardi, 1918.

Diagnosis. Dorsal tubercles absent; dorsal setae present 2 types; dorsal tubular ducts absent; preopercular pore present 2 sizes; marginal setae with blunt apices; multilocular disc pores with 4-6 loculi; ventral tubular absent; each leg without a tibio-tarsal articulatory sclerosis; antenna usually 8 segmented.

Living appearance. Body round to oval, strongly convex. Dorsum dark brown to black, shiny with punctate surface (Kosztarab & Kozár, 1988).

Slide-mounted material. Body oval to slightly rounded, without stigmatic clefts; anal cleft about 1/5-1/6 of body length.

Dorsum. Derm membranous, but a distinct sclerotisation present around anal plates in older specimens. Dorsal tubercles absent. Dorsal setae present 2 types: setose setae, frequently scattered on entire dorsum; flagellate setae, much longer than setose setae, abundantly distributed on a median region longitudinally with Type I of preopercular pores. Dorsal tubular ducts absent. Dorsal microducts small, frequently present over dorsum. Dorsal pores, flat, slightly larger, evenly scattered on dorsum. Preopercular pore present 2 sizes: large sized pores, circular, convex and sclerotized, abundantly distributed in a medial band between anterior to anal plates and antennae; small sized pores, similar to large pores, but much smaller, present laterad to band of large pores. Anal plates each triangular in shape, mostly length of posterolateral margin similar to anterolateral margin. Each plate with 2 apical and 3 subapical setae.

Margin. Marginal setae, variable sized, with blunt apices, present about 19-29 setae on each side between anterior and posterior stigmatic clefts. Stigmatic clefts not distinct each with 3 stigmatic spines, slightly shorter and wider than marginal setae, median spine similar or slightly longer than lateral spine. Eyespots present on dorsal margin.

Venter. Derm membranous. Pregenital disc-pores usually each with 4-6 loculi, frequently distributed around vulvar area, less frequently present on anterior area of abdomen, especially small group also present laterad or mesad of metacoxa. Spiracular pores each with 5 loculi, in a wide band between each spiracles and margin. Ventral tubular absent. Ventral microducts frequently scattered on venter, except for medial area. Ventral submarginal setae rather large, present in a distinct submarginal band. Ventral setae with 3 pairs of long pregenital setae present, also 3 pairs of long or short setae between antennae and other setae sharply spinose, evenly distributed on entire venter. Leg normal, each with a tibio-tarsal peudo-articulation, and without a sclerosis. Tarsal digitules thinner than claw digitules, but equal in length. Spiracles normally developed, rather large, usually posterior peritreme much broader than anterior. Antenna 7 or 9 segmented, usually 8. Clypeolabral shield normal.

Host. Rosaceae: *Prunus cerasifera*, *P. persica*; *P. spinosa* (Argyriou & Paloukis, 1976; Marotta, 1987).

Distribution. Korea, China, Russia, USA, Europe.

Remarks. In Shiraki, 1952, *Sphaerolecanium prunastri* was firstly recorded from Korea as *Eulecanium prunastri.* However, any specimens could not be examined in this study and above diagnosis and description was written according to Hodgson, 1994.

Subfamily Filippiinae Bodenheimer, 1952

Type genus: *Filippia* Targioni-Tozzetti, 1868

Diagnosis. The subfamily Filippinae is typically characterized by zero to three stigmatic spines in each stigmatic clefts; occasionally having dorsal tubercles and pocket-like sclerotisations.

Key to Korean genera of Filippiinae

1. Dorsal setae large and cone shaped, arranged in 2 rows between anterior *anal plates to each antenna; Legs each with a tibio-tarsal articulatory sclerosis………………………………………………………………………………………………Metaceronema*

- Dorsal setae irregularly scattered; Legs each without a tibio-tarsal articulatory sclerosis………………………………………………………………. *Takahashia*

Genus *Metaceronema* Takahashi, 1955 과자깍지벌레속

Type species: *Ceronema japonicum* Maskell, 1897

Diagnosis. Distinctive large and cone shaped dorsal setae arranged in 2 rows extending near to anterior anal plates to each antenna (Hodgson, 1994).

38. *Metaceronema japonica* (Maskell, 1897) 괴자깍지벌레

Ceronema japonicum Maskell, 1897a: 243.

Eriochiton theae Green, 1900: 10.

Lichtensia japonica Kuwana, 1909a: 152.

Euphilippia aquifoliae Chen, 1937: 383.

Euphilippia monicola Wang, 1976: 342.

Diagnosis. Dorsal tubercles absent; dorsal setae cone shaped, arranged in 2 rows in medial area; dorsal tubular ducts present 2 types; dorsal pore present 5 types; marginal setae with pointed apices; stigmatic clefts each with 4-12 stigmatic spines; multilocular disc pores with 7 loculi; ventral tubular duct present 2 types; legs each with a tibio-tarsal articulatory sclerosis; Antenna 8 segmented.

Living appearance. Body elongate oval, flat or slightly convex. Dorsum yellowish or light brownish with black mottling around a median longitudinal area. White curled wax distinctively present on the longitudinal ridge and fine filamentous wax scattered on the rest of dorsum, also other wax secretion attached to each spiracles and anal plates (Fig. 33).

Slide-mounted material. Body elongate oval 1.6-3.0mm long, 1.1-1.8mm wide, with moderately furrowed stigmatic cleft; anal cleft rather short, about 1/9-1/10 of body length (Fig. 54).

Dorsum. Derm membranous. Dermal areolations absent. Dorsal tubercles absent. Dorsal setae spinose, cone shaped, each 11.9-17.1μm long, arranged in 2 rows between each antenna and near to anterior anal plates. Dorsal tubular ducts 25.3-35.7μm long, present 2 types: Type I with a short outer ductule, a quite narrow or filamentous inner ductule, and a small terminal gland, mainly distributed on dorsum submarginally. Type II with a developed outer ductule, a moderately narrow inner ductule and a large flower-head-like terminal gland, rarely present throughout dorsum except for the median longitudinal area. Dorsal pore present 5 types: Oval shaped pore (Type I) sclerotized, without an inner ductule, 3.1-4.1μm wide, distributed around the medial rows of dorsal setae; Ventral microduct (Type II) small, with an inner ductule, 1.9-2.9μm wide, primarily intermixed with oval shaped pore (Type I); Tubercle-like pore (Type III) large, sclerotized, 6.3-8.1μm wide, with an inner filament, present on entire dorsum, especially in the lines of dorsal seta medially. Small convex pore (Type IV), with an inner ductule, 3.2-4.3μm wide, scattered on both sides of dorsum. Minute pore (Type V) small, 1.9-2.6μm wide, evenly present on entire dorsum, especially attached to tubercle-like pore (Type III). Anal plates each triangular in shape, each with rounded outer angles and inner margin sharply diverging outward, 104.6-154.0μm long, 108.1-180.0μm wide, usually posterolateral margin rather shorter than anterolateral margin: anterolateral margin 84.8-114.8μm long, posterolateral margin 69.6-94.9μm long. Each plate with 4 stout inner margin setae.

Margin. Marginal setae spinose, long, stout, each 31.4-56.7μm long, mostly with pointed apices, about 19-28 laterally between stigmatic areas. Stigmatic clefts moderately deep each with 4-12 stigmatic spines, bluntly spinose, stout, median spine less 1.5 times as long as the longest lateral spine: medians 30.2-117.0μm long, laterals 24.5-95.5μm long.

Venter. Derm membranous. Pregential disc-pores 7.0-8.9μm wide, usually each with 7 loculi, mainly distributed around vulvar area, less frequently present on anterior area of abdomen. Spiracular pores 4.4-6.1μm wide, each with 5 loculi, in a very broad band 4-5 pores wide between each spiracles and margin. Ventral tubular duct 24.9-29.3μm long, present 2 type: Type I with a broad outer ductule, a slightly wide inner ductule, and a developed flower-head-like terminal gland, usually distributed on submarginal area. Type II with a moderately narrow inner ductule, rather narrow outer ductule, and a developed flower-head-like terminal gland, rarely scattered around head and anal plates. Ventral microducts small, each 1.9-3.2μm wide, evenly distributed on entire venter, especially on submarginal area. Ventral setae sharply pointed, scarcely scattered over venter. Leg normally developed, each with a tibio-tarsal articulation and an articulation sclerosis, total length of metathoracic leg each 433.4-830.1μm long: each coxa 111.5-234.5μm long, trochanter+femer 145.8-286.8μm long, tibia+tarsus 156.2-297.8μm long, claw 19.9-31.9μm long. Tarsal digitules thinner and longer than claw digitules. Spiracles normally developed, mostly posterior peritreme much broader than anterior: anterior peritremes each 21.6-64.4μm wide, posterior peritremes each 22.5-83.5μm wide. Antenna 8 segmented, each 219.2-436.4μm long. Clypeolabral shield 128.4-209.4μm wide.

Specimens examined. 4♀, Yesong-ri, Bogil-myeon, Wando-gun, JN, 11.iv.2015, coll. J.Y. Choi, on *Camellia japonica* L. (Theaceae), Coll#.150411-JY-03; 2♀, Seogwipo-si, JJ, 22.iii.1972, collector data absent, on *Eurya japonica* for. Integra (Nakai) (Theaceae), Slide#. M1AV00649, M1AV00650; 1♀, Yoseon-ri, Pyoseon-myeon, Seogwipo-si, JJ, 25.iv.1973, collector data absent, on *Camellia japonica* L. (Theaceae), Slide#. M1AV00680; 1♀, Jindo-gun, JN, collector data absent, on *Camellia japonica* L. (Theaceae), Slide#. M1AV00685; 2♀, Udo-myeon, Jeju-si, JJ, coll. G.M. Kwon, on *Fortunella japonica* (Thunb.) (Rutaceae), Slide#. M1AV00689, M1AV00692.

Host. Aquifoliaceae: *Ilex crenata*; *I. integra*; Buxaceae: *Buxus microphylla*; Theaceae: *Camellia japonica*; *Eurya japonica*; *Thea japonica* (Takahashia, 1955a; Takahashia & Tachikawa, 1956; Borchsenius, 1957).

Distribution. Korea, Japan, China, Taiwan.

Genus *Takahashia* Cockerell, 1896 줄솜깍지벌레속

Type species: *Pulvinaria* (*Takahashia*) *japonica* Cockerell, 1896

Diagnosis. Very long white ovisac extremely lifting body of mature adult female; only one type of ventral tubular ducts; absence of a tibio-tarsal articulatory sclerosis (Hodgson, 1994)

39. *Takahashia japonica* (Cockerell, 1896) 줄솜깍지벌레

Pulvinaria (*Takahashia*) *Japonica* Cockerell, 1896b: 20.

Takahashia wuchangensis Tseng, 1947.

Diagnosis. Body of mature adult female extremely lifted by long ovisac; dorsal tubercles absent; dorsal tubular ducts present; preopercular pores absent; multilocular disc-pores each with 10 loculi; ventral tubular duct present 1 type; each leg without a tibio-tarsal articulatory sclerosis; antenna 7 segmented.

Living appearance. Body elongate oval, highly convex or hemispherical. Dorsum light or dark brownish, slightly covered with white wax secretion. White ovisac about two or three times as long as body. Body of mature adult female extremely lifted by long ovisac. Eggs orange or red in color, and stored in ovisac (Fig. 24).

Slide-mounted material. Body elongate oval, 5.2-9.2mm long, 4.5-7.6mm wide without distinct stigmatic cleft; anal cleft approximately 1/8 of body length (Fig. 55).

Dorsum. Derm membranous. Dermal areolations absent. Dorsal tubercles not detached. Dorsal setae spinose, stout, rather pointed, each 10.9-14.9μm long, rarely scattered on entire dorsum. Dorsal tubular ducts 21.2-29.7μm long, each with a normal outer ductule and a long filamentous inner ductule with a small terminal gland, evenly present on dorsum. Dorsal pores ring shaped and sclerotized, each 4.2-6.5μm wide, frequently distributed on dorsum. Preopercular pores absent. Anal plates together quadrate, 180.7-204.0μm long, 155.0-194.6μm wide, usually posterolateral margin longer than anterolateral margin: anterolateral margin 114.1-136.5μm long, posterolateral margin 116.6-139.4μm long. Each plate with about 5 apical setae.

Margin. Marginal setae spinose, straight, and stout, each 17.4-28.0μm long, usually with pointed apices, about 18-21 laterally between stigmatic areas. Stigmatic clefts not distinct, each with 3 stigmatic spines, more blunt and stout, usually median spine and lateral spine having similar sizes and shorter than marginal setae: medians 15.9-22.1μm long, laterals 12.4-18.3μm long. Eye spots located near to margin.

Venter. Derm membranous. Pregential disc-pores 7.0-10.5μm wide, each with 10 loculi, numerously distributed around vulvar area, also scattered on almost areas of body. Spiracular pores 6.0-7.1μm wide, each with 5-7 loculi, sometimes pregenital disc pores intermixed in an obscure band between each spiracles and margin. Ventral tubular duct present 1 type with a long and developed outer ductule and a rather shorter inner ductule with a large flower-head-like terminal gland, frequently distributed around vulvar area, also present on marginal area and head, but not detected on medial area of thorax and both sides of submarginal area. Ventral microducts small, each 3.9-4.7μm long, evenly present over venter. Ventral setae with 2 or 3 pairs of long pregenital setae present, also about 3 pairs of long setae between antennae and other setae sharply spinose, each 10.2-15.6μm long, scarcely present on entire venter. Leg normally developed, each with tibio-tarsal articulation, but an articulation sclerosis absent, total length of metathoracic leg each 308.6-482.8μm long: each coxa 54.2-104.3μm long, trochanter+femer 87.1-137.1μm long, tibia+tarsus 128.4-208.9μm long, claw 13.9-32.6μm long. Tarsal digitules similar to claw digitules and both long and narrow. Spiracles normally developed, mostly posterior peritreme much broader than anterior: anterior peritremes each 95.1-131.131.6μm wide, posterior peritremes each 114.6-155.5μm wide. Antenna 7 segmented, each 163.0-252.1μm long, occasionally a pseudo-articulation present on the third segment. Clypeolabral shield 113.3-289.2μm wide.

Specimens examined. 1♀, Seodun-dong, Gwonseon-gu, Suwon-si, GG, 29.v.2000, coll. G.M. Kwon, on *Cornus officinalis* Torr. Ex Dur. (Cornaceae), Slide#. M1AV00990; 1♀, Maetan-dong, Yeongtong-gu, Suwon-si, GG, 1.vi.2000, same collector, on *Pyrus serotine* L. (Rosaceae), Slide#. M1AV00997; 3♀, Seodun-dong, Gwonseon-gu, Suwon-si, GG, 23.v.2003, same collector, on *Magnolia obovata* Thunb. (Magnoliaceae), Slide#. M1AV01026, M1AV01027, M1AV01028; 1♀, Irwol-myeon, Yeongyang-gun, GB, 25.vi.2014, coll. J.Y. Choi, on *Lespedeza* sp. (Leguminosae), Coll#. 140625-JY-01.

Host. Cornaceae: *Cornus officinalis*; Leguminosae: *Lespedeza* sp.; Magnoliaceae: *Magnolia obovata*; Rosaceae: *Prunus salicina*; *P. serotine*; Salicaceae: *Salix glandulosa*; Ulmaceae: *Celtis sinensis*; *Zelkova serrata* (Takahashi & Tachikawa, 1956; Hodgson, 1994).

Distribution. Korea, Japan, China.

IV. Discussion

The family Coccidae was reviewed as 39 species of 19 genera in the Korean Peninsula, including 7 new records, *Ceroplastes floridensis* Comstock, *Leptopulvinaria kawaii* Tanaka & Amano, *Parthenolecanium fletcheri* (Cockerell), *Pulvinaria hydrangeae* Steinweden, *P. idesiae* Kuwana, *P. photiniae* Kuwana, and *Saissetia Miranda* (Cockerell & Parrott). Among them, one species, *Pulvinaria torreyae*, was examined as misidentification.

So far, taxonomic study of the family Coccidae have been pooly studied in Korean Peninsula. According to the history of Korean records, only 4 species had been recorded after Paik reported *Metaceronema japonica* in 1958. In this study, 7 species were newly discovered for 2 years. This study implicated that taxonomic status of the family Coccidae would be underestimated and have possible to be increased by intensive study.

Unfortunately, 7 species, *Parthenolecanium orientale* (Borchsenius), *Eulecanium kostylevi* Borchsenius, *E. secretume* Borchsenius, *Rhodococcus sariuoni* Borchsenius, *Eriopeltis sachalinensis* Borchsenius, *Luzulaspis bisetosa* Borchsenius, and *Psilococcus ruber* Borchsenius which were only reported from North Korea could not be examined in this study. Only one species, *Didesmococcus koreanus* Borchsenius were confirmed to exist in South Korea (Type spcimens of those species are deposited in Zoological Institute, Russian Academy of Sciences).

Among species which were recorded in South Korea, any specimens of 4 species, *Parthenolecanium glandi* (Kuwana), *Pulvinaria floccifera* (Westwood), *Eucalymnatus tessellatus* (Signoret), and *Sphaerolecanium prunastri* (Fonscolombe) were unavailable, and 5 species, *Parasaissetia nigra* (Nietner), *Pulvinaria nishigaharae* (Kuwana), *Eulecanium cerasorum* (Cockerell), *E. takachihoi* (Kuwana), and *E. kunoense* Kuwana could not be examined exactly because fresh samples were highly convex and sclerotized, or slide specimens were too old or in bad condition. Those species should be more sampled and included in further study.

In regard of reviewing previous records, one species, *Pulvinaria torreyae* Takahashi, was confirmed as misidentification. The examined samples may be a new species or other Palearctic continental one. After further taxonomic works for this species, *P. torreyae* should be excluded from Korean fauna and reported as another species which were exactly identified.

Table 3. Checklist of Coccidae in the Korean peninsula. Species name with an asterisk (*) indicates new records to the fauna from this study.

No.	Subfamily	Tribe	Species	Korean name
1	Ceroplastinae	Ceroplastini	*Ceroplastes ceriferus* (Fabricius, 1798)	뿔밀깍지벌레
2			*Ceroplastes floridensis* Comstock, 1881*	
3			*Ceroplastes japonicus* Green, 1921	거북밀깍지벌레
4			*Ceroplastes rubens* Maskell, 1893	루비깍지벌레
5	Coccinae	Coccini	*Coccus hesperidum* Linnaeus, 1758	무화과깍지벌레
6			*Coccus pseudomagnoliarum* (Kuwana, 1914)	어리목련깍지벌레
7			*Eucalymnatus tessellatus* (Signoret, 1873)	남생이깍지벌레
8		Pulvinariini	*Leptopulvinaria kawaii* Tanaka & Amano, 2008*	
9			*Nipponpulvinaria horii* (Kuwana, 1902)	단풍공깍지벌레
10			*Pulvinaria floccifera* (Westwood, 1870)	동백솜깍지벌레
11			*Pulvinaria hydrangeae* Steinweden, 1946*	
12			*Pulvinaria idesiae* Kuwana, 1914*	
13			*Pulvinaria nipponica* Lindinger, 1933	무궁화솜깍지벌레
14			*Pulvinaria nishigaharae* (Kuwana, 1907)	노랑솜깍지벌레
15			*Pulvinaria photiniae* Kuwana, 1914*	
16			*Pulvinaria torreyae* Takahashi, 1956	주목솜깍지벌레
17		Saissetiini	*Parasaissetia nigra* (Nietner, 1861)	검은철모깍지벌레
18			*Parthenolecanium corni* (Bouché, 1844)	말채나무공깍지벌레
19			*Parthenolecanium fletcheri* (Cockerell, 1893)*	
20			*Parthenolecanium glandi* (Kuwana, 1907)	큰공깍지벌레
21			*Parthenolecanium orientale* (Borchsenius, 1957)	애기공깍지벌레
22			*Parthenolecanium persicae* (Fabricius, 1776)	복숭아공깍지벌레
23			*Saissetia coffeae* (Walker, 1852)	철모깍지벌레
24			*Saissetia miranda* (Cockerell & Parrott, 1899) *	
25		Eriopeltini	*Eriopeltis festucae* (Fonscolombe, 1834)	사다리털깍지벌레
26			*Eriopeltis sachalinensis* Borchsenius, 1956	진사다리털깍지벌레
27			*Luzulaspis bisetosa* Borchsenius, 1952	쌍털깍지벌레
28			*Psilococcus ruber* Borchsenius, 1952	대륙털깍지벌레
29	Eulecaniinae	Eulecaniini	*Didesmococcus koreanus* Borchsenius, 1955	진공깍지벌레
30			*Ericerus pela* (Chavannes, 1848)	쥐똥밀깍지벌레
31			*Eulecanium cerasorum* (Cockerell, 1900)	포도공깍지벌레
32			*Eulecanium kostylevi* Borchsenius, 1955	북쪽공깍지벌레
33			*Eulecanium secretum* Borchsenius, 1955	개야광공깍지벌레
34			*Eulecanium takachihoi* (Kuwana, 1902)	밤나무깍지벌레
35			*Eulecanium kunoense* (Kuwana, 1907)	공깍지벌레
36			*Rhodococcus sariuoni* Borchsenius, 1955	사리원깍지벌레
37			*Sphaerolecanium prunastri* (Fonscolombe, 1834)	오얏공깍지벌레
38	Filippinae	Filippiini	*Metaceronema japonica* (Maskell, 1897)	과자깍지벌레
39			*Takahashia japonica* (Cockerell, 1896)	줄솜깍지벌레

PART II. Molecular phylogeny of Coccidae (Hemiptera: Coccoidea)

Abstract

The soft scales (Hemiptera: Coccidae) are plant-sucking insects, some of which are considered as serious agricultural pests. Their phylogenetic works have been poorly conducted even some hypotheses have been suggested only based on the alpha taxonomy. Here, we performed preliminary phylogenetic analysis of Coccidae based on molecular fragments 1813bp containing mitochondrial DNA (COI), nuclear ribosomal RNA genes (18S and 28S), and elongation factor 1α (EF-1α). Data sets of 55 taxa were analyzed using maximum likelihood (ML) and Bayesian inference (BI). Our molecular analyses represent that any subfamily is not completely monophyletic except for Ceroplastinae; monophyletic clade of Ceroplastinae is nested within the major clade of Coccinae; Four tribes of Coccinae are paraphyletic except for Saissetiini in ML tree, and *Megapulvinaria* and *Paralecanium* are not clustered within the major clade of Coccinae; *Didesmococcus* is separated from the clade of Eulecaniinae; Filippiinae and Cardiococcinae are paraphyletic with respect to some of Coccinae and Eulecaniinae.

Key words: Coccidae, soft scales, molecular phylogeny, COI, 18S, 28S, EF1-α**.**

I. Introduction

Coccidae (Hemiptera: Coccoidea) is the third richest family of scale insects, consist of 1,134 described species of 168 genera in the world (Ben-Dov *et al*., 2014). This group which belonged to the neococcids has been inferred as sister to Aclerdidae or Kerriidae in several higher classification of the Coccoidea (Fig.4. a. Cook *et al.,* 2002; b. Gullan & Cook, 2007; c. Hodgson & Hardy, 2013). The latest classification of Coccidae was suggested by Hodgson (1994) who introduced 10 subfamilies including the Coccinae subdivided into 4 tribes, based on morphology of adult males and females. Although some phylogenetic analyses of subgroups within soft scales were attempted by Qin & Gullan (1995) and Miller and Williams (1995), the first comprehensive phylogeny of Coccidae was accomplished by Miller and Hodgson, (1997), using 105 characters of 24 taxa which represent all subfamilies, tribes of Coccidae and outgroups (Fig. 3). In this cladistic analysis, monophyly of Coccidae was well supported and most relationships of higher taxa of Coccidae were rather constant, however other relationships of Filippiinae, Eulecaniinae and Cissococcinae were changed according to outgroups. Miller and Hodgson, (1997) suggested that the Filippiinae, Eulecaniinae and Cissococcinae is basal groups and Myzolecaniinae, Eriopeltinae, Pseudopulvmariinae and Cyphococcinae are intermediate within Coccidae. In addition, they suggested Paralecaniini closely sister to Cardiococcinae is not a group belonging the Coccinae. Although they provided the hypotheses based on the morphological characters, further phylogenetic works have not been conducted to define relationships of groups in Coccidae. For that reason, we constructed preliminary molecular phylogeny of Coccidae to estimate the monophyly of higher groups of Coccidae and the previous hypotheses.

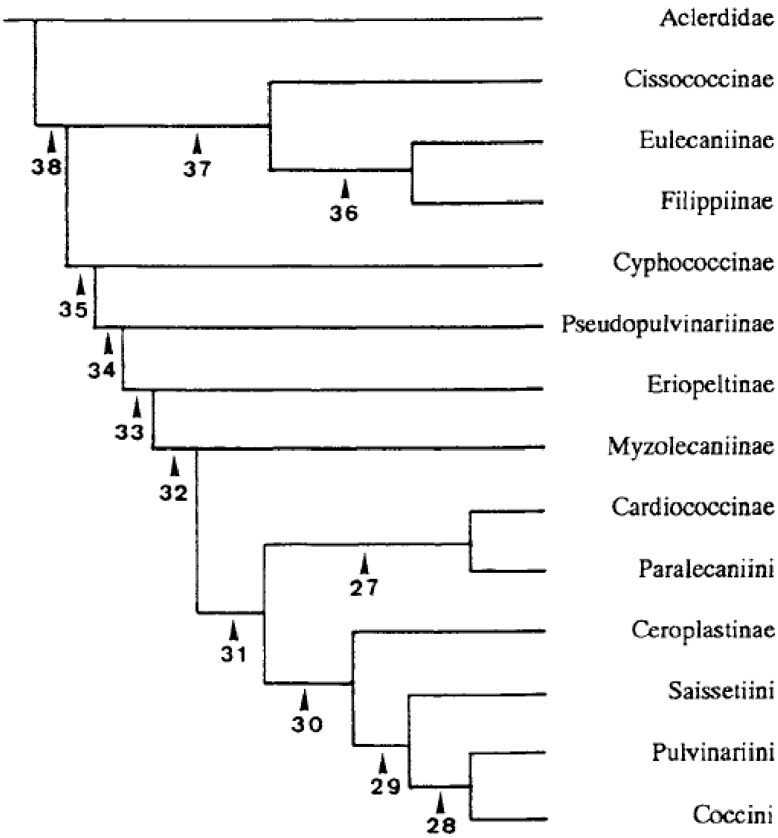

Fig. 3. The morphological phylogeny of the family Coccidae, using 105 characters (Miller & Hodgson, 1997).

II. Materials and methods

Taxon Sampling

Total 55 taxa including 49 ingroup species and 6 outgroup of three families sister to Coccidae were used in analyses (Table 5). Among them, sequenced data for 30 samples were downloaded from NCBI (Lin *et al*., 2013; Wang *et al*., 2015). These

a. Cook & Gullan, b. Gullan & Cook, c. Hodgson & Hardy,

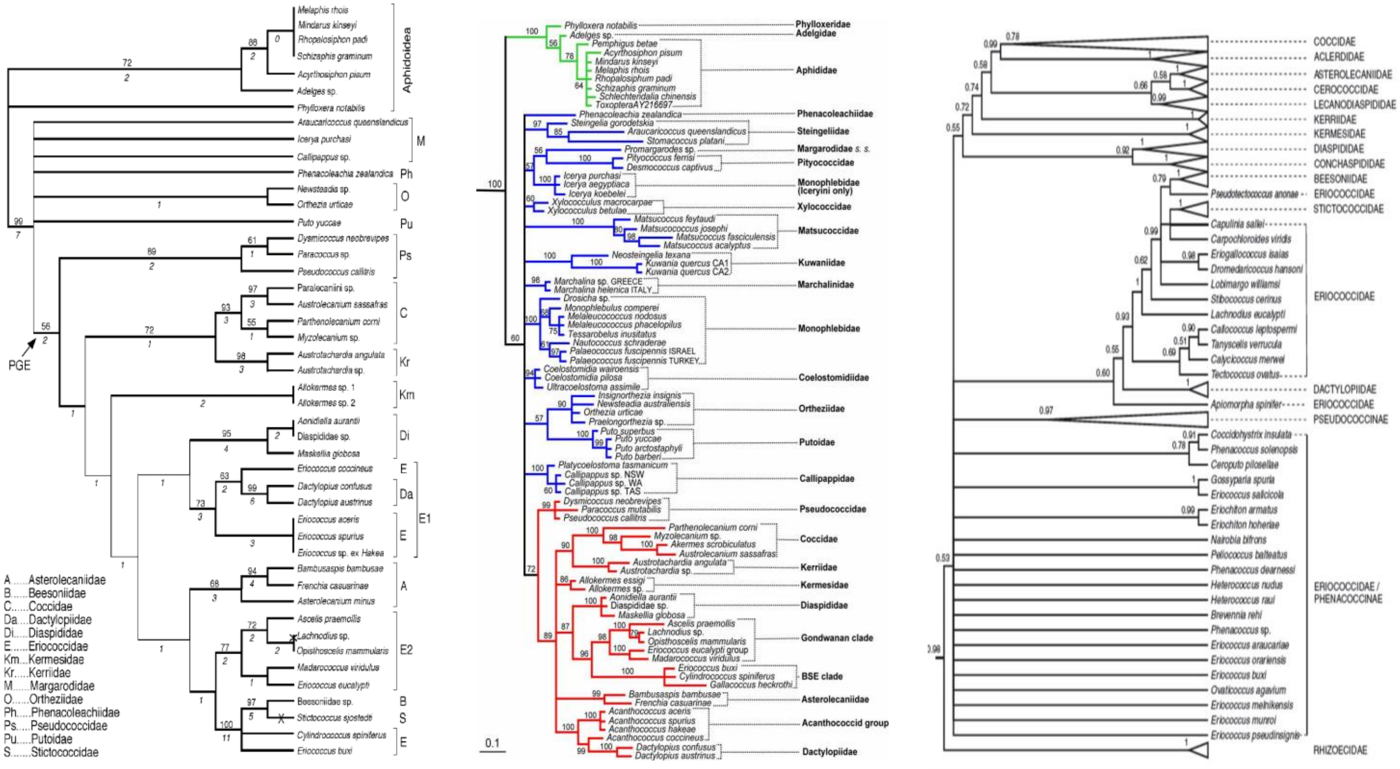

Fig. 4. Phylogenetic relationships of the superfamily Coccoidea.

(a) The first phylogenetic hypothesis based on the nuclear small subunit ribosomal RNA gene (SSU rRNA); (b) The developed phylogenetic tree using 18S and an expanded taxon set; (c) The phylogeny based on the morphology of macropterous males.

ingroup taxa comprise 5 subfamilies; Cardiococcinae, Ceroplastinae, Coccinae, Eulecaniinae and Filippiinae and 4 tribes of Coccinae; Coccini, Pulvinariini, Paralecaniini and Saissetiini of Coccidae. The outgroup taxa, *Nipponaclerda biwakoensis* (Kuwana, 1907) from Aclerdidae; *Kermes miyasakii* Kuwana, 1907 from Kermesidae; Diaspididae sp.1, Diaspididae sp.2, *Pseudaulacaspis eugeniae* (Maskell, 1892) and *Pseudaulacaspis* sp. from Diaspididae are chosen.

DNA extraction, PCR amplification, and Sequencing

Genomic DNA was extracted by a non-destructive method to further identifications, using DNeasy Blood & Tissue kit (QIAGEN, Inc., Dusseldort, Germany) and following the manufacturer's protocol. The preserved vouchers were slide-mounted according to the method given by Hodgson & Henderson (2000). All slide specimens are deposited in the College for Agriculture and Life Sciences, Seoul National University (SNU). In PCR amplification, four genes were selected as follows: mitochondrial protein coding gene (the cytochrome c oxidase subunit I gene, COI), nuclear ribosomal RNA genes (18S and 28S) and elongation factor-1α (EF-1α). Primers for amplifying each genes are given in Table 4. The thermal cycling program was performed according to protocols of each markers. The COI marker was amplified as 95℃/2 min, 5 cycles of 94℃/40s, 45℃/40s, and 72℃/70s, and 40 cycles of 94℃/40s, 51℃/40s, and 72℃/70s, followed by a final extension at 72℃/5 min. The 18S and 28S markers were conducted as 94℃/4min, 35 cycles of 55℃/30s, and 72℃/30s, followed by a final extension at 72℃/3min. The EF-1α was followed the protocol of 18S and 28S, but the annealing temperature changed to 50℃. Then, PCR products were sequenced at MACROGEN Inc (Geumcheon-Gu, Seoul, Republic of Korea).

Table 4. Primers used in the present study.

Gene regions	Direction	Primer name	Sequences (5'-3')	Annealing temperature	References
COI	Forward	ProF1	CCTTCAACTAATCATAAAAATATYAG	51℃	Park *et al*. (2010)
	Reverse	HCO	TAAACTTCAGGGTGACCAAAAAATCA		Folmer *et al*. (1994)
	Reverse	LepR1	TAAACTTCAGGGTGACCAAAAAATCA		Park *et al.* (2010)
18S	Forward	2880	CTGGTTGATCCTGCCAGTAG	55℃	Tautz *et al*. (1988)
	Reverse	Br	CCGCGGCTGCTGGCACCAGA		von Dohlen & Moran (1995)
28S	Forward	S3660	GAGAGTTMAASAGTACGTGAAAC	55℃	Dowton & Austin (1998)
	Reverse	A335	TCGGARGGAACCAGCTACTA		Whiting *et al.* (1997)
EF1-α	Forward	ScutA	ATTGTCGCTGCTGGTACCGGTGAATT	50℃	Hardy *et al*. (2008b)
	Reverse	rcM52.6	GCYTCGTGGTGCATYTCSAC		Cho *et al.* (1995)

Alignment and Characterization of Gene Fragments

Sequence assembling and editing were performed using SeqMan Pro ver. 7.1.0 (DNASTAR, Inc., Madison, WI). Sequences were aligned with MEGA software ver. 5.0 (Tamura *et al*., 2011). Each sequence data was combined using SequenceMatrix ver. 1.7.8. (Vaidya *et al*., 2010).

The complete data sets were used to Maximum likelihood and Bayesian inference analyses.

Maximum likelihood (ML) was performed with PhyML v. 3.0 (Lanave *et al*., 1984). The nodes were estimated with 100 bootstrap replications.

Bayesian inference (BI) was conducted with GTR+I+G model in MrBayes ver. 3.1.2 (Ronquist and Huelsenbeck, 2003). The BI analyses ran for 10 million Markov chain Monte Carlo (MCMC) generations. Burn-in was set at 15% of the sampled number of trees. Tracer ver. 1.4 (Rambaut and Drummond, 2003) was used to view the graphical representation of MCMC chain mixing in order to ensure that the distribution had stabilized. A 50% majority-rule consensus tree was constructed from the remaining trees to estimate posterior probabilities.

Table 5. Taxa used in this study with GenBank accession numbers.

Subfamily	Tribe	Specific Name	Host	Locality	COI	18S	28S	EF-1α
Cardiococcinae		*Dicyphococcus ficicola* Borchsenius	*Ficus microcarpa*	Kunming,Yunnan, China	KP190014	-	KP189735	-
Cardiococcinae		*Drepanococcus chiton* (Green, 1908)	*Ficus benjamina*	Taipei City, Taiwan	JX853913	JX866686	JX866699	JX965106
Ceroplastinae		*Ceroplastes ceriferus* (Fabricius, 1798)	*Ilex rotunda*	Wando-gun, Jeollanam-do, Korea	O	O	O	O
Ceroplastinae		*Ceroplastes japonicus* Green, 1921	*Pittosporum tobira*	Seogwipo-si, Jeju-do, Korea	O	O	O	O
Ceroplastinae		*Ceroplastes rubens* Maskell, 1893	*Citrus* sp.	Jeju-si, Jeju-do, Korea	O	O	O	-
Ceroplastinae		*Ceroplastes rusci* (Linnaeus)	*Ficus microcarpa*	Maoming, Guangdong, China	KP189752	-	KP189489	-
Ceroplastinae		*Ceroplastes stellifer* (Westwood, 1871)	*Mangifera indica*	Vientiane province, Laos	O	O	O	O
Coccinae	Coccini	*Coccus formicarii* (Green, 1896)	*Ficus microcarpa*	New Taipei City, Taiwan	JX853902	JX566901	JX866687	-
Coccinae	Coccini	*Coccus hesperidum* Linnaeus, 1758	*Asplenium antiquum*	Seogwipo-si, Jeju-do, Korea	O	O	O	O
Coccinae	Coccini	*Coccus pseudomagnoliarum* (Kuwana, 1914)	*Citrus* sp.	Davis, CA, USA	JX845479	JX566919	JX645352	JX965089
Coccinae	Coccini	*Coccus sp.*	*Ficus banghalensis*	Gangnam-gu, Seoul, Korea	O	O	O	O
Coccinae	Coccini	*Coccus viridis* (Green, 1889)	*Lagerstroemia* sp.	Bolikhamsai Province, Laos	O	O	O	O
Coccinae	Coccini	*Eucalymnatus* sp.	*Michelia yunnanensis*	Kunming,Yunnan, China	KP189854	-	KP189591	-
Coccinae	Coccini	*Eucalymnatus tessellatus* (Signoret)	*Trachycarpus fortunei*	Jinghong, Yunnan, China	KP189801	-	KP189535	-
Coccinae	Coccini	*Prococcus acutissimus* (Green)	*Trachycarpus fortunei*	Jinghong, Yunnan, China	KP189789	-	KP189523	-
Coccinae	Pulvinariini	*Leptopulvinaria kawaii* Tanaka & Amano, 2008	*Ilex cornuta*	Wando-gun, Jeollanam-do, Korea	O	-	O	O
Coccinae	Pulvinariini	*Megapulvinaria maxima* (Green)	*Artocarpus heterophyllus*	Puer, Yunnan, China	KP189889	-	KP189630	-
Coccinae	Pulvinariini	*Milviscutulus mangiferae* (Green, 1889)	*Plumeria obtusa*	Pingtung County, Taiwan	JX845482	JX566920	JX645355	JX965093
Coccinae	Pulvinariini	*Milviscutulus sp.*	*Mangifera indica*	Vientiane province, Laos	O	O	O	-
Coccinae	Pulvinariini	*Nipponpulvinaria horii* (Kuwana, 1902)	*Acer* sp.	Gwanak-gu, Seoul, Korea	O	O	O	O
Coccinae	Paralecaniini	*Neosaissetia tropicalis* Tao & Wong in Tao, Wong & Chang, 1983	*Palaquium formosanum*	Pingtung County, Taiwan	JX853911	JX866685	JX866697	JX965104
Coccinae	Paralecaniini	*Paralecanium expansum* (Green, 1896)	*Litsea glutinosa*	Kinmen	JX853909	JX866683	JX866695	JX965102

Coccinae	Paralecaniini	*Paralecanium frenchii* (Maskell, 1891)	*Banksia integrifolia*	Brisbane, QLD, Australia	JX853910	JX866684	JX866696	JX965103
Coccinae	Paralecaniini	*Paralecanium sp.*	*Mangifera indica*	Vientiane province, Laos	O	O	O	-
Coccinae	Saissetiini	*Parasaissetia nigra* (Nietner)	*Strelitzia reginae*	Jinghong, Yunnan, China	KP189865	-	KP189603	-
Coccinae	Saissetiini	*Parasaissetia* sp.	*Hibiscus syriacus*	Sanya, Hainan, China	KP189874	-	KP189611	-
Coccinae	Saissetiini	*Parthenolecanium corni* (Bouché, 1844)	*Platanus* sp.	Anyang-si, Gyeonggi-do, Korea	O	O	O	-
Coccinae	Saissetiini	*Parthenolecanium fletcheri* (Cockerell, 1893)	*Thuja orientalis*	Jincheon-gun, Chungcheongbuk-do, Korea	O	O	O	-
Coccinae	Saissetiini	*Parthenolecanium persicae* (Fabricius, 1776)	*Magnolia sp.*	Suwon-si, Gyeonggi-do, Korea	O	-	O	-
Coccinae	Pulvinariini	*Protopulvinaria pyriformis* (Cockerell, 1894)	*Jasminum* sp.	Crete, Greece	JX853912	JX566900	JX866698	JX965105
Coccinae	Pulvinariini	*Pulvinaria aurantii* Cockerell	*Pittosporum tobira*	Guilin, Guangxi, China	KP189810	-	KP189544	-
Coccinae	Pulvinariini	*Pulvinaria idesiae* Kuwana, 1914	*Acer* sp.	Sillim-dong, Gwanak-gu, Seoul, Korea	O	O	O	O
Coccinae	Pulvinariini	*Pulvinaria neocellulosa* Takahashi	*Ficus* sp.	Menglun, Yunnan, China	KP200686	-	KP189621	-
Coccinae	Pulvinariini	Pulvinaria photiniae Kuwana, 1914	*Styrax obassia*	Jincheon-gun, Chungcheongbuk-do, Korea	O	O	O	O
Coccinae	Pulvinariini	*Pulvinaria psidii* Maskell, 1893	*Tabebuia chrysantha*	Chiayi City, Taiwan	JX845481	JX560411	JX645354	JX965092
Coccinae	Pulvinariini	*Pulvinaria* sp.	*Cephalotaxus koreana*	Gwangyang-si, Jeollanam-do, Korea	O	O	O	O
Coccinae	Saissetiini	*Saissetia coffeae* (Walker, 1852)	*Cycas revoluta*	Seogwipo-si, Jeju-do, Korea	O	O	O	O
Coccinae	Saissetiini	*Saissetia miranda* (Cockerell & Parrott in Cockerell, 1899)	*Mangifera indica*	Chiayi County, Taiwan	JX853908	JX866682	JX866694	JX965101
Coccinae	Saissetiini	*Saissetia oleae* (Olivier)	*Capparis masaikai*	Menglun, Yunnan, China	KP189778	-	KP189512	-
Eulecaniinae		*Didesmococcus koreanus* Borchsenius, 1955	*Prunus armeniaca*	Yeongdeungpo-gu, Seoul, Korea	O	O	O	O
Eulecaniinae		*Ericerus pela* (Chavannes, 1848)	*Ligustrum obtusifolium*	Chuncheon-si, Gangwon-do, Korea	O	O	O	O
Eulecaniinae		*Eulecanium cerasorum* (Cockerell, 1900)	*Cornus officinalis*	Gwanak-gu, Seoul, Korea	O	-	O	-
Eulecaniinae		*Eulecanium kuwanai* Kanda	*Ulmus pumila*	Hefei, Anhui, China	KP189953	-	KP189681	-
Eulecaniinae		*Eulecanium* sp.	*Ulmus pumila*	Korla, Xinjiang, China	KP189940	-	KP189672	-
Eulecaniinae		*Physokermes jezoensis* Siraiwa	*Picea koraiensis*	Harbin, Heilongjiang, China	KP189989	-	KP189717	-

Eulecaniinae	*Rhodococcus sariuoni* Borchsenius	*Crataegus pinnatifida*	Cangshan, Shandong, China	KP189911	-	KP189648	-
Filippiinae	*Metaceronema japonica* (Maskell, 1897)	*Camellia japonica*	Wando-gun, Jeollanam-do, Korea	-	O	O	O
Filippiinae	*Takahashia japonica* (Cockerell, 1896)	*Lespedeza* sp.	Yeongyang-gun, Gyeongsangbuk-do, Korea	-	O	-	O
Aclerdidae	*Nipponaclerda biwakoensis* (Kuwana)	*Phragmites australis*	Linyi, Shandong, China	KP189751	-	KP189488	-
Kermesidae	*Kermes miyasakii* 2	*Castanea crenata*	Gwanak-gu, Seoul, Korea	O	O	O	O
Diaspididae	*Diaspididae* sp.1		Australia	-	-	GQ325582	GQ403938
Diaspididae	*Diaspidida* sp.2		Arizona, USA	-	-	GQ325587	GQ403947
Diaspididae	*Pseudaulacaspis* sp.		Australia	-	-	GQ325582	GQ403936
Diaspididae	*Peudaulacaspis eugeniae*		Australia	-	-	GQ325582	GQ403932

O: unpublished sequences; -: unavailable sequences

III. Result

The phylogenetic trees from Maximum Likelihood (ML) and Bayesian Inference (BI) based on molecular fragments of mitochondrial DNA, nuclear ribosomal RNA genes and elongation factor 1α (EF-1α) were compared and shown in Fig. 5-8.

The monophyletic clade of Coccidae was recovered except for *Drepanococcus* which was nested within a clade of outgroups in the BI tree (Fig. 5; Fig. 7). No subfamily is completely monophyletic except for Ceroplastinae. The monophyletic clade of the Ceroplastinae was placed in a basal position in BI tree (Fig. 7). and an intermediate in ML tree (Fig. 5). within the major clade of the Coccinae. In case of the Coccinae, relatively many exemplars formed a major clade, however some taxa, *Megapulvinaria* and *Paralecanium,* were distinctively separated from the major one of Coccinae (Fig. 6; Fig. 8). Eulecaniinae was paraphyletic because *Didesmococcus koreanus* was nested within the major clade of Coccinae from both trees (Fig. 5; Fig. 7). Filippiinae and Cardiococcinae were recovered as paraphyletic with respect to some of Coccinae and Eulecaniinae and placed in the most basal position of Coccidae although both subfamilies didn’t have sufficient exemplars (Fig. 5; Fig. 7).

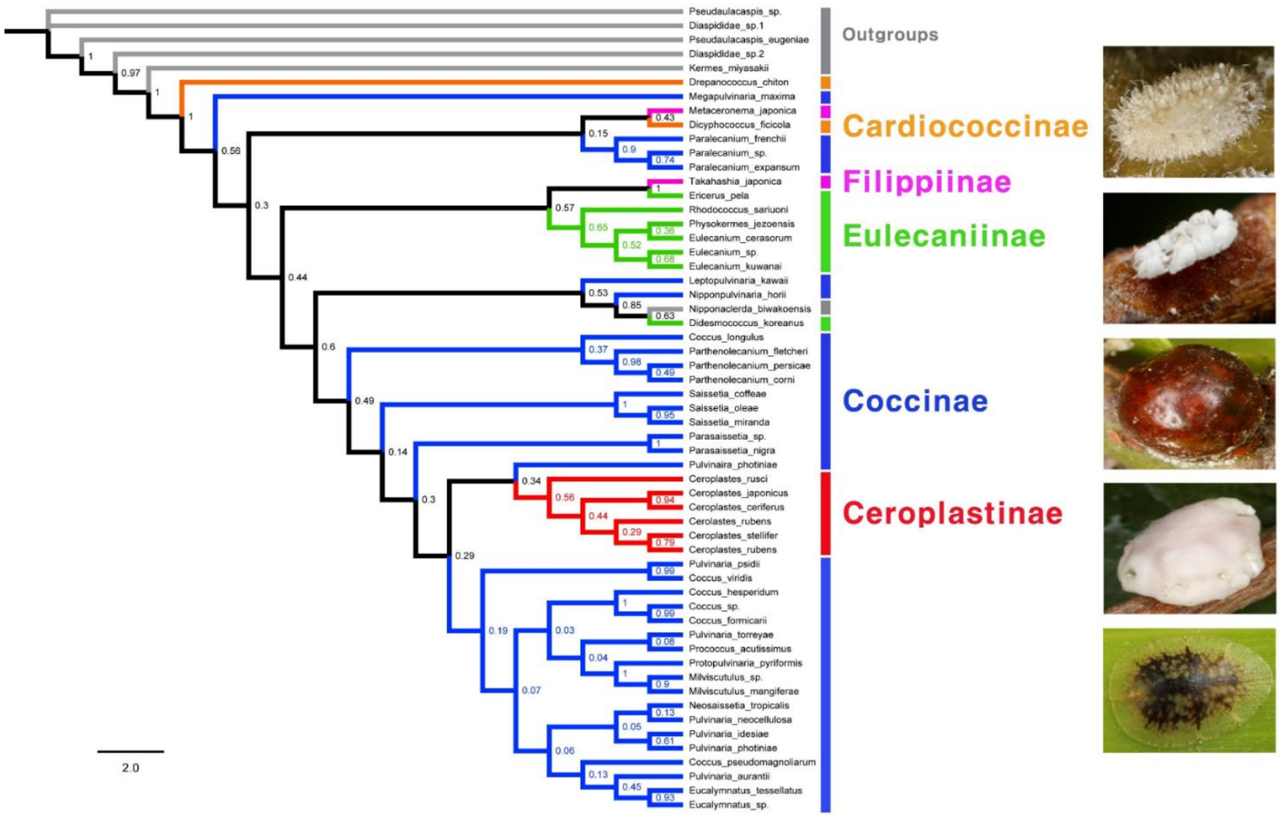

Fig. 5. Maximum likelihood tree from the combined analysis of all nuclear and mitochondrial fragments. Branches are colored by subfamilies of the family Coccidae. Numbers indicate bootstrap values for each node.

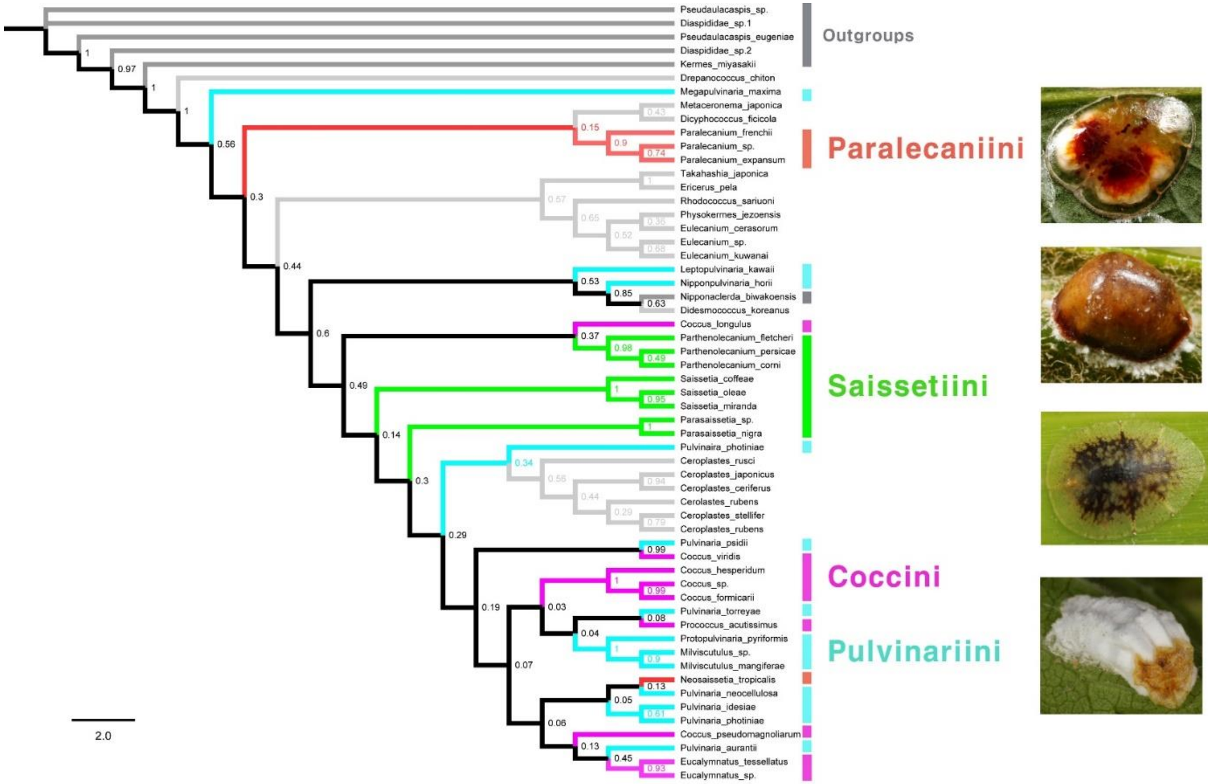

Fig. 6. Maximum likelihood tree from the combined analysis of all nuclear and mitochondrial fragments. Branches are colored by tribes of the subfamilies Coccinae. Numbers indicate bootstrap values for each node.

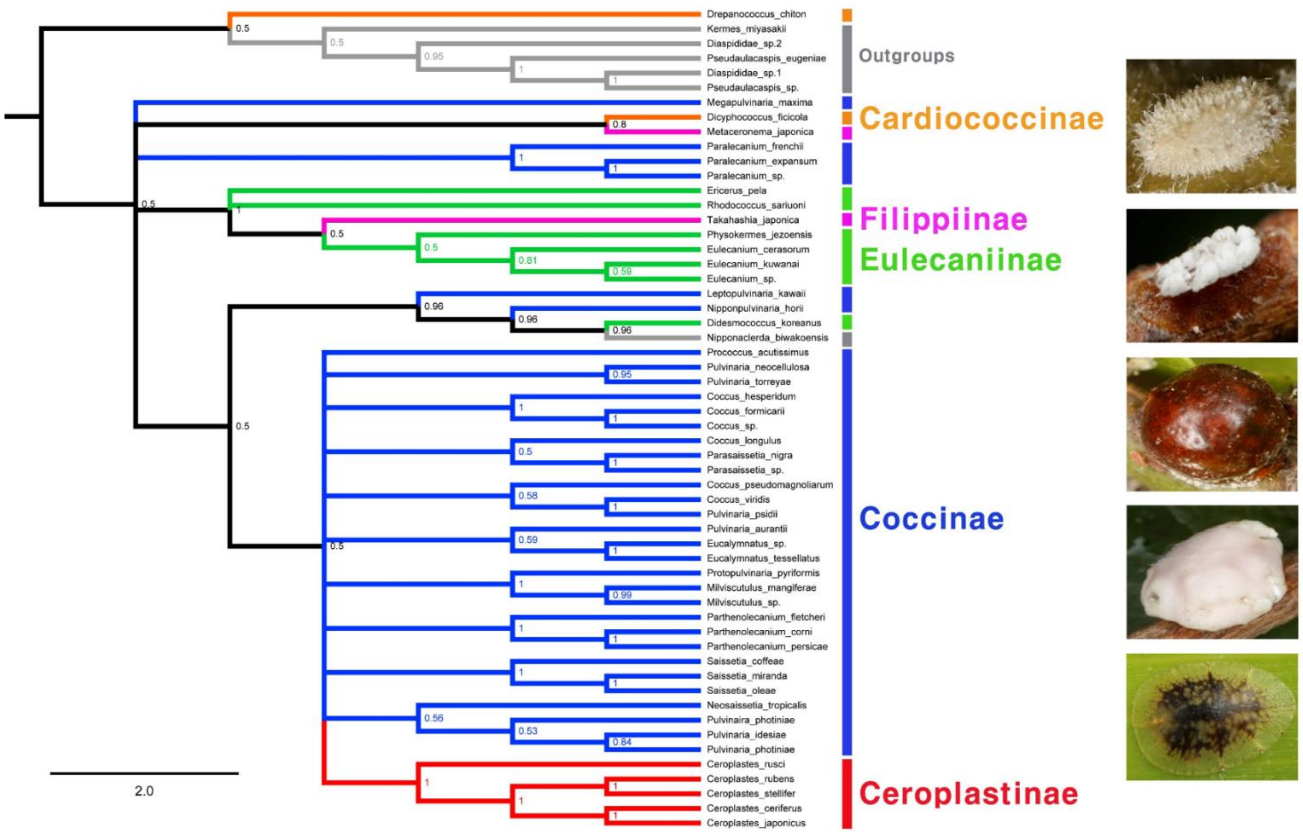

Fig. 7. Bayesian inference tree from the combined analysis of all nuclear and mitochondrial fragments. Branches are colored by subfamilies of the family Coccidae. Numbers indicate Bayesian posterior probability values.

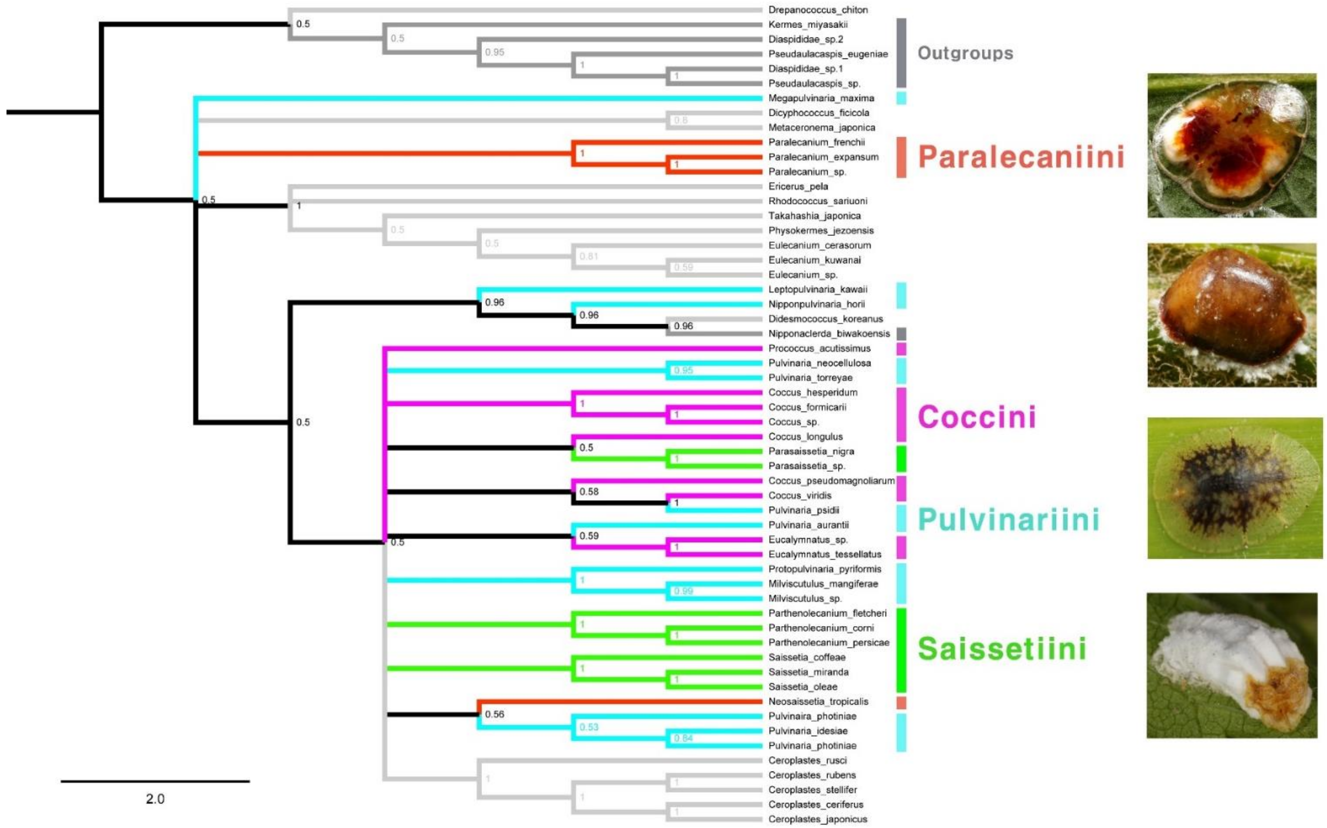

Fig. 8. Bayesian inference tree from the combined analysis of all nuclear and mitochondrial fragments. Branches are colored by tribes of the subfamilies Coccinae. Numbers indicate Bayesian posterior probability values.

IV. Discussion

The Coccidae was recovered as a monophyletic group from the two phylogenetic trees, which was identical to previous cladistic analysis (Miller & Hodgson, 1997). However, an exemplar of Aclerdidae was nested within a major clade of Coccinae (Fig. 5; Fig. 7). Miller & Hodgson (1997) also found a result that the Aclerdiae showed in the monophyletic clade of the Coccidae when Tachardiidae, Micrococcidae and Aclerdidae used as outgroups. Although our result was insufficient to define the exact relationship between the Coccidae and Aclerdidae, it was suggested that the Aclerdidae might be close to the Coccidae, which was also strongly supported by a phylogenetic study of superfamily Coccoidea (Hodgson & Hardy, 2013). Other detail relationships among subfamilies, tribes and genera were as below.

Saissetiini

Each genus *Parthenolecanium*, *Saissetia* and *Pasaissetia* of Saissetiini were monophyletic in both phylogenetic results and each monophyletic clade of genera formed a cluster in the ML tree (Fig. 6; Fig. 8). Morphologically, they share following characters: ventral tubular ducts with 1 or 2 types making a wide submarginal band; dorsal tubular ducts usually absent; dorsal tubercles and pocket-like sclerotisations typically present, but both could be absent; multilocular disc-pores each with 10 loculi, present between anal plates and thorax; eyespots located near margin; stigmatic clefts shallow and unsclerotised. The phylogenetic results implied that these morphological characters of Saissetiini are adequate for grouping the genera. The monophyly of Saissetiini was only supported by ML tree because *Parasaissetia* was nested within a major clade of Coccini in Bayesian analysis, therefore further studies need to be conducted in this tribe.

Coccini

The genus *Coccus*, *Prococcus* and *Eucalymnatus* were used for exemplars of Coccini. This tribe was apparently paraphyletic because each clades of Coccini were scattered across 4 or 5 different places and intermixed with paraphyletic clades of Pulvinariini in a major clade of Coccinae (Fig. 6; Fig. 8). The tribe Coccini was grouped by following characters: dorsal tubular ducts usually absent, if present, very rarely distributed in submargin; ventral tubular ducts absent or restricted to medial thorax; pocket-like sclerotisations absent; eyespots located near to margin; stigmatic areas unsclerotised; stigmatic spines distinct from marginal setae; multilocular disc-pores densely present on pregenital segment, but absent medial area of thorax. Although they share these morphological characters, the phylogenetic results conflicted with the previous grouping of these taxa. Further, the paraphyly of the genus *Coccus* which was referred by Lin *et al.* (2013) was identical with the result of present study and *Eucalymnatus* with 2 species were monophyletic.

Pulvinariini

The monophyletic clade of Pulvinariini which was represented by the genus *Pulvinaria, Milviscutulus, Protopulvinaria, Leptopulvinaria, Nipponpulvinaria,* and *Megapulvinaria* was not recovered, especially *Megapulvinaria* was distinctively separated from the major clade of Coccinae and sister to Cardiococcinae or Filippiinae in each phylogenetic trees (Fig. 6; Fig. 8). The tribe Pulvinariini was grouped based on following characters: a white ovisac produced by mature adult female; ventral tubular ducts with 3 or 4 types (scarcely 2) present; ovisac not covering dorsum; dorsal tubular ducts present or absent; spinose dorsal setae present; a tibio-tarsal articulatory sclerosis present; pocket-like sclerotisations absent; an eyespots located near margin; stigmatic clefts shallow and unsclerotised. The morphology of *Megapulvinaria* correspond the above characters, however they have 2 types of marginal setae and anal plates each with a discal seta and truncate spines along inner margin which are distinct from other groups of Pulvinariini. Especially, the stout spines along inner margins of anal plates is very unique in Pulvinariini as well as among all genera of Coccinae except for *Pulvinarisca* which was closely related with *Megapulvinaria*. On the other hand, most genera of Cardiococcinae and some of Filippiinae share this unique character of *Megapulvinaria.* From these evidences, we assumed that *Megapulvinaria* is not part of Coccinae and more related with Cardiococcinae or Filippiinae. The phylogenetic positon of *Pulvinarisca* is open to question because they have a high possibility of forming a distinct clade outside of Coccinae. The genus *Pulvinaria* was clearly paraphyletic in the both analyses, which showed that 3 or 4 separated clades were scattered with *Coccus* on the major clade of Coccinae. These problematic groups, the genus *Coccus* and *Pulvinaria*, and the tribe Coccini and Pulvinariini should be reclassified with comprehensive studies based on morphological and molecular data.

Paralecaniini

The genus *Paralecanium* and *Neosaissetia* were used for representing Paralecaniini in the present study. This tribe was apparently paraphyletic in that one clade of *Neosaissetia* placed within the major clade of Coccinae, whereas the other clade of *Paralecanium* was distinctively separated from the Coccinae and sister to Cardiococcinae, Filippiinae and Eulecaniinae in two phylogenetic trees (Fig. 6; Fig. 8). These molecular results was consensus with the morphological phylogeny of Miller & Hodgson (1997) who pointed out that the Paralecaniini may not belong to the Coccinae and have close relationship with Cardiococcinae (Fig. 3). According to the classification of Hodgson (1994), the 12 genera of Paralecaniini shared following characters: stigmatic cleft deep and sclerotized; eyespots located onto dorsum; ventral tubular ducts generally restricted to vulvar area; preopercular pores usually arranged in 2 bands between anal plates and anterior head. On the other hand, the three other tribes, Coccini, Pulvinariini and Saissetiini, have different characters with Paralecaniini as follows: stigmatic cleft shallow and unsclerotized; eyespots present near margin; ventral tubular ducts present submarginal area or medial abdomen, thorax and head, not restricted to prevulvar area; preopercular pores typically present in a single band anterior area of anal plates. These results suggested that the distinct characters of Paralecaniini may cause the different phylogenetic placements with the other tribes of Coccinae. In case of the closely related subfamilies, they also don't share the unique characters of Paralecaniini and have quite different morphologies. Particularly, Cardiococcinae was treated as the most distinct group in the Coccidae (Hodgson, 1994). These evidences more supported the independent identity of Paralecaniini. However, the presence of remained taxon of Paralecaniini in the clade of Coccinae left the possibility that other genera also show the phylogenetic positions like *Neosaissetia*. Morphologically, the *Neosaissetia* possesses 2-4 pairs of dorsal tubercles which are completely absent in all genera of Paraelcaniini except for *Perilecanium*. In contrast, all type genera of the three tribes in Coccinae have the dorsal tubercles although not all the species share this character. Additionally, above defined characters of Paralecaniini are weakly appeared in the *Neosaissetia*, especially anal clefts distinct, but shallow and preopercular pores restricted to anterior area of anal plates, not extending to head. It seems possible that these differences affected the phylogenetic positon of *Neosaissetia* which was placed in the clade of Coccinae and not related with *Paralecanium*. The phylogenetic result of the *Paralecanium* which is the type genus of Paralecaniini suggested that the tribe Paralecaniini should be separated from the subfamily Coccinae and elevate to the rank of an independent subfamily Paralecaninae based on the congruence of morphological and molecular analyses. However, the genus *Neosaissetia* would remain in the Coccinae and be treated as a genus of other tribes or new tribe.

Ceroplastinae

The 5 species of *Ceroplastes* which is the type genus of Ceroplstinae formed a monophyletic clade and it was nested within the major clade of Coccinae in both phylogenetic trees (Fig. 5; Fig. 7). In the cladistic analysis of Miller & Hodgson (1997), Ceroplastinae was positioned between each clade of Coccini+Pulvinariini+Saissetiini and Paralecaniini, which was roughly similar to our result in that Ceroplastinae was placed to a same clade with Coccinae (Fig. 3). Their close relationship was recognized by Giliomee (1967) who considered *Ceroplastes* as one of *Coccus*-group because of morphological similarities of the adult males. After the generic group, *Coccus*, was elevated to the subfamilies, Coccinae by Kosztarab & Kozar (1988), Tang *et al*. (1990) proposed the subfamily Ceroplastinae which was separated from the subfamily Coccinae based on the adult female. Hodgson (1994) agreed the previous argue of Giliomee (1967), however he accepted the subfamily Ceroplastinae of Tang *et al*. (1990) because of very distinctive characters of the adult females: thick wax covering dorsum of mature adult; having caudal process; derm with dorsal lobes and clear area; highly differentiated dorsal pores called as *Ceroplastes*-type pores; variable shaped and abundant stigmatic spines. The adult females of Ceroplasinae have the differentiated characters from Coccinae, whereas they also share many other characters: body usually highly convex and sclerotized (= Saissetiini of Coccinae); doral tubercle, pocket-like sclerotisation and dorsal tubular ducts absent (= some groups of Coccinae); anal plates together quadrate, with apical setae; ano-genital fold with setae present along anterior and lateral margins; marginal setae usually setose; eyespots generally present near margin(except for Paralecaniini of Coccinae); multilocular disc-pores each with 10 loculi (= some groups of Coccinae); spiracular disc-pores each with 5 loculi; ventral tubular ducts usually present; antennae each with 6-8 segments (5-9 segments in Coccinae). These evidences that Coccinae and Ceroplastinae share the morphological characters and form a monophyletic clade in molecular and morphological phylogenies suggested that Ceroplastinae should be degraded one of tribes in the subfamily Coccinae.

Eulecaniinae

The genus *Ericerus*, *Physokermes*, *Rhodococcus* as well as the type genus *Eulecanium* were clustered in a clade sister to the Coccinae in the two phylogenetic results (Fig. 5; Fig. 7). However, *Didesmococcus* was separated from the major clade and nested within the Coccinae. In the classification of Hodgson (1994), he distinguished the Eulecaniinae as 4 distinct groups: the *Eulecanium*-group, the *Sphaerolecanium*-group, the *Cryptes*-group, and the *Ericerus*-group. Among them, the *Didesmococcus* was included in the *Sphaerolecanium*-group which was considered as quite distinct from other members of the Eulecaniinae because of following characters: ventral tubular ducts absent (usually 1 or more types present); dorsal setae sharply setose (typically stout setose or spinose present); spiracular disc-pores forming wide bands; stigmatic spines differentiated from marginal setae or not. Their differences were supported by Giliomee (1967) and Boratyński (1970) who assumed this group may be more related with either *Eriopeltis*-group or the *Coccus*-group based on the adult males. In the present study, the phylogenetic result of *Didesmococcus* was identical to their predictions and it suggested that the *Sphaerolecanium*-group would be separated from the subfamily Eulecaniinae and assign to a new position through further study with the species of *Spherolecanium*. The genus *Eulecanium*, *Physokermes* and *Rhodococcus* which were treated as the *Eulecanium*-group showed a monophyletic clade sister to the *Ericerus*-group which was placed in the most basal position of the major clade of Eulecaniinae.

Filippiinae

Among two genera, *Takahashia* and *Metaceronema*, of Filippiinae, the *Takahashia* was nested within the major clade of the Eulecaniinae from the both phylogenetic trees (Fig. 5; Fig. 7). The close relationship between Eulecaniinae and Filippiinae was recognized by the cladistic analysis of Miller & Hodgson, (1997), which showed that both subfamilies were cluster in a clade or closely related lineages on the basal part of Coccidae (Fig. 3). Although the phylogenetic result implied that the *Takahashia* was related with the Eulecaniinae, it was insufficient to clarify the exact relationship between Eulecaniinae and Filippiinae because the two exemplars formed the paraphyletic clades, especially the *Takahashia* is not a typical genus of the Filippiinae. In order to get reliable results, additional taxa need to be sampled for defining their relationship.

Cardiococcinae

The two genera, *Dicyphococcus* and *Drepanococcus* were paraphyletic in the both trees (Fig. 5; Fig. 7). The clade of the *Dicyphococcus* which is one of the typical genera of the Cardiococcinae was closely sister to *Metaceronema* of Filippiinae. Morphologically, the *Dicyphococcus* more shares important characters with the *Drepanococcus,* whereas they don’t have reasonable similarity with the *Metaceronema.* These conflict results called into question the relationships of them and future work is highly needed to interpret the results.

V. Conclusion

This analyses performed by maximum likelihood and bayesian inference using mitochondrial DNA, nuclear ribosomal RNA genes and elongation factor 1α implicated preliminary hypotheses for phylogenetic relationships between subfamilies, tribes and genera of Coccidae. Although the present results are not completely consensus with the previous classification of Coccidae, we could discuss the cause of conflict results with morphological evidences and predictions of several authors. Especially, the significant results suggest as follows: Ceroplastinae may be treated as one of tribes in Coccinae; *Coccus* and *Pulvinaria* as well as their tribes are problematic groups and should be reclassified; Paralecaniini is a distinct group from Coccinae and would be elevate to the subfamily level; *Didesmococcus* is separated from Eulecaniinae and may need a new position. In order to answer the unresolved questions and understand comprehensive relationships within Coccidae, additional taxa and informative genes should be included in further study.

PART III. Genetic diversity and cryptic species of brown soft scales, *Coccus hesperidum* (Hemiptera: Coccidae) revealed by molecular analyses

Abstract

The brown soft scales, *Coccus hesperidum* (Linnaeus, 1758) is one of the serious agricultural pests in the family Coccidae, particularly on *Citrus* spp. and various greenhouse crops. Ironically, *C. hesperidum* has a cosmopolitan distribution and an extremely wide range of host plants, despite the very low dispersal abilities. Their wide geographic distribution may be explained by human mediation or an unrevealed cryptic diversity. In order to investigate above questions, we analyses the genetic patterns of *C. hesperidum* populations collected from South Korea, Lao PDR and USA with available sequences of various geographical populations. In the results, all populations were grouped into three distinct clades with ~9% of high genetic divergence levels. In the major clades, their genetic divergence was observed regardless of geographical distances and/or host plant differences. Based on the results of molecular analyses, we propose cryptic species of *C. hesperidum*, and explain that a worldwide distribution of *C. hesperidum* is closely related to human mediated transport.

I. Introduction

The modern taxonomy based on morphological characters has been used to describe and delimitate numerous species (Dunn, 2003). However, this concept has a limitation to clarify species boundaries when species complex not only having variable characters but also sharing morphological similarities (Lefébure, 2006). These ambiguity made the species complex subdivided as different species or treated as single one when the different characters were considered as one of morphological variations. For that reason, the species with high morphological variation have a taxonomic history that synonymizing many resemble species with primary one (Kosztarab & Kozár, 1988). Recently, cryptic species which are two or more species that are considered as a single species by traditional taxonomy have been rescued by new molecular tools, especially, a fraction of mitochondrial DNA, COI, which provides a high resolution result for molecular taxonomy and relatively high genetic divergence of intraspecies as well as interspecies (Pfenninger & Schwenk, 2007; Galtier et al., 2009). In general, cryptic species have frequently found from species which have wide distribution, highly polyphagy and low dispersal ability (Andersen et al., 2010; Gwiazdowski *et al.*, 2011; Pérez-Portela *et al.*, 2013). Under these conditions, strong divergent selection may drives speciation according to different host plants and local environments (Bush, 1969; Via, 2001; Drès & Mallet, 2002). The brown soft scale, *Coccus hesperidum* (Linnaeus, 1758) is the one of the most widespread species extending to almost biogeography (Williams & Kosztarab, 1972). Also, this species is highly polyphagous feeder and have numerous records of host plants belonging to about 133 families, particularly diverse ornamental plants originated from tropical or subtropical areas (Gill *et al*., 1977; Ben-Dov *et al*., 2014). High variability of morphology have been observed in the species. Morphological variations include not only superficial appearances, body shapes and color, but also taxonomically important characters, positions of dorsal or ventral tubular ducts, sizes of a tibio-tarsal sclerosis, and shapes of anal plates (Hodgson, 1994). For that reason, the list of synonyms for *C. hesperidum* is very long, consisting of over 20 names (Ben-Dov, 1993; Ben-Dov *et al*., 2014). This species has an ecological controversy that an organism with a limited dispersal ability successfully could become a cosmopolitan species. Their global spreading may be related with human activities, mainly an export or import of the horticultural products among diverse countries (AIPH statistic, 1998). The individuals transferred to each regions have been exposed to different climates and maintained distinct gene pools through the isolated populations on specific places (Mayr, 1963; Queiroz, 1992). In other words, *C. hesperidum* has a high possibility to possess their concealed genetic diversity and cryptic species, which were overlooked by the morphological taxonomy.

Here, we perform molecular analyses of Cytocrome oxidase subunit I *COI* for populations from various geographical regions. From the analyzed genetic patterns of populations, we purpose to assess genetic diversity of *Coccus hesperidum* and discover cryptic species which have high molecular distances.

II. Materials and methods

Sample collection

A total of 209 individuals from 56 different localities were used in analyses. Among them, 193 individuals were collected in Korean peninsula (n=161), Lao PDR (n=20) and USA (n=12). In addition, 16 sequences of various geographical populations downloaded from NCBI.

DNA extraction and sequencing

In total, 193 samples of *C. hesperidum* were used for extracting DNA using a DNeasy Blood & Tissue kit (QIAGEN, Inc., Dusseldort, Germany) and following protocol of the manufacturer. The primers ProF1, 5' CCTTCAACTAATCATAAA AATATYAG 3', and LepR1, 5' TAAACTTCTGGATGTCCAAAAAATCA 3', or CocR6, 5' AATTATTGTGATTCCTCTTG 3' were used to amplify a fragment of the COI mitochondrial gene. Using AccuPowerH PCR PreMix (BIONEER, Corp., Daejeon), the DNA fragments were amplified in a total volume of 20 μl including 0.4 μM of each primer, 20 μM dNTPs, 20 μM MgCl2, and 0.05 μg template DNA. PCR reaction was performed by following procedure: a denaturation at 95℃ for 2 min, followed by 5 cycles at 94℃ for 40s, 45℃ for 40s, and 72℃ for 70s, then 40 cycles at 94℃ for 40s, 51℃ for 40s, and 72℃ for 70s, and a final extension at 72℃ for 5 min. Each PCR product showing a single band on a 1.5% agarose gel during electrophoresis were purified using a QIAquick PCR purification kit

(QIAGEN, Inc.), and then sequenced with an automated sequencer (ABI Prism 3730 XL DNA Analyzer) at © MACROGEN LIC.

Molecular analyses

All sequences for molecular analyses were edited with SeqMan Pro ver. 7.1.0 (DNASTAR, Inc., Madison, WI), and then aligned using MEGA software ver. 5.0 (Tamura *et al*., 2011). In order to compare sequences from other countries, we retrieved 16 COI sequences of the known *C. hesperidum* from the the GenBank. Using DnaSP ver. 5, COI haplotypes of each species were analyzed (Rozas *et al*., 2003). Maximum likelihood (ML) was performed with PhyML v. 3.0 (Lanave *et al*., 1984). The nodes were estimated with 1000 bootstrap replications. Genetic divergences between phylogenetic clades were calculated using MEGA based on the Kimura-2-Parameter (K2P) model (Kimura, 1980). Analyses of the molecular variance (AMOVA) with haplotype frequencies were conducted by Arlequin v. 3.5 (Excoffier & Lischer, 2010), which is for analyzing the molecular variations in populations.

III. Results

A total of 209 samples from 56 different populations were sequenced for molecular analyses. All analyzed sequences of COI (Cytochrome c Oxidase subunit I) with a length of 444 bp revealed 19 haplotypes including 7 (37%) private ones (Table 6).

Phylogenetic tree based on Maximum Likelihood (ML) constructed from all fragments of the COI separated the haplotypes of *Coccus hesperidum* into three distinct clades (named clades A, B, and C) with high node values (Fig. 9). The K2P-distances between each clade showed that high genetic divergences of interclades ranged from a 6.6 to 7.6% between clades A and B, 8.1-9.1% between clades B and C, and 6.6 to 9.7% between clades A and C. Whereas intraclades genetic divergences indicated low ranges from 0 to 2.1% in clades A, 0% in clades B, and 0 to 4.2% in clades C (Table 7).

A haplotype network constructed with the all sequences divided into three clades which was supported by phylogenetic tree (Fig. 10). Clade A showed high diversities of the COI haplotype and localities, including 13 haplotypes of the analyzed 158 samples which was from 48 different localities. Among the haplotypes in clade A, most samples had H1 and H2 types, and H9 presents geographic diversity containing almost continents except for East-Asia. One the other hands, clade B appeared very simple diversity of the haplotype which was from the only locality from Laos. Intermediate haplotypes also not existed between clad A and B. Clade C contained 5 haplotypes including 3 intermediate ones, which was from 8 different localities in Korea. Although the haplotype network distinctively separated to the three clades, it did not infer that the haplotypes had no correlation with geographies and host plants.

Pairwise Fst values revealed that Laos and some of Korea were obviously distinct from the other populations, each with one and five haplotypes respectively (Table. 9).

IV. Discussion

The molecular analyses of mitochondrial genes for *Coccus hesperidum* revealed the presence of haplotype diversity and cryptic species with high intraspecific genetic divergences. The genetic diversity of *Coccus hesperidum* is the result of exposures to many different kinds of geographical environments and adaptations to a sessile lifestyle as plant feeders on diverse hosts because they are cosmopolitan and polyphagous species (Gullan & Kosztarab, 1997). However, each haplotypes was not grouped by the related geographies and host plants as well as Korean populations showed irregular genetic patterns of 15 haplotypes with high molecular divergences (Fig. 10). Especially, some haplotypes (H 2, H 8 and H 9) of Korean populations were identical to ones of USA, UK, Europe, Taiwan and China regardless of physical or geographical distances. Those results of the species with a low dispersal ability were caused by human activities accompanied with export or import of agricultural or horticultural products. Also, the diverse haplotypes in Korean populations means the presence of multiple introductions of *Coccus hesperidum* because most ornamental products including tropical or subtropical plants were imported from other countries. Above all, the exogenous plants were grown indoors, *Coccus hesperidum* which was feeding the host was not effected by natural environments.

Although *C. hesperidum* have been regarded as one species only based on morphology, the results of molecular analyses provide an evidence to separate species. In *C. hesperidum* populations, 13 haplotypes belonged to clade A which showed the highest diversity of the haplotype and localities (Table 6). However, H 13 and 4 private haplotypes in clade C, and H 3 in clade B were distinctively separated to the haplotypes in clade A with high divergence levels (Table 7; Fig. 10). In order to define the boundary of genetic divergence to distinguish species, we analyzed the interspecific distances in the genus *Ceroplastes* of the family Coccidae. As a result, the total interspecific divergences ranged from 3.3 to 8.9% between each species in the genus *Ceroplastes*, especially the lowest value showed the range from 3.3 to 4.8 between *C. ceriferus* and *C. pseudoceriferus*. From the comparison with the genus *Ceroplastes*, we observed the intraspecific divergences of *C. hesperidum* exceeded the interspecific distances of other species. That is to say, our result implicated the presence of cryptic species in the complex populations of *C. hesperidum*.

Table 6. Haplotype localities with values of frequencies and genetic diversities.

Clade	Locality	Code	N	NH	Haplotypes	HD	ND	Tajima's D	Fu's Fs
A	Africa	AF	1	1	H10	-	-	-	-
	Asia	AS	139	12(3)	H1, H2, H4, H5, H6, H7, H8, H9, H10, H11, H18, H19	0.752±0.024	0.006±0.001	0.063	-0.078*
	Europe	EU	4	2	H2, H9	0.5±0.265	0.005±0.002	-0.780	2.197
	North America	NA	12	2	H2, H9	0.485±0.106	0.004±0.001	1.633	4.240
	Australia	OC	2	2(1)	H9, H12	1.0±0.5	0.007±0.003	-	-
	Total A		**158**	**13(4)**		**0.776±0.02**	**0.007±0.0004**	**0.102**	**-0.163***
B	Asia	AS	20	1	H3	0	0	-	-
C	Asia	AS	31	5(4)	H13, H14, H15, H16, H17	0.245±0.101	0.007±0.003	-1.845*	3.068
Total			**209**	**19**		**0.847±0.012**	**0.034±0.003**	**0.858**	**14.285**

N, number of analysed individuals, NH, number of haplotypes, HD, haplotype diversity, ND, nucleotide diversity, HR, haplotype richness (*significant at $P < 0.05$)

Table 7. Percentage of genetic divergence (based on K2P-distances) between clades of *C. hesperidum* and two *Ceroplastes* species for the COI region.

	Clade A	**Clade B**	**Clade C**
Clade A	0 - 2.1%	-	-
Clade B	6.6 - 7.6%	0%	-
Clade C	6.6 - 9.7%	8.1 – 9.1%	0 - 4.2%
C. stellifer	19.5 - 21.0%	20.7%	19.5 - 21.0%
C. japonicas	22.2 - 23.2%	23.5%	20.1 - 22.5%

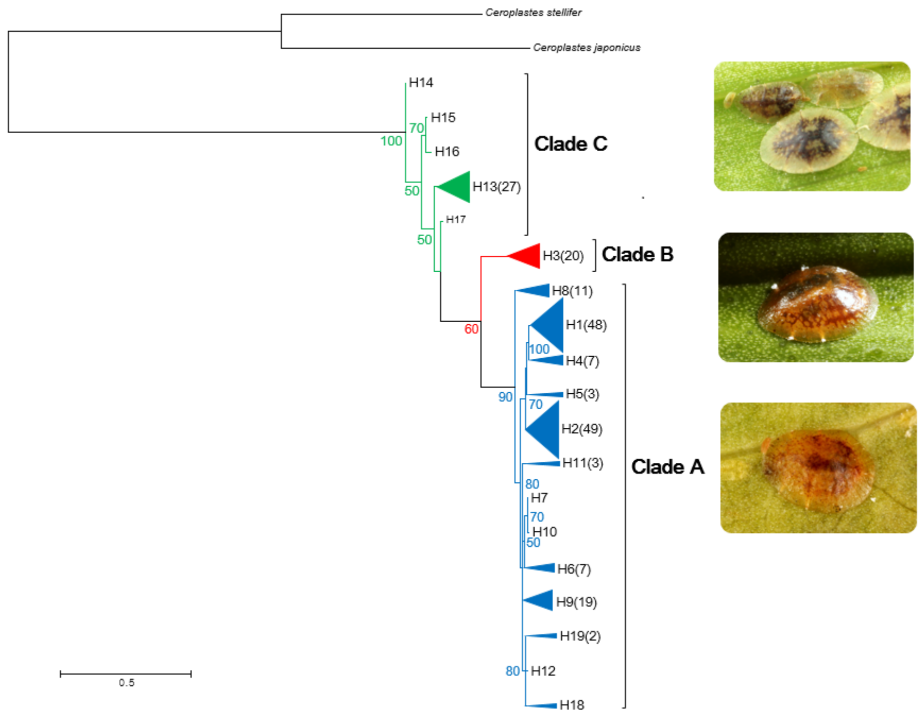

Fig. 9. Maximum likelihood tree for all mtDNA haplotypes of *C. hesperidum*. All haplotypes are grouped into three distinct clades A (blue), B (red) and C (green). Branch topography supported by bootstrap values more than 50% is shown. The number in bracket indicates the number of individuals sharing identical haplotypes.

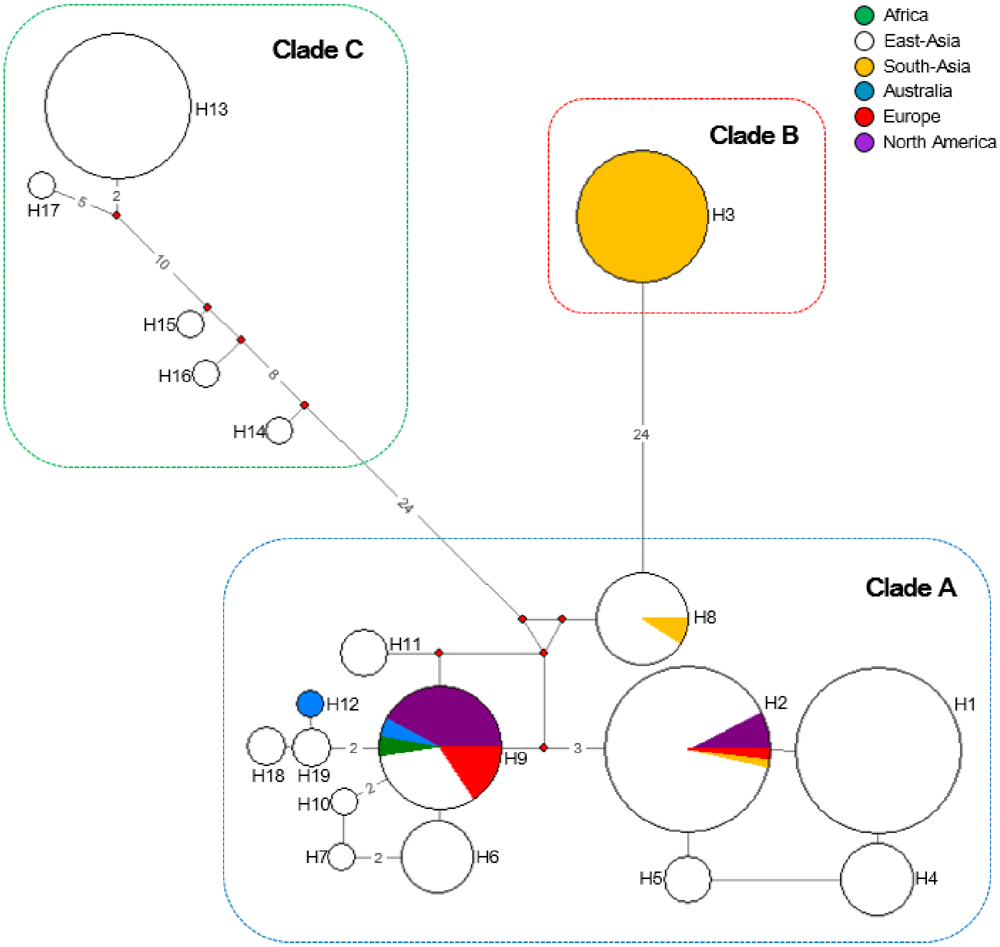

Fig. 10. Haplotype network for *Coccus hesperidum* from COI data. Each circle indicates a unique haplotype. The colour represents the locality of sample and size is proportional to the number of individuals. Pie charts inside the circles show the frequency of each local population. The numbers in the middle of lines exhibit the number of mutations between haplotypes, if one mutational step, the number is absent.

Table 8. AMOVA results of *C. hesperidum.*

Source of variation		Sum of squares	Variance components	Percentage variation
	Among groups	1300.422	15.176	89.571 (FCT= 0.896, p < 0.001)
Phylogenetic clades	Among populations within groups	25.745	0.510	3.011 (FSC= 0.289, p <0.001)
	Within populations	252.588	1.257	7.417 (FST= 0.926, p < 0.001)
	Among groups	442.805	7.486	62.2 (FCT= 0.622, p = 0.265)
Geographical region	Among populations within groups	2.441	-1.532	-12.73 (FSC= -0.337, p = 0.555)
	Within populations	1234.664	6.082	50.53 (FST= 0.495, p < 0.001)

Table 9. Pairwise Fst values between phylogenetic clades of *C. hesperidum* for *COI* region.

	AF	AU	NA	SA1	EA1	EU	SA2
AU	-1.000	-					
NA	-0.455	0.071	-				
SA1 (Taiwan)	0.001 >	0.001>	0.282	-			
EA1 (Korea & China)	0.215	0.179	0.238*	-0.030	-		
EU (Greece, Spain & UK)	-1.000	-0.081	-0.180	0.245	0.232	-	
SA2 (Laos)	1.000*	0.936*	0.812*	0.936*	0.480*	0.922*	-
EA2 (Korea)	0.755	0.675	0.675*	0.675*	0.429*	0.710*	0.854*

AF, Africa, AU, Australia, NA, North America, SA, Southeast Asia, ES, East Asia, EU, Europe (*significant at $P < 0.05$)

Conclusion

In the taxonomic study of the family Coccidae, a total of thirty-eight species of nineteen genera were reviewed in the Korean Peninsula, containing six new records, *Leptopulvinaria kawaii* Tanaka & Amano, *Parthenolecanium fletcheri* (Cockerell), *Pulvinaria hydrangeae* Steinweden, *P. idesiae* Kuwana, *P. photiniae* Kuwana, and *Saissetia Miranda* (Cockerell & Parrott). Keys to subfamilies, diagnosis and descriptions for all Korean species were redescribed with illustrations, photographs, and other ecological information.

The Phylogenetic study of the family Coccidae indicated that any subfamily is not completely monophyletic except for Ceroplastinae which is clustered within the major clade of Coccinae. Four tribes of the Coccinae are paraphyletic except for Saissetiini in ML tree. Especially, Coccini and Pulvinariini are highly scattered. *Megapulvinaria* and *Paralecanium* which are sister to Cardiococcinae or Filippiinae are distinctively separated from the clade of Coccinae. Also, *Didesmococcus* is separated from clade of Eulecaniinae and nested within the clade of Coccinae.

Analyzing the genetic patterns of *C. hesperidum* revealed high degree of COI haplotype diversity and two cryptic species. Phylogenetic tree based on Maximum Likelihood (ML) separated all haplotypes of *Coccus hesperidum* into three distinct clades. A haplotype network also divided the sequences into three clades. In addition, the K2P-distances showed that high genetic divergences among interclades.

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Appendix I. Living appearances of Korean Coccidae species

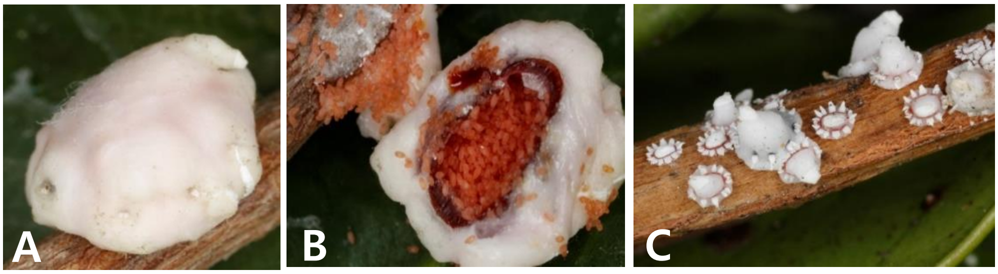

Fig. 11. *Ceroplastes ceriferus* (Fabricius, 1798) 뿔밀깍지벌레
Mature adult female (A); Eggs stored under venter (B); Population of nymphs (C).

Fig. 12. *Ceroplastes floridensis* Comstock, 1881
Mature adult female (A); Population of adult females (B); Population of nymphs (C).

Fig. 13. *Ceroplastes japonicus* Green, 1921 거북밀깍지벌레
Mature adult female (A); Population of adult females (B); Population of nymphs (C).

Fig. 14. *Ceroplastes rubens* Maskell, 1893 루비깍지벌레
Mature adult female (A); Population of adult females (B); Population of nymphs (C).

Appendix I. Living appearances of Korean Coccidae species

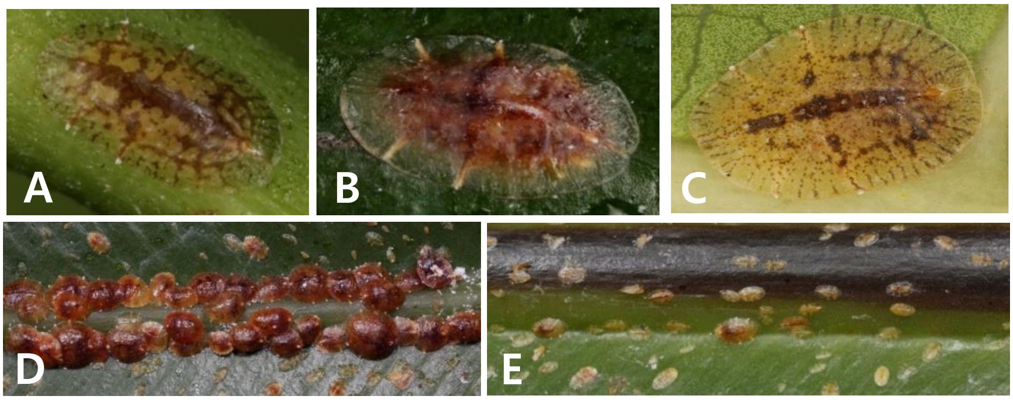

Fig. 15. *Coccus hesperidum* Linnaeus, 1758 무화과깍지벌레
Mature adult female (A-C); Population of adult females (D); Population of nymphs (E).

Fig. 16. *Coccus pseudomagnoliarum* (Kuwana, 1914) 어리목련깍지벌레
Mature adult female (A-B); Population of the first instar nymphs (C).

Fig. 17. *Leptopulvinaria kawaii* Tanaka & Amano, 2008
Mature adult female with ovisac (A); Immature adult female (B); Population of adult females (C).

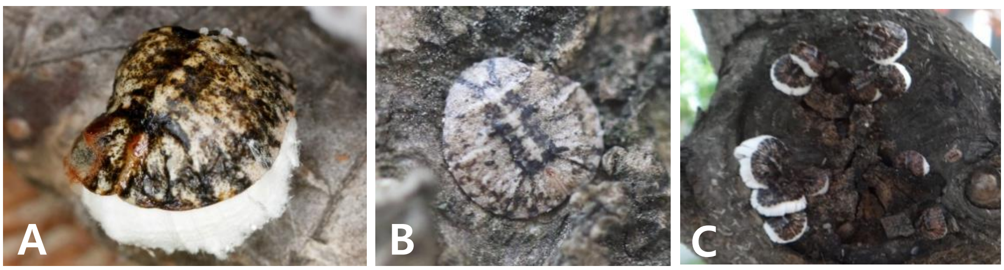

Fig. 18. *Nipponpulvinaria horii* (Kuwana, 1902) 단풍공깍지벌레
Mature adult female with ovisac (A); Immature adult female (B); Population of adult females (C).

Appendix I. Living appearances of Korean Coccidae species

Fig. 19. *Pulvinaria nipponica* Lindinger, 1933 무궁화솜깍지벌레
Mature adult female with ovisac (A); Immature adult female (B); Population of adult females (C).

Fig. 20. *Pulvinaria hydrangeae* Steinweden, 1946
Mature adult female with ovisac (A-B); Population of adult females (C).

Fig. 21. *Pulvinaria idesiae* Kuwana, 1914
Mature adult female with ovisac (A); Eggs in ovisac (B); Immature adult female (C).

Fig. 22. *Pulvinaria nishigaharae* (Kuwana, 1907) 노랑솜깍지벌레
Mature adult female (A); Eggs stored under venter (B); Population of adult female (C).

Appendix I. Living appearances of Korean Coccidae species

Fig. 23. *Pulvinaria photiniae* Kuwana, 1914
Mature adult female with ovisac (A); Immature adult female (B); Population of adult females (C).

Fig. 24. *Takahashia japonica* (Cockerell, 1896) 줄솜깍지벌레
Mature adult female with ovisac (A); Immature adult female (B); Population of adult females (C).

Fig. 25. *Parthenolecanium corni* (Bouché, 1844) 말채나무공깍지벌레
Mature adult female (A); Immature adult female (B); Population of adult females (C).

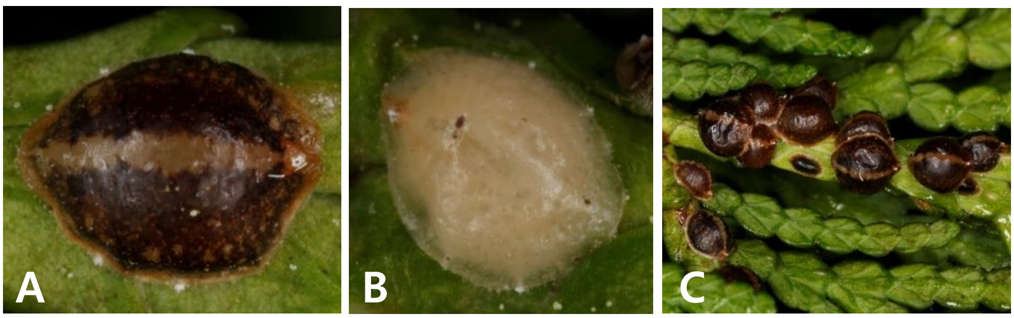

Fig. 26. *Parthenolecanium fletcheri* (Cockerell, 1893)
Mature adult female (A); Immature adult female (B); Population of adult females (C).

Appendix I. Living appearances of Korean Coccidae species

Fig. 27. *Parthenolecanium persicae* (Fabricius, 1776) 복숭아공깍지벌레
Mature adult female (A); Immature adult female (B); Population of adult females (C).

Fig. 28. *Saissetia coffeae* (Walker, 1852) 철모깍지벌레
Mature adult female (A); Immature adult female (B); Eggs stored under venter (C).

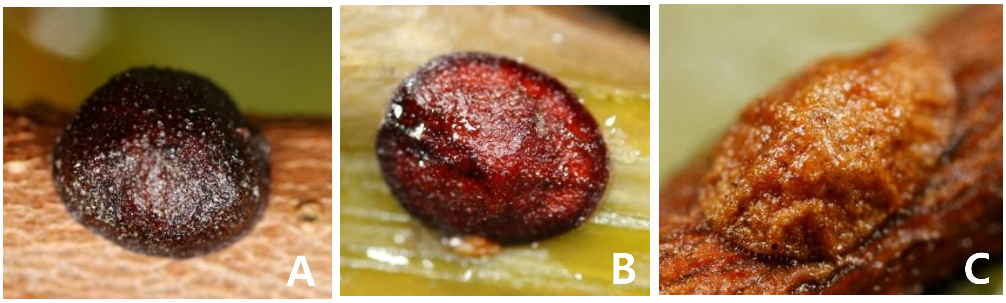

Fig. 29. *Saissetia miranda* (Cockerell & parrott, 1899)
Mature adult female (A); Immature adult female (B-C).

Fig. 30. *Didesmococcus koreanus* Borchsenius, 1955 진공깍지벌레
Mature adult female (A); Immature adult female (B-C).

Appendix I. Living appearances of Korean Coccidae species

Fig. 31. *Ericerus pela* (Chavannes, 1848) 쥐똥밀깍지벌레
Mature adult female (A); Immature adult female (B); Mass of white wax of male nymphs

Fig. 32. *Eulecanium cerasorum* (Cockerell, 1900) 포도공깍지벌레
Mature adult female (A-B); Eggs stored under venter (C).

Fig. 33. *Metaceronema japonica* (Maskell, 1897) 과자깍지벌레
Mature adult female (A-B); Population of adult females (C).

Appendix II. Illustration of adult females

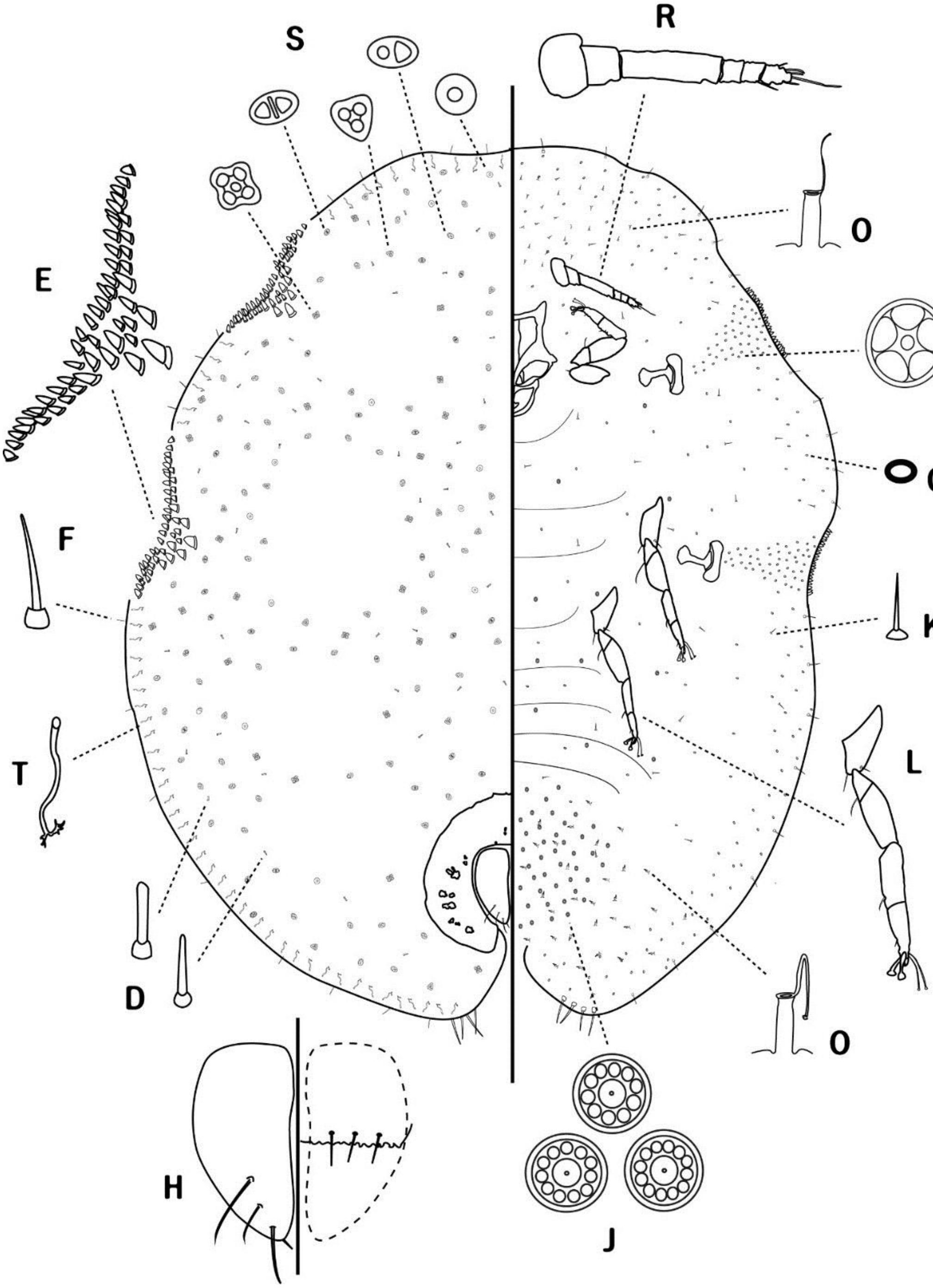

Fig. 34. *Ceroplastes ceriferus* (Fabricius, 1798)

Appendix II. Illustration of adult females

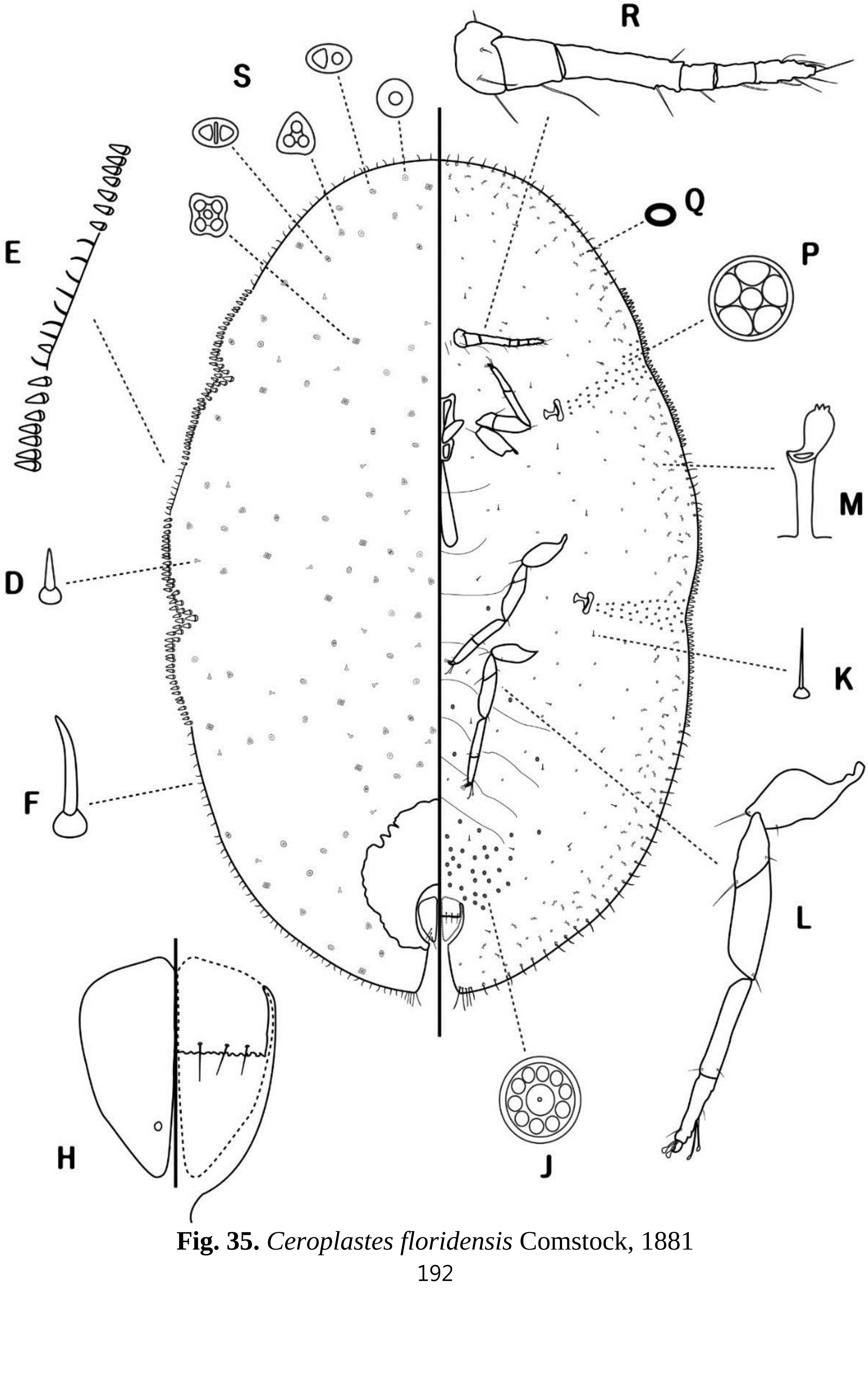

Fig. 35. *Ceroplastes floridensis* Comstock, 1881

Appendix II. Illustration of adult females

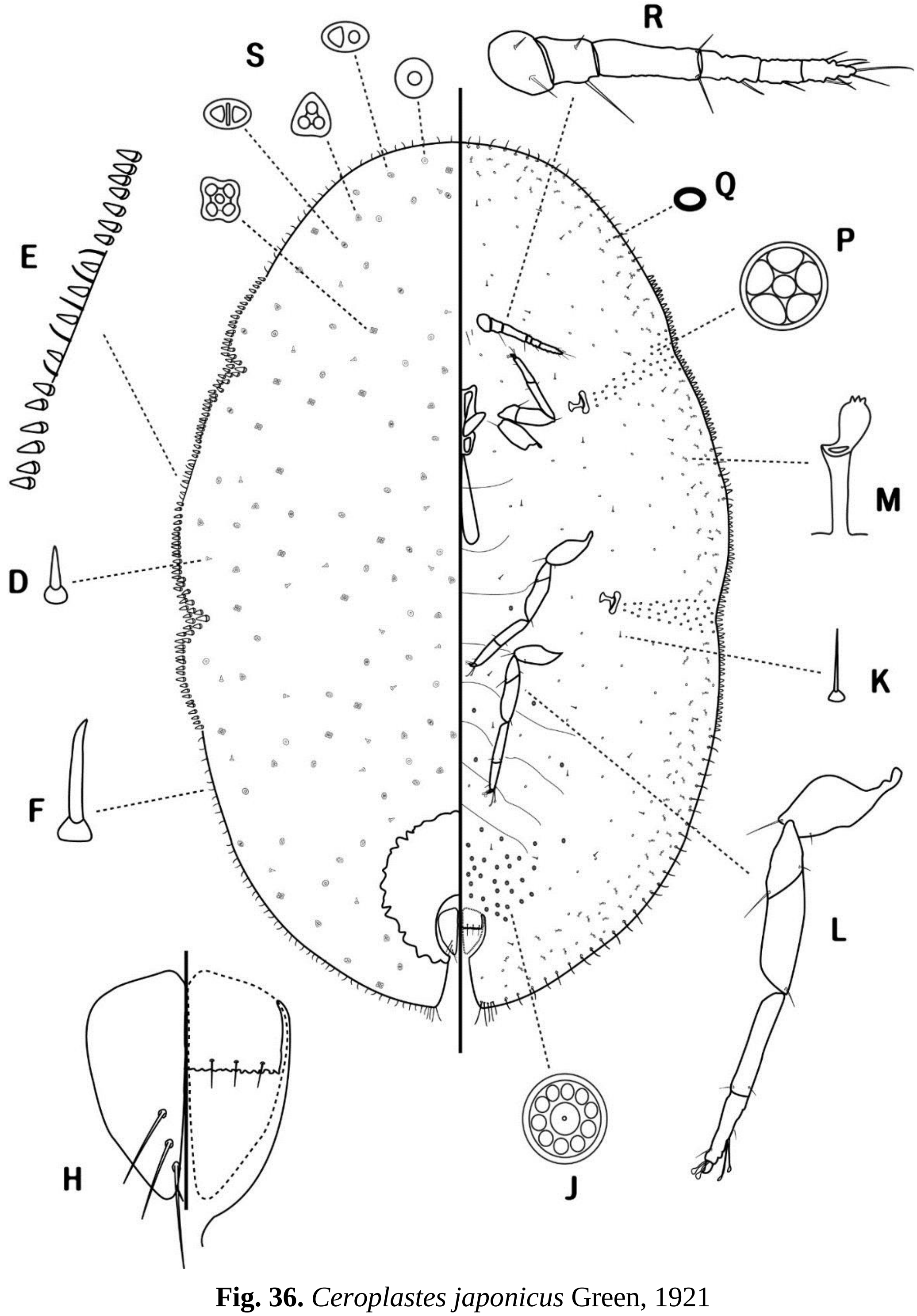

Fig. 36. *Ceroplastes japonicus* Green, 1921

Appendix II. Illustration of adult females

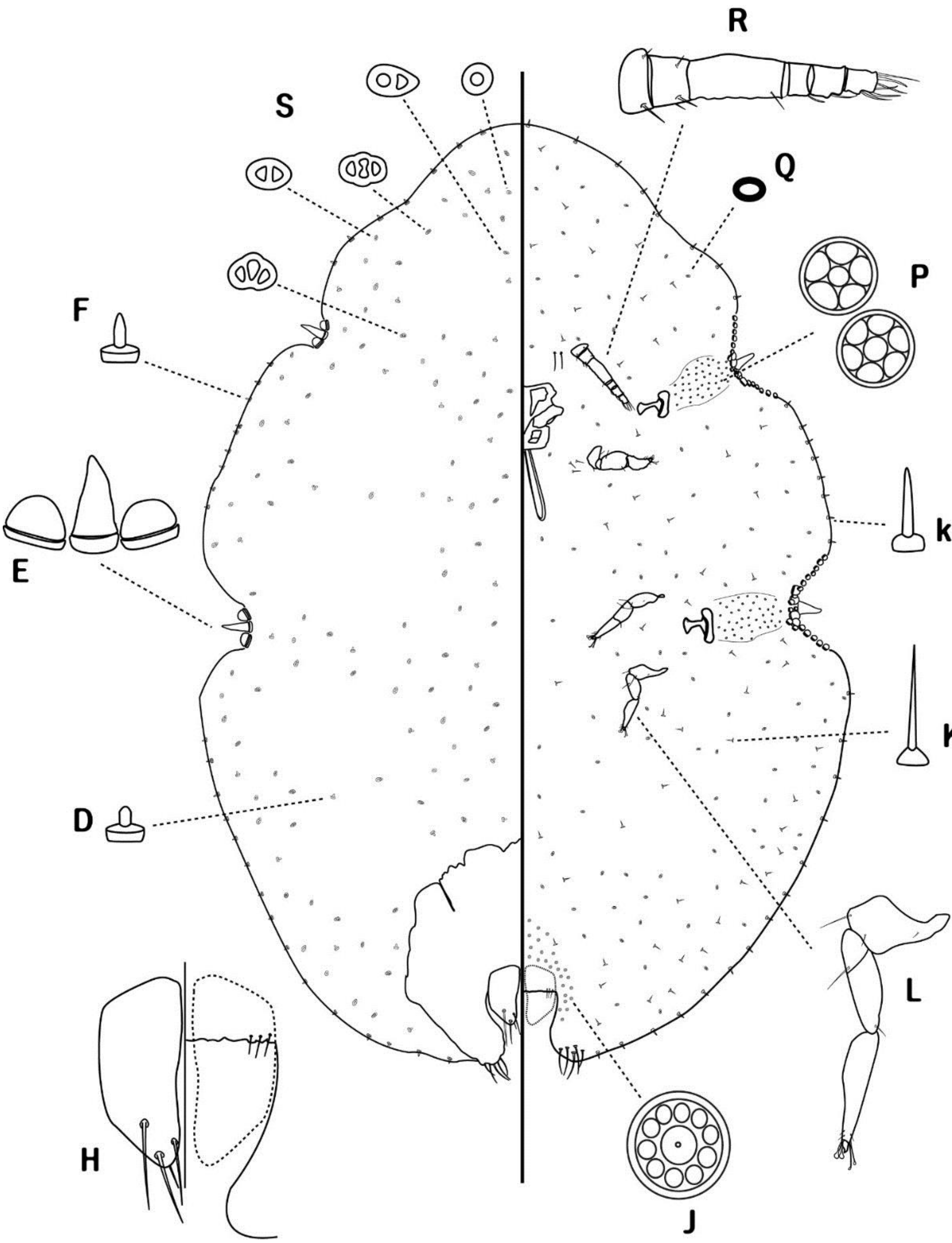

Fig. 37. *Ceroplastes rubens* Maskell, 1893

Appendix II. Illustration of adult females

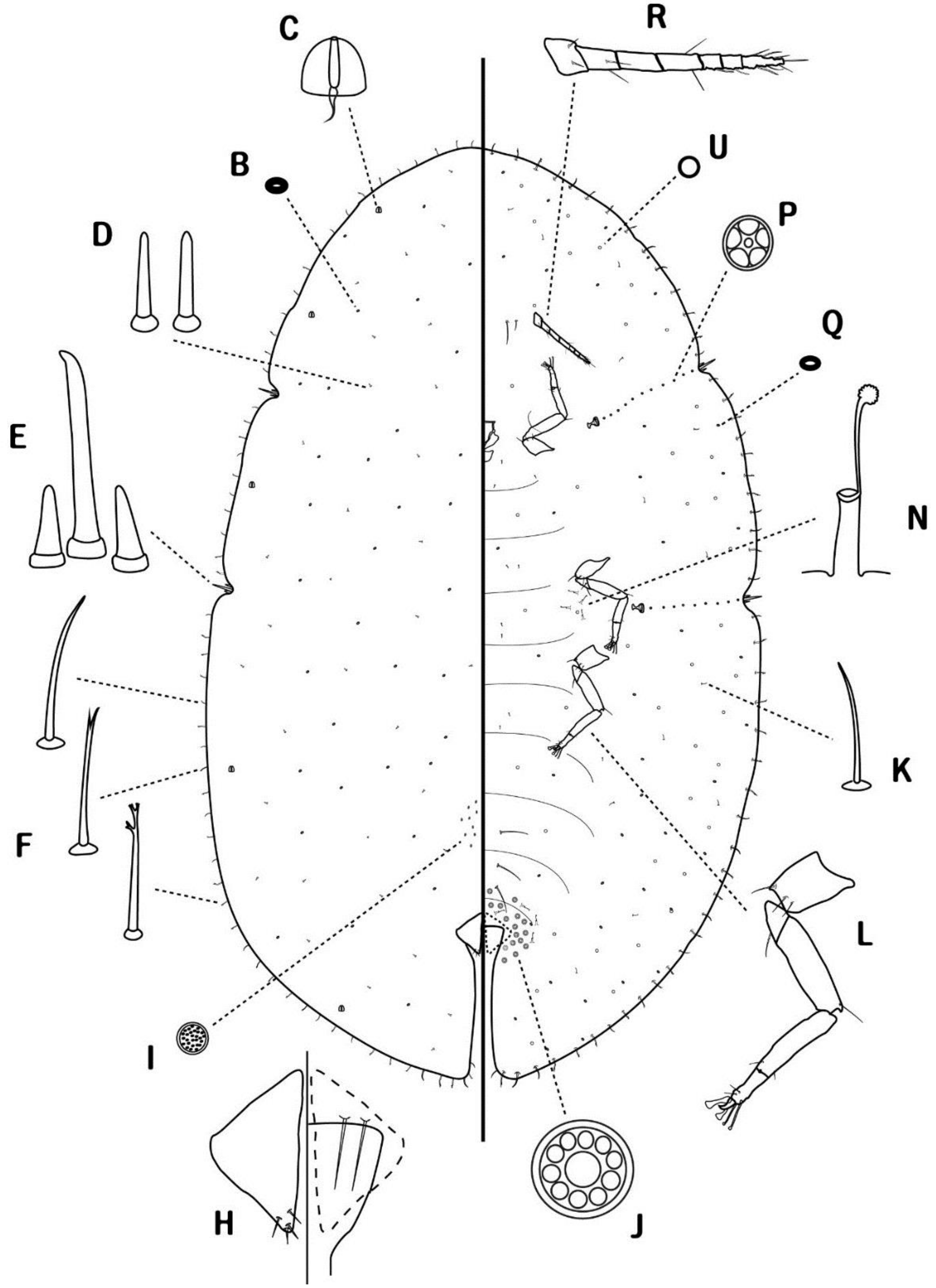

Fig. 38. *Coccus hesperidum* Linnaeus, 1758

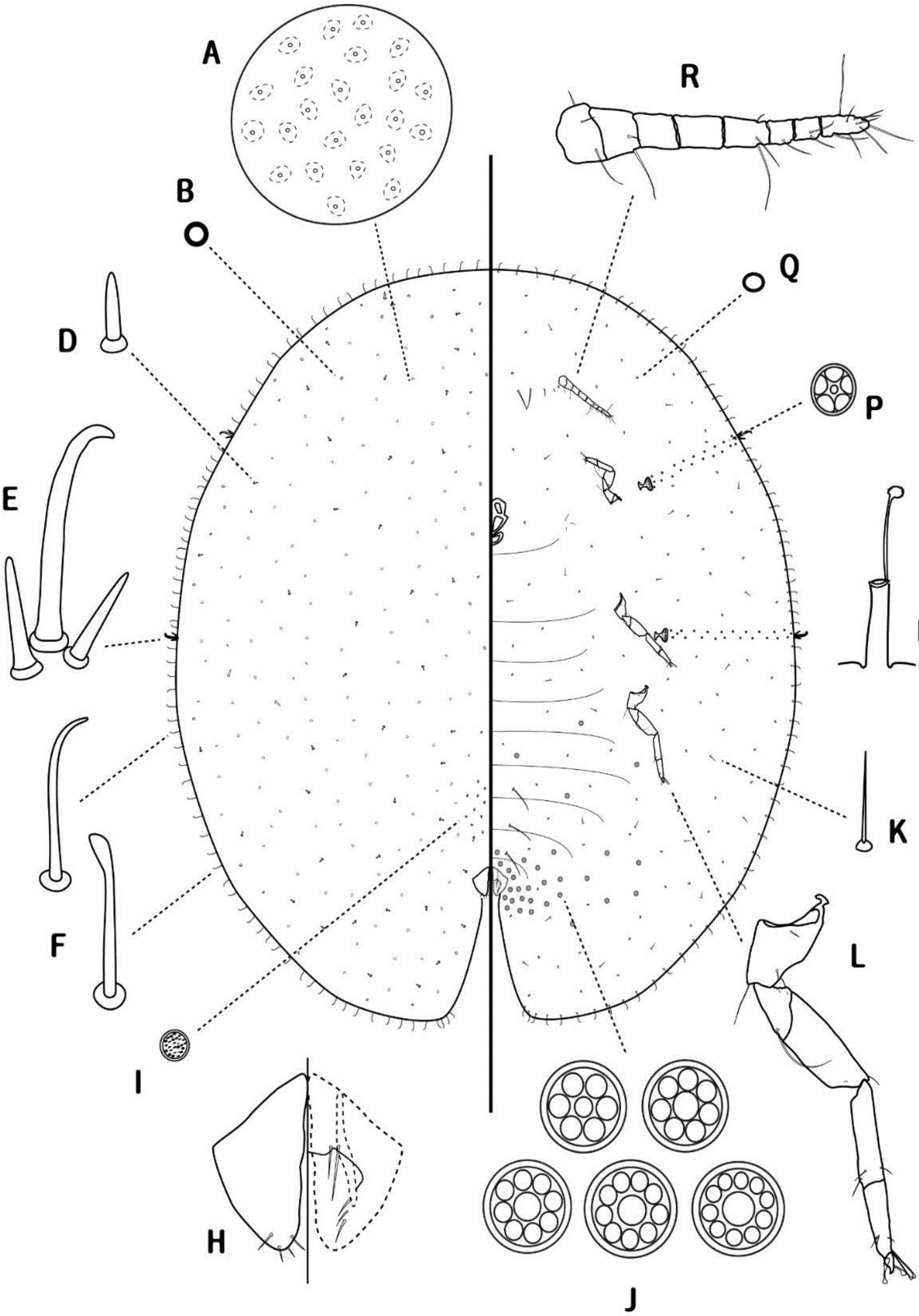

Fig. 39. *Coccus pseudomagnoliarum* (Kuwana, 1914)

Appendix II. Illustration of adult females

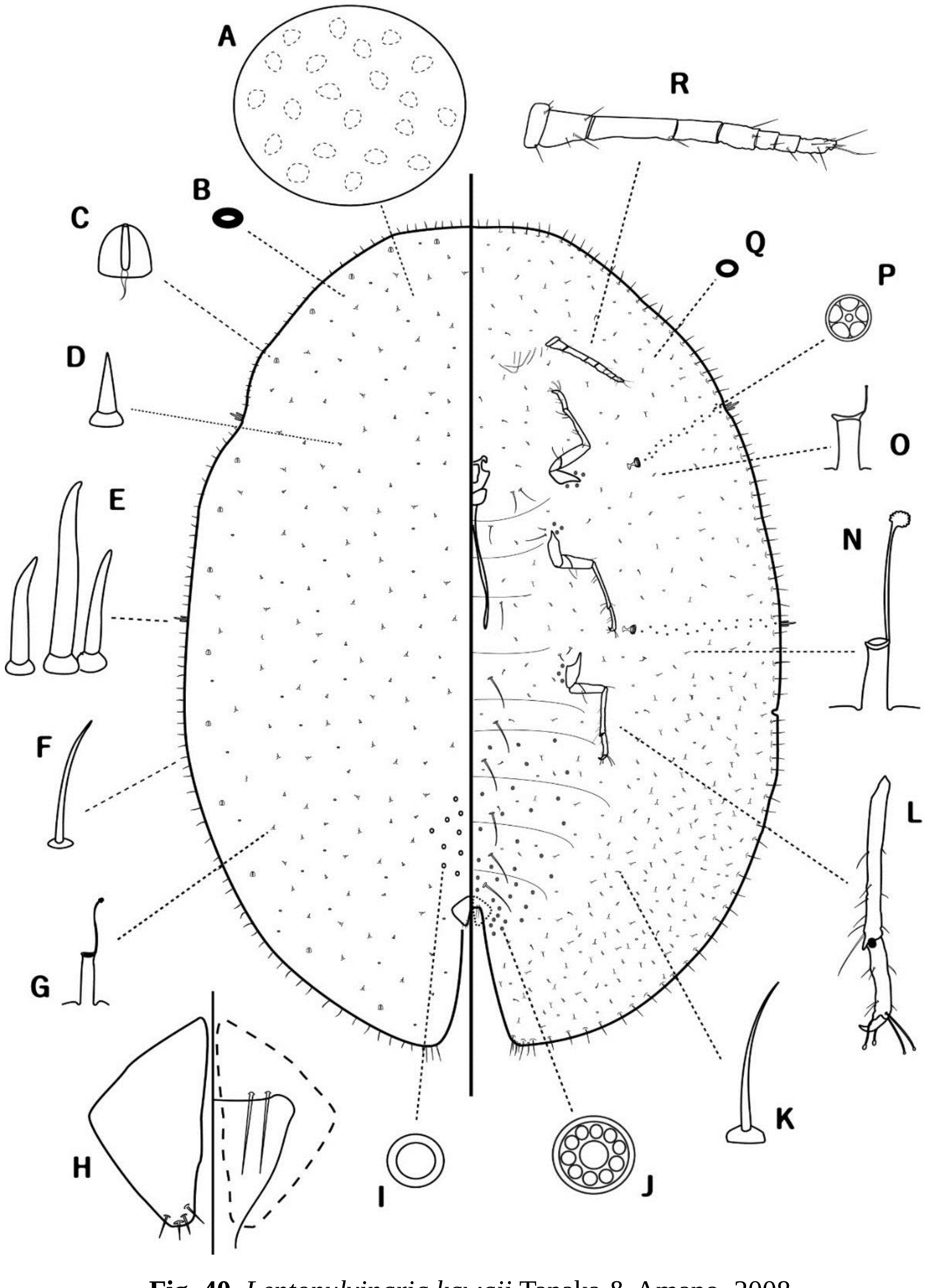

Fig. 40. *Leptopulvinaria kawaii* Tanaka & Amano, 2008

Appendix II. Illustration of adult females

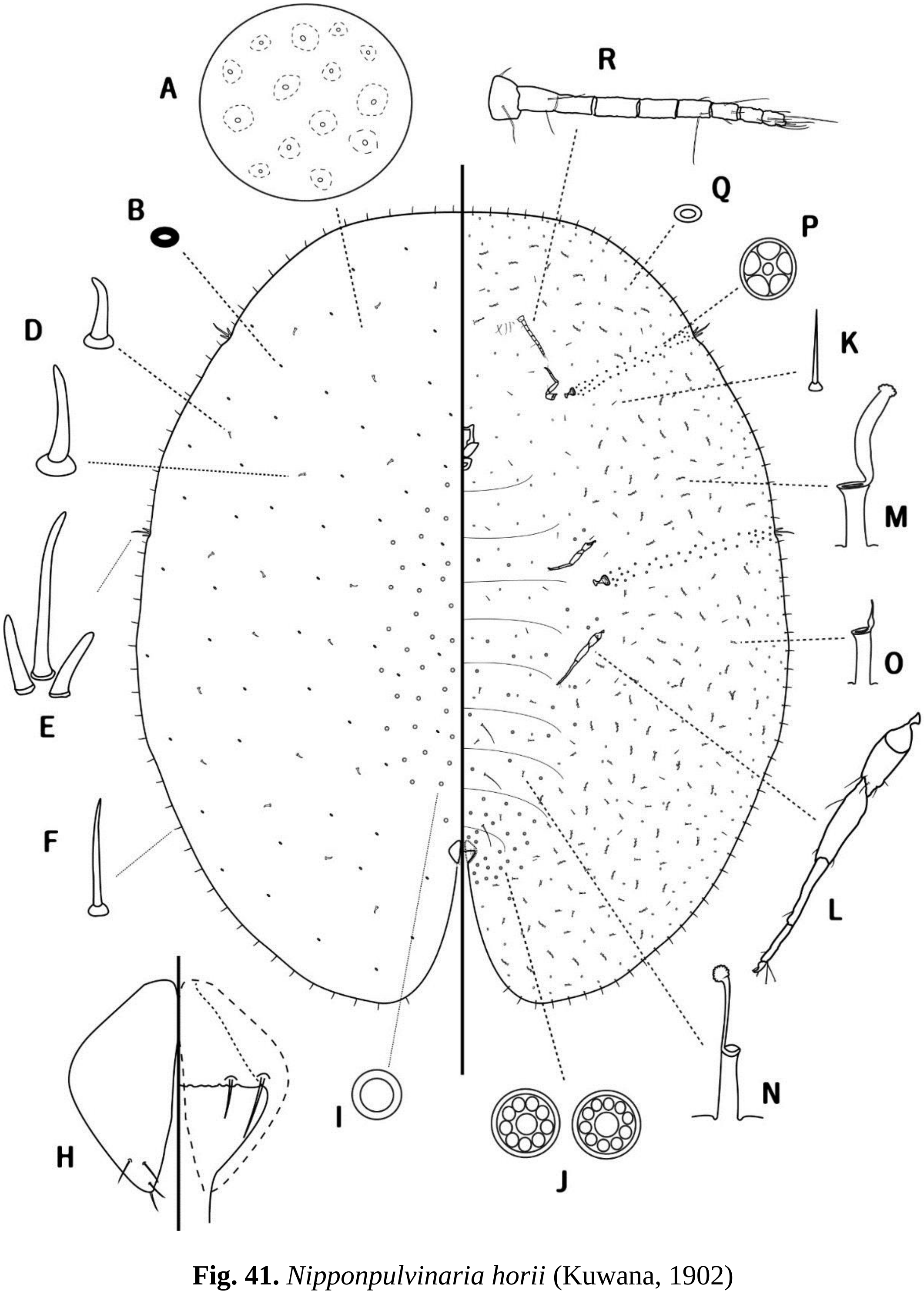

Fig. 41. *Nipponpulvinaria horii* (Kuwana, 1902)

Appendix II. Illustration of adult females

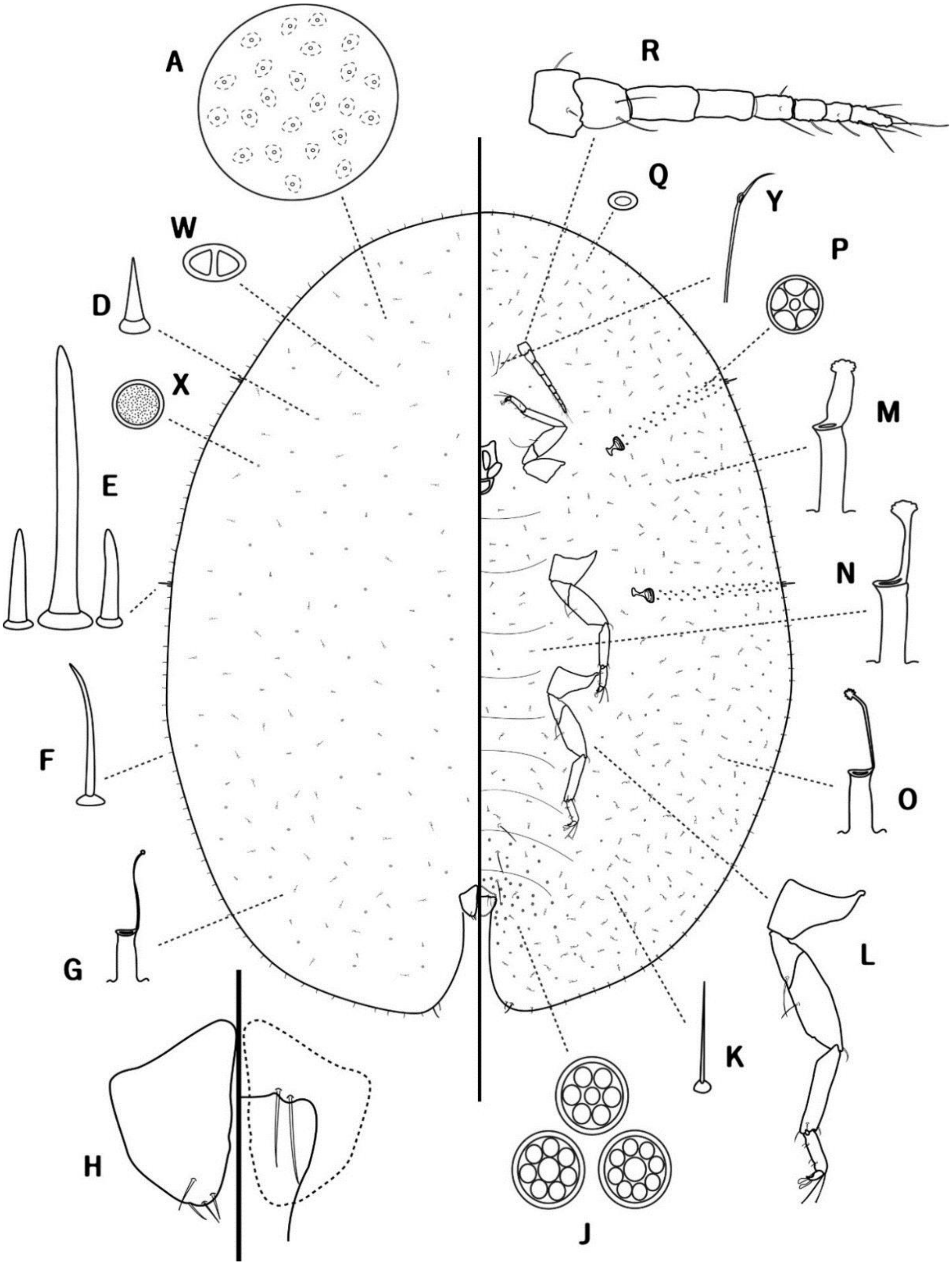

Fig. 42. *Pulvinaria nipponica* Lindinger, 1933

Appendix II. Illustration of adult females

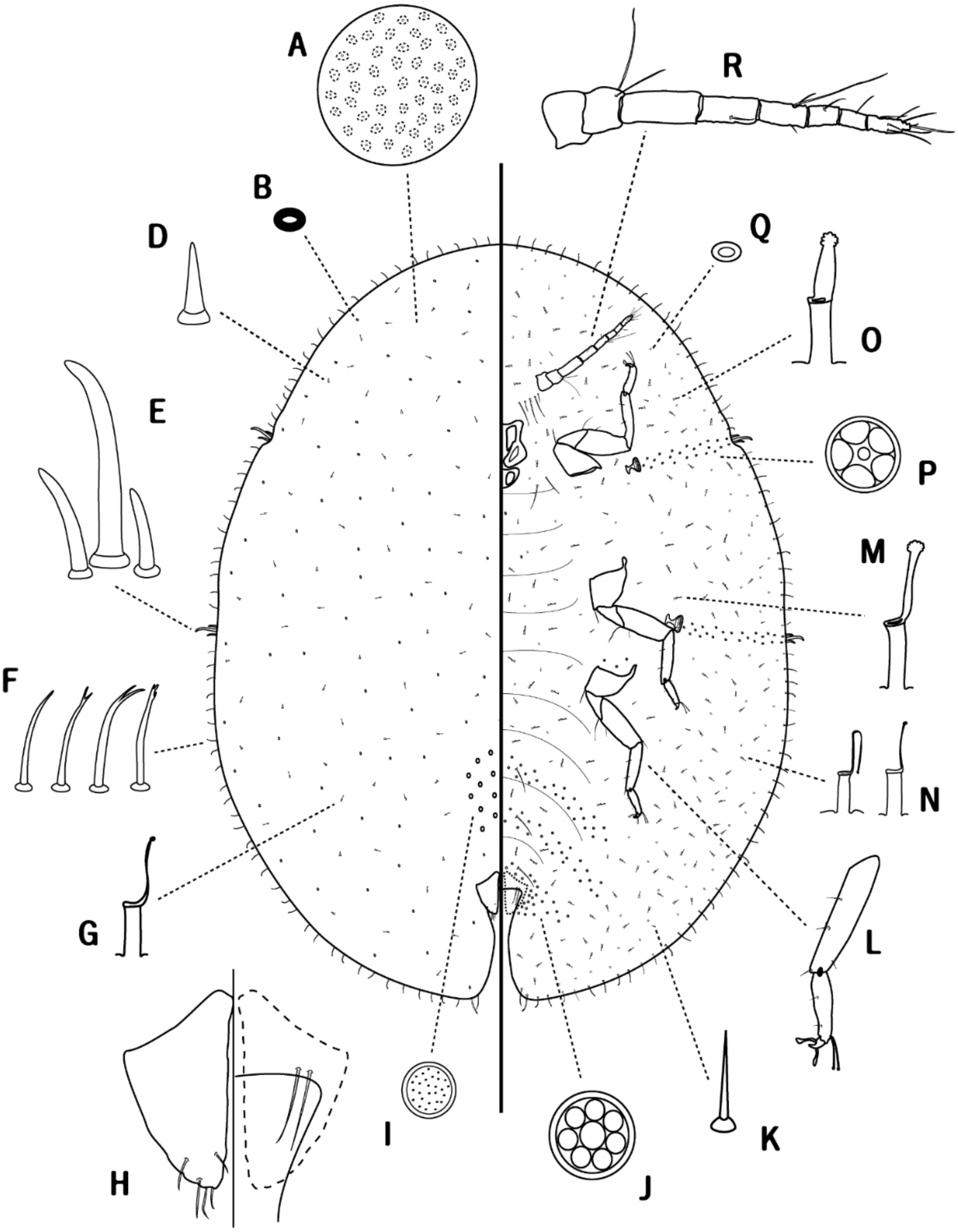

Fig. 43. *Pulvinaria hydrangeae* Steinweden, 1946

Appendix II. Illustration of adult females

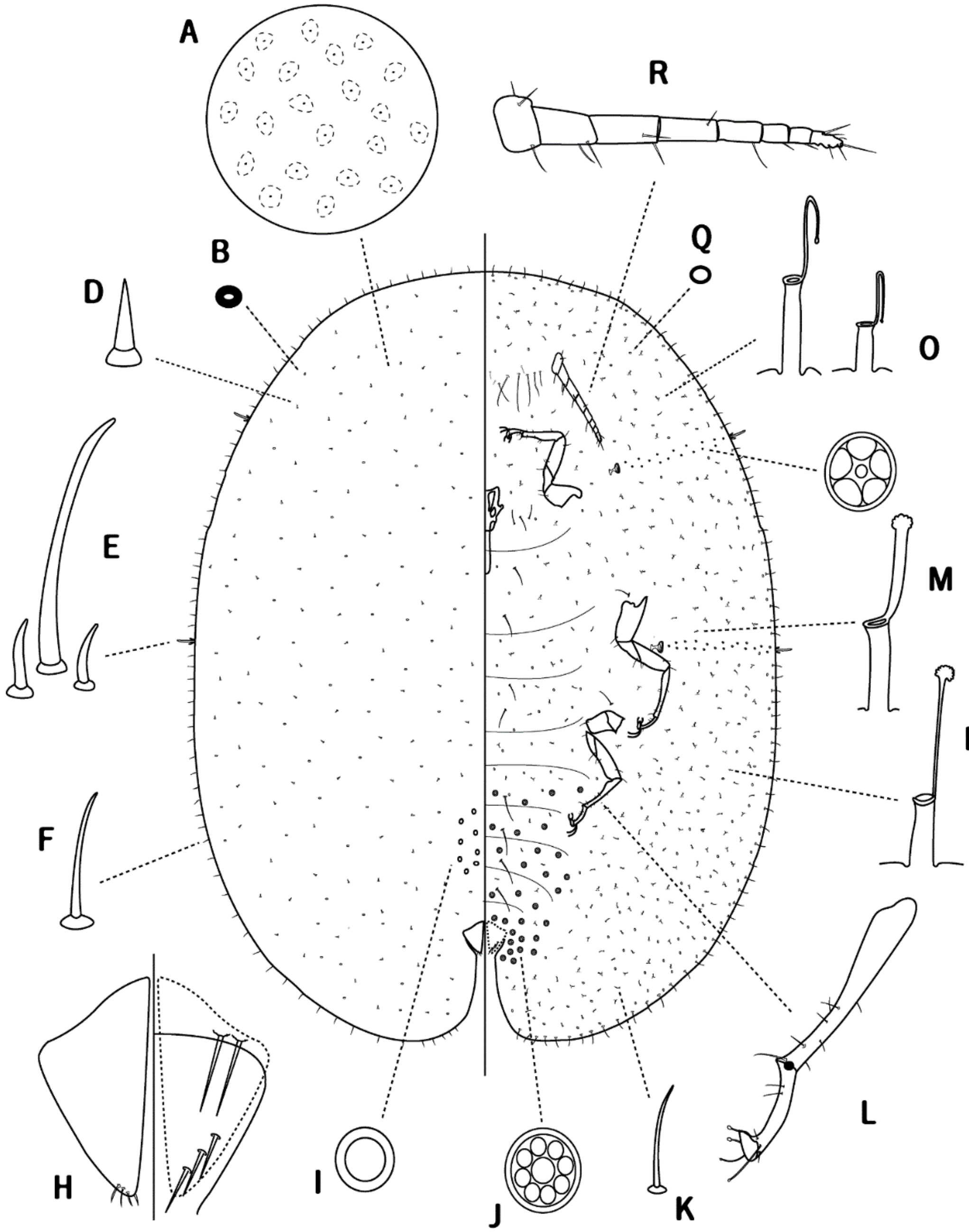

Fig. 44. *Pulvinaria idesiae* Kuwana, 1914

Appendix II. Illustration of adult females

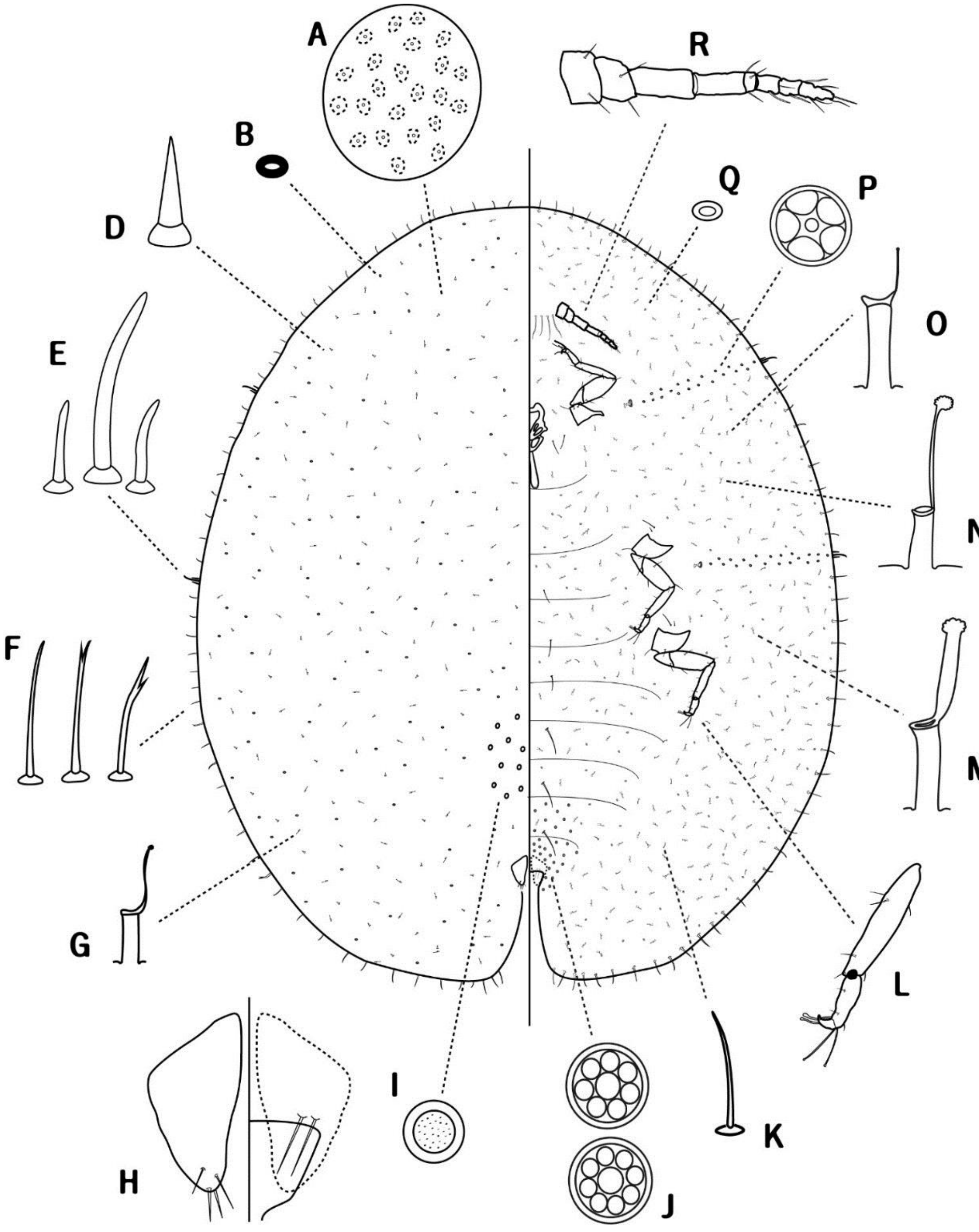

Fig. 45. *Pulvinaria photiniae* Kuwana, 1914

Appendix II. Illustration of adult females

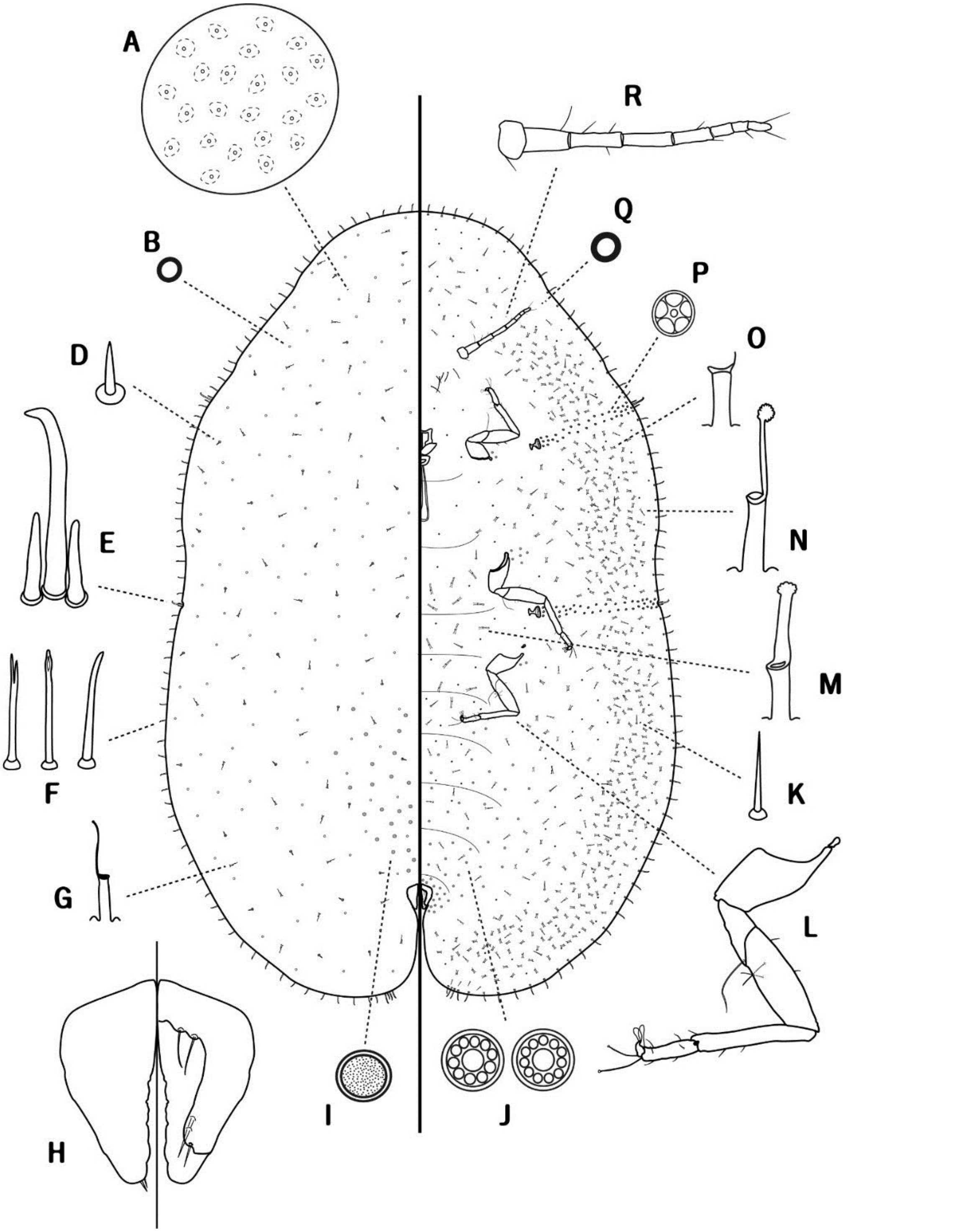

Fig. 46. *Pulvinaria* sp. (misreported as *Pulvinaria torreyae* Takahashi, 1956)

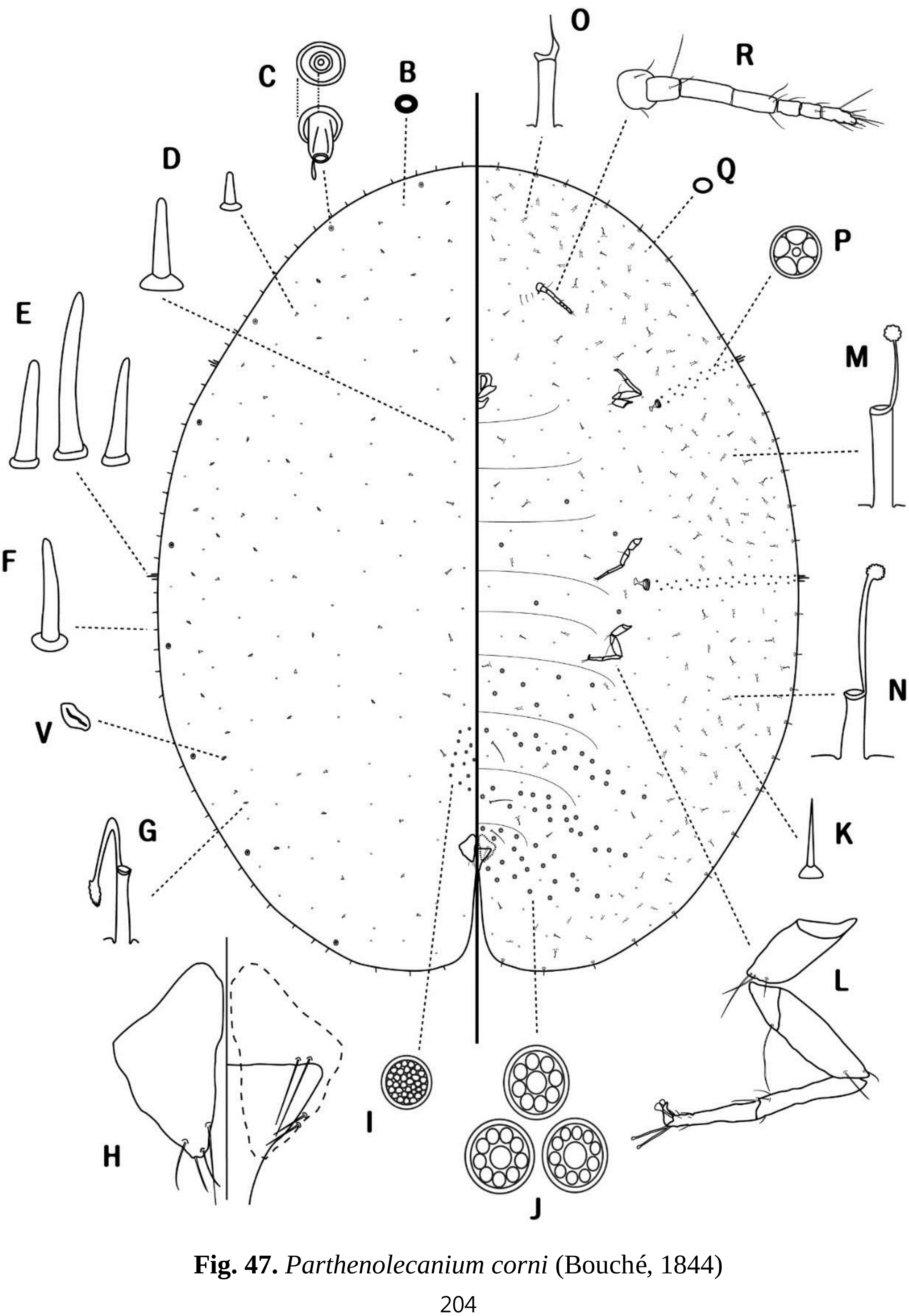

Fig. 47. *Parthenolecanium corni* (Bouché, 1844)

Appendix II. Illustration of adult females

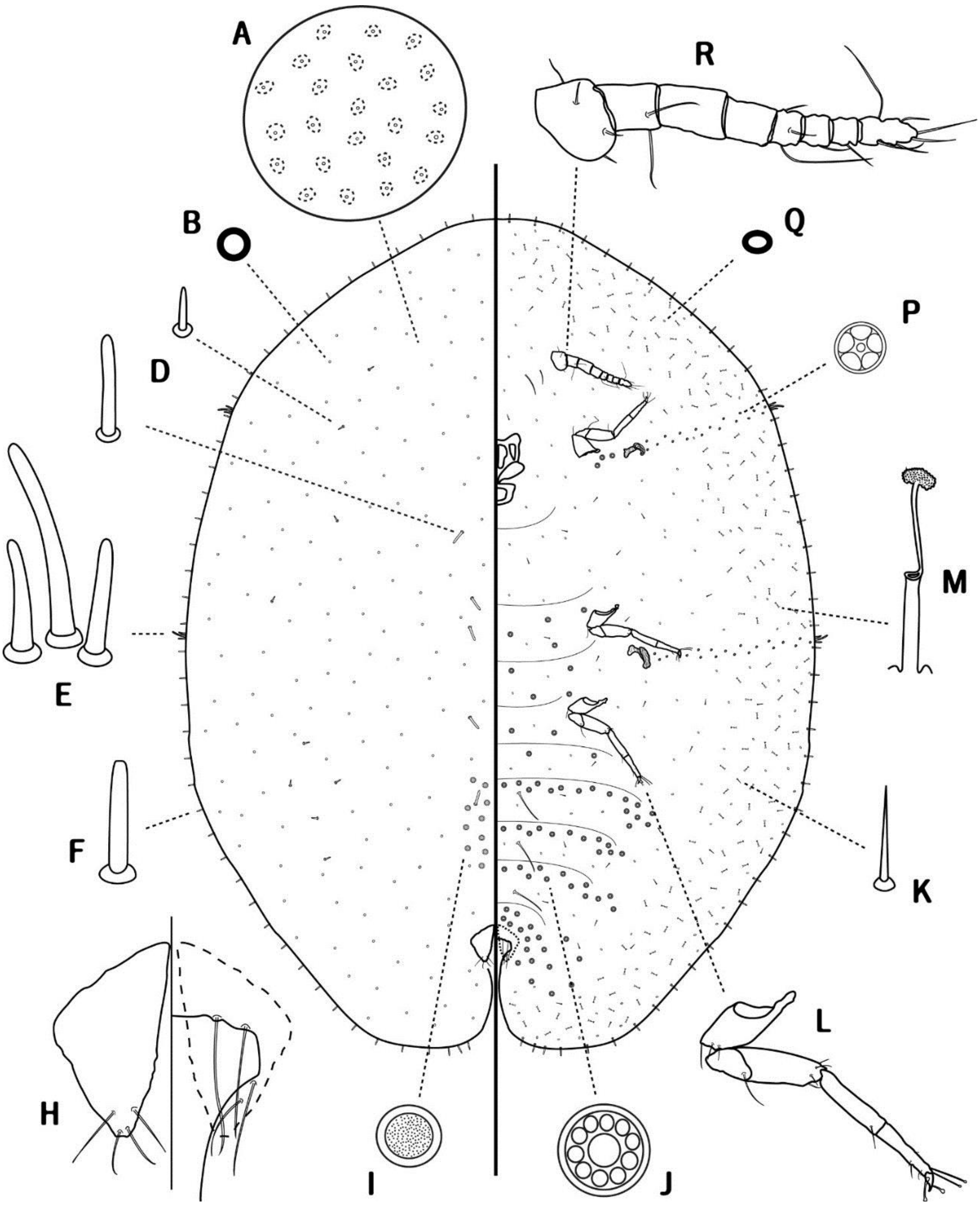

Fig. 48. *Parthenolecanium fletcheri* (Cockerell, 1893)

Appendix II. Illustration of adult females

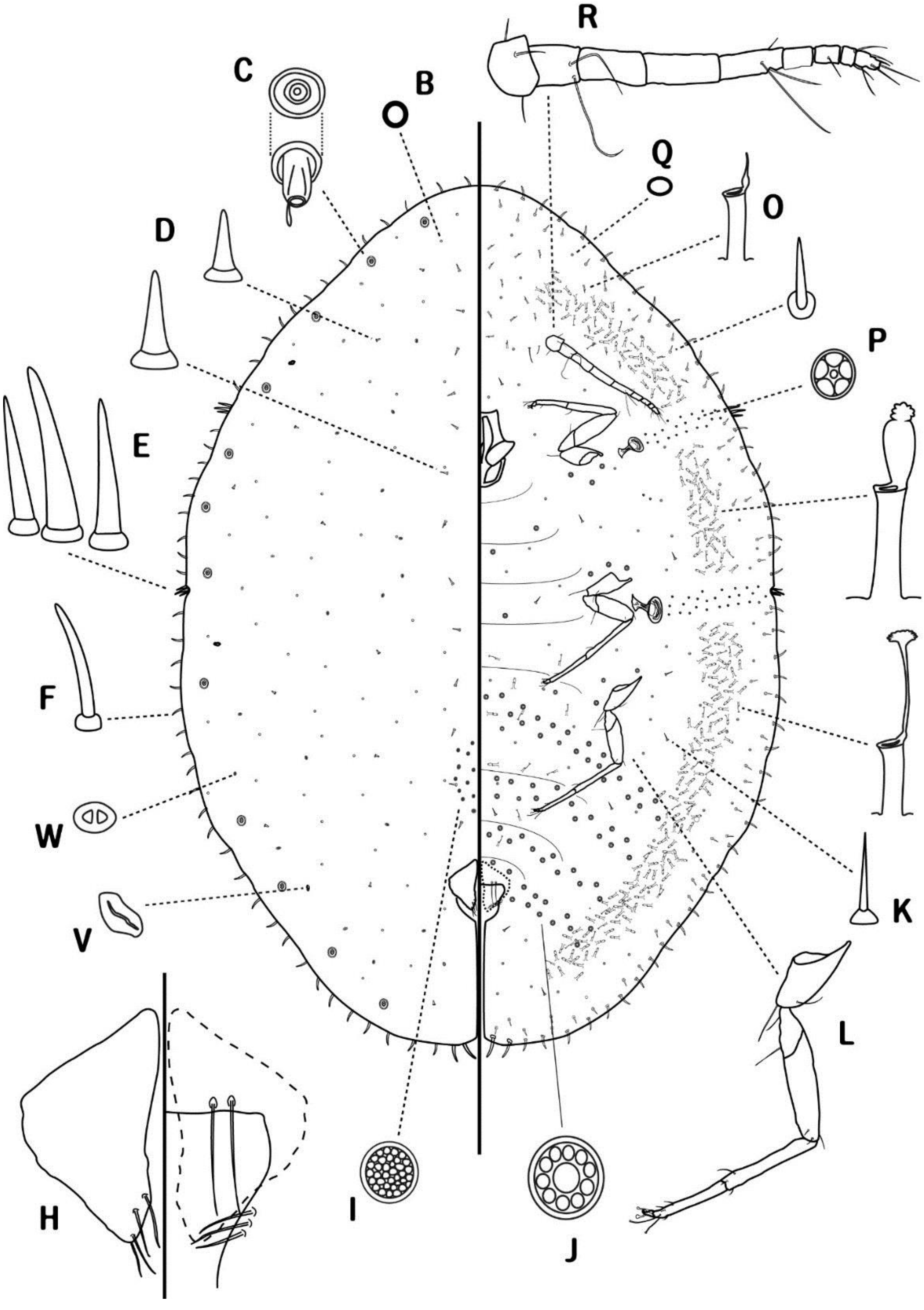

Fig. 49. *Parthenolecanium persicae* (Fabricius, 1776)

Appendix II. Illustration of adult females

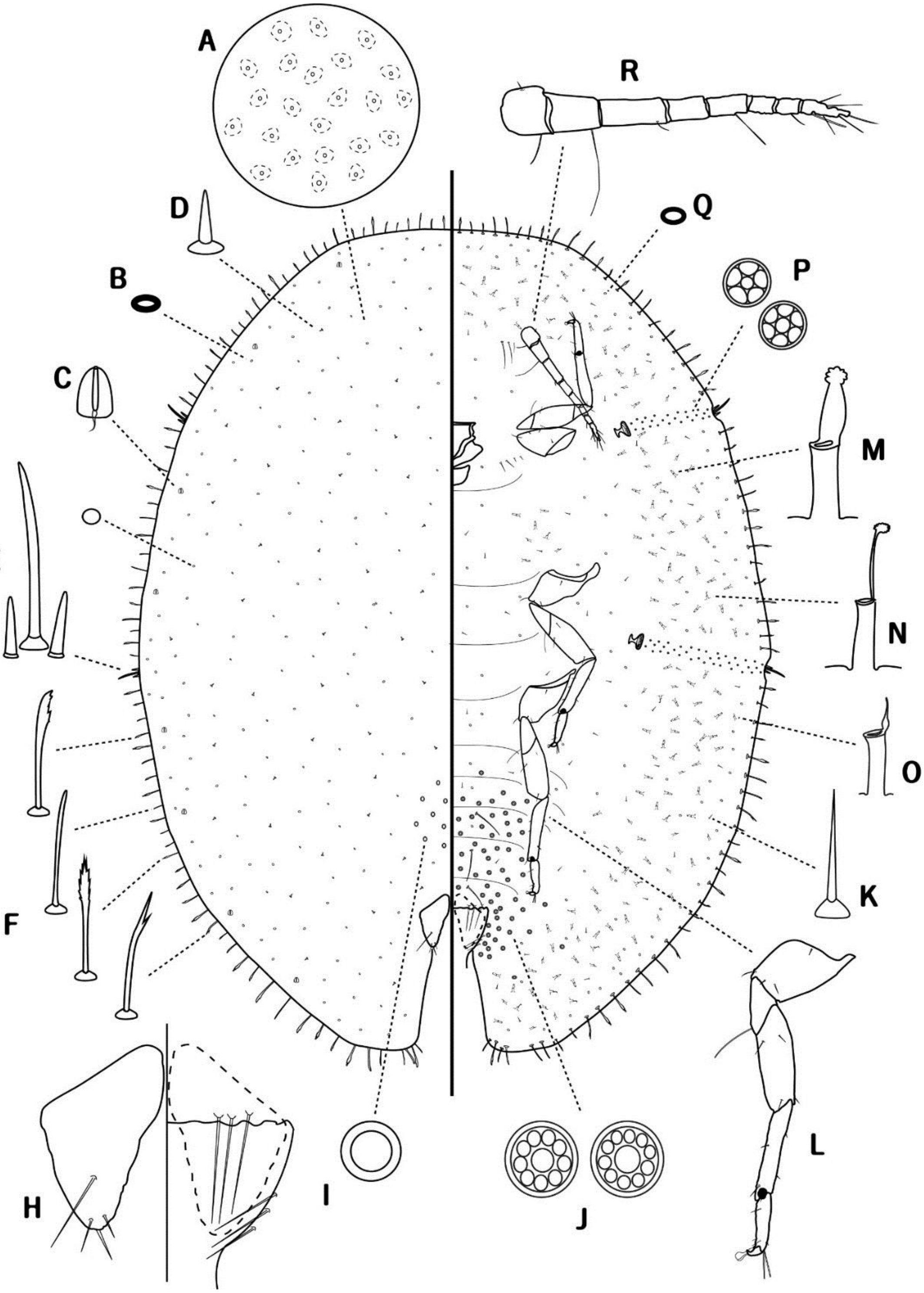

Fig. 50. *Saissetia coffeae* (Walker, 1852)

Appendix II. Illustration of adult females

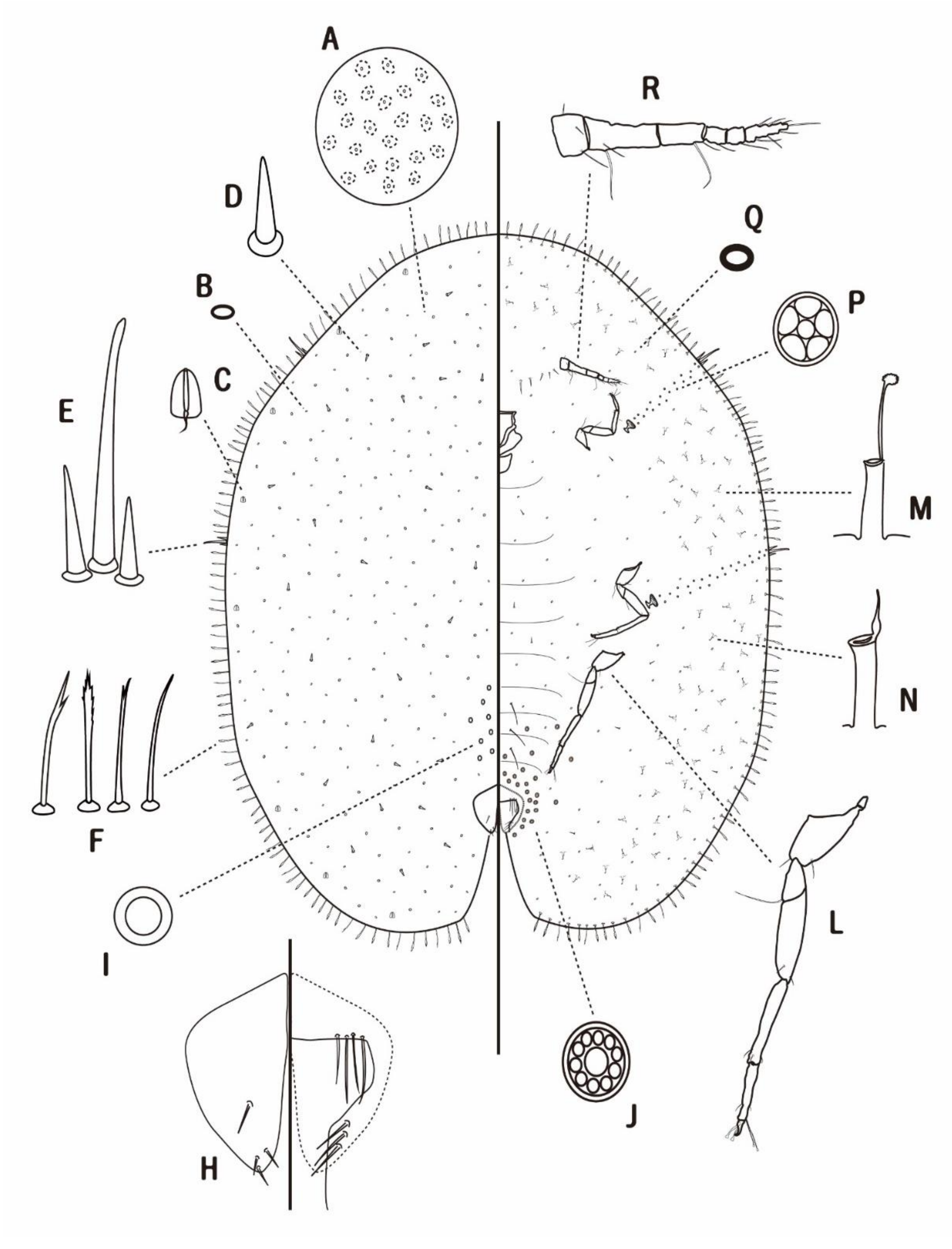

Fig. 51. *Saissetia miranda* (Cockerell & Parrott, 1899)

Appendix II. Illustration of adult females

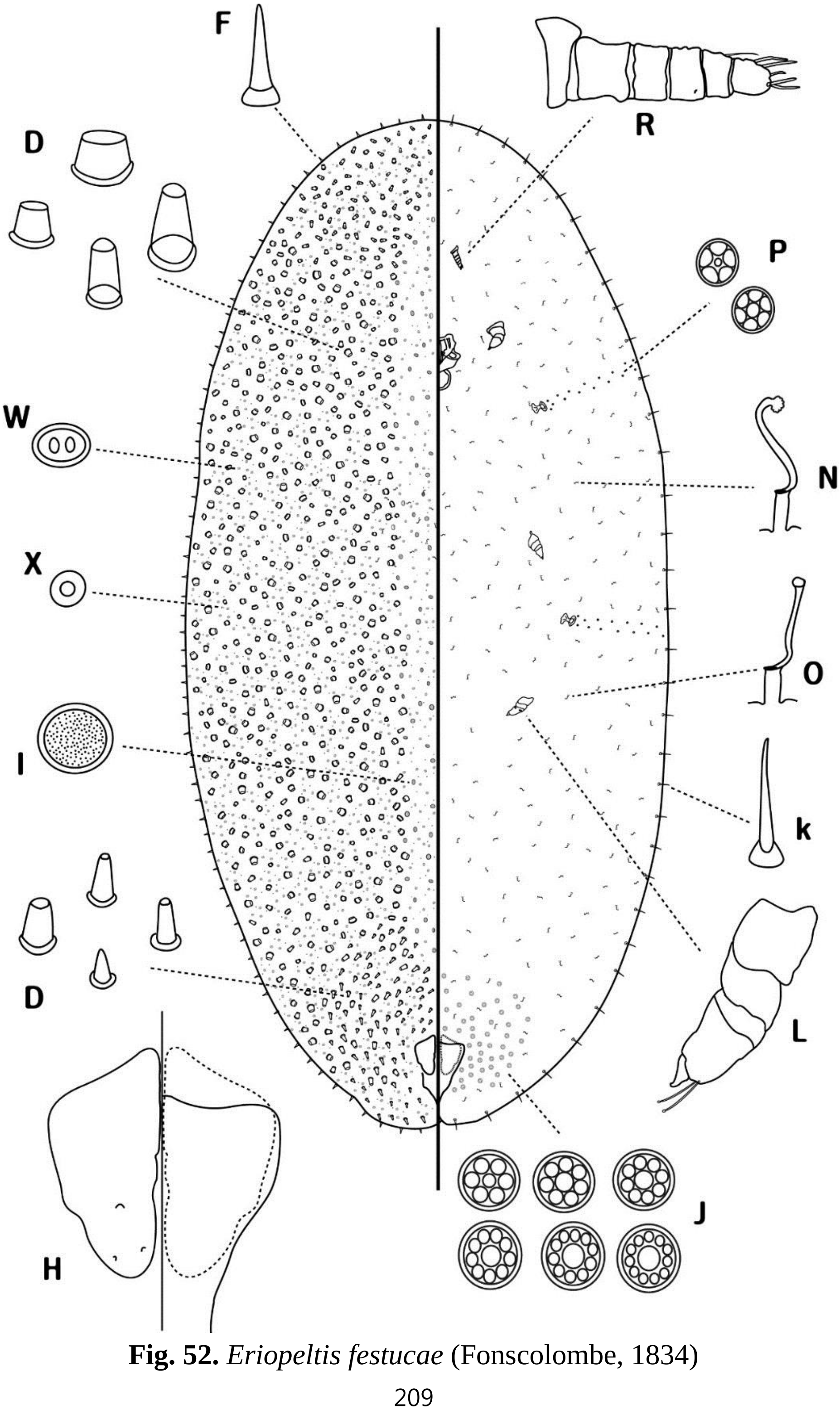

Fig. 52. *Eriopeltis festucae* (Fonscolombe, 1834)

Appendix II. Illustration of adult females

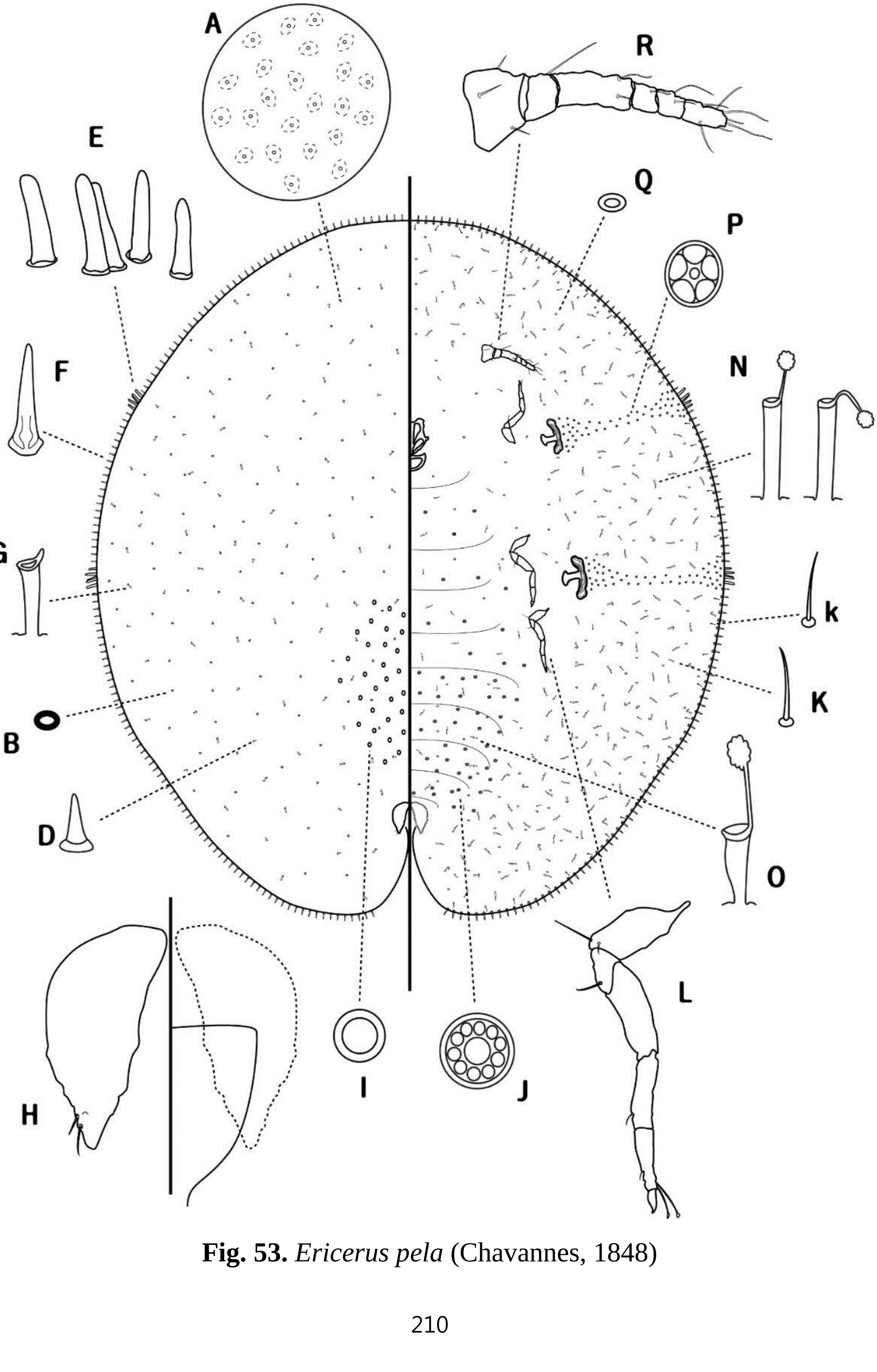

Fig. 53. *Ericerus pela* (Chavannes, 1848)

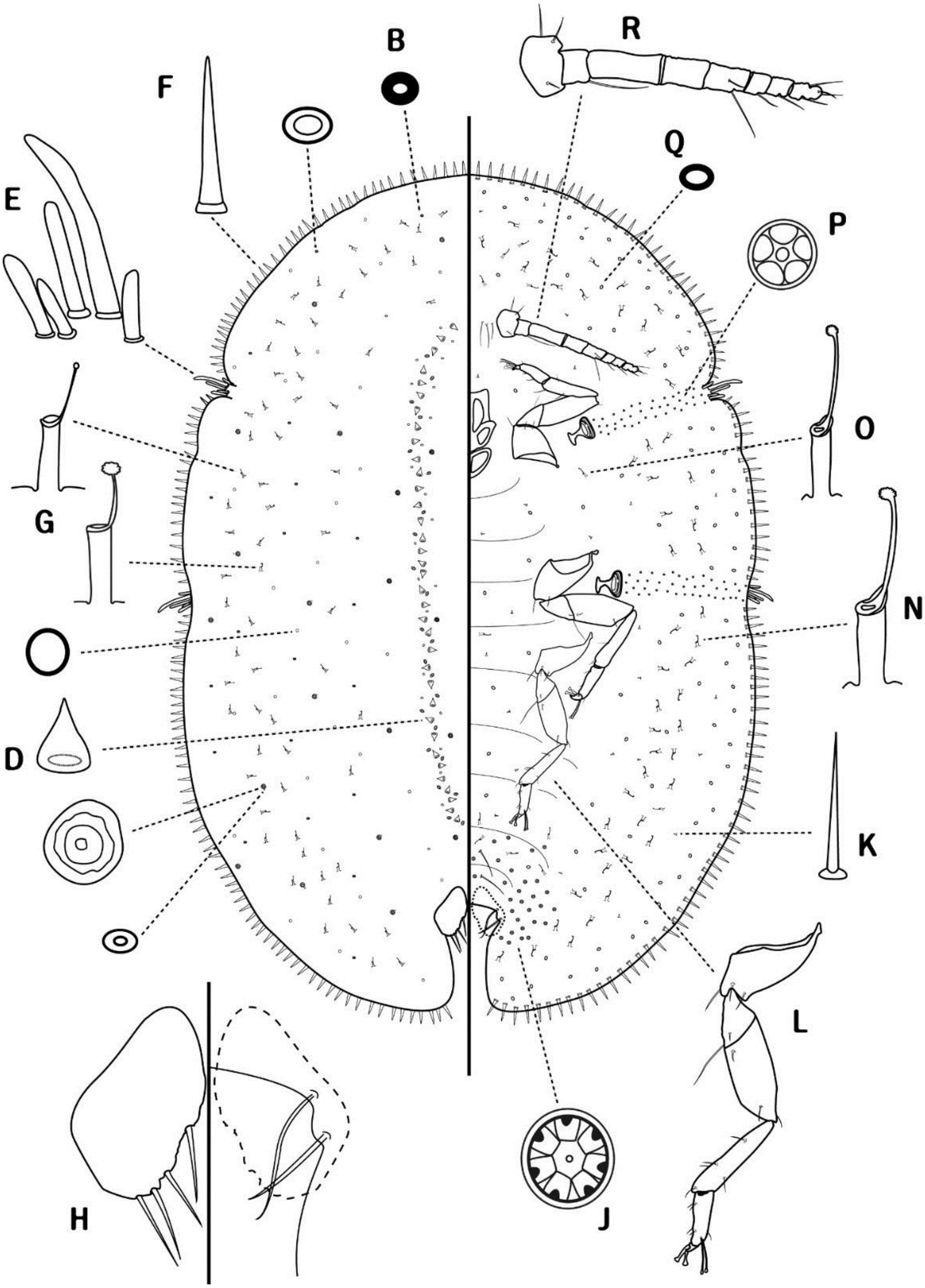

Fig. 54. *Metaceronema japonica* (Maskell, 1897)

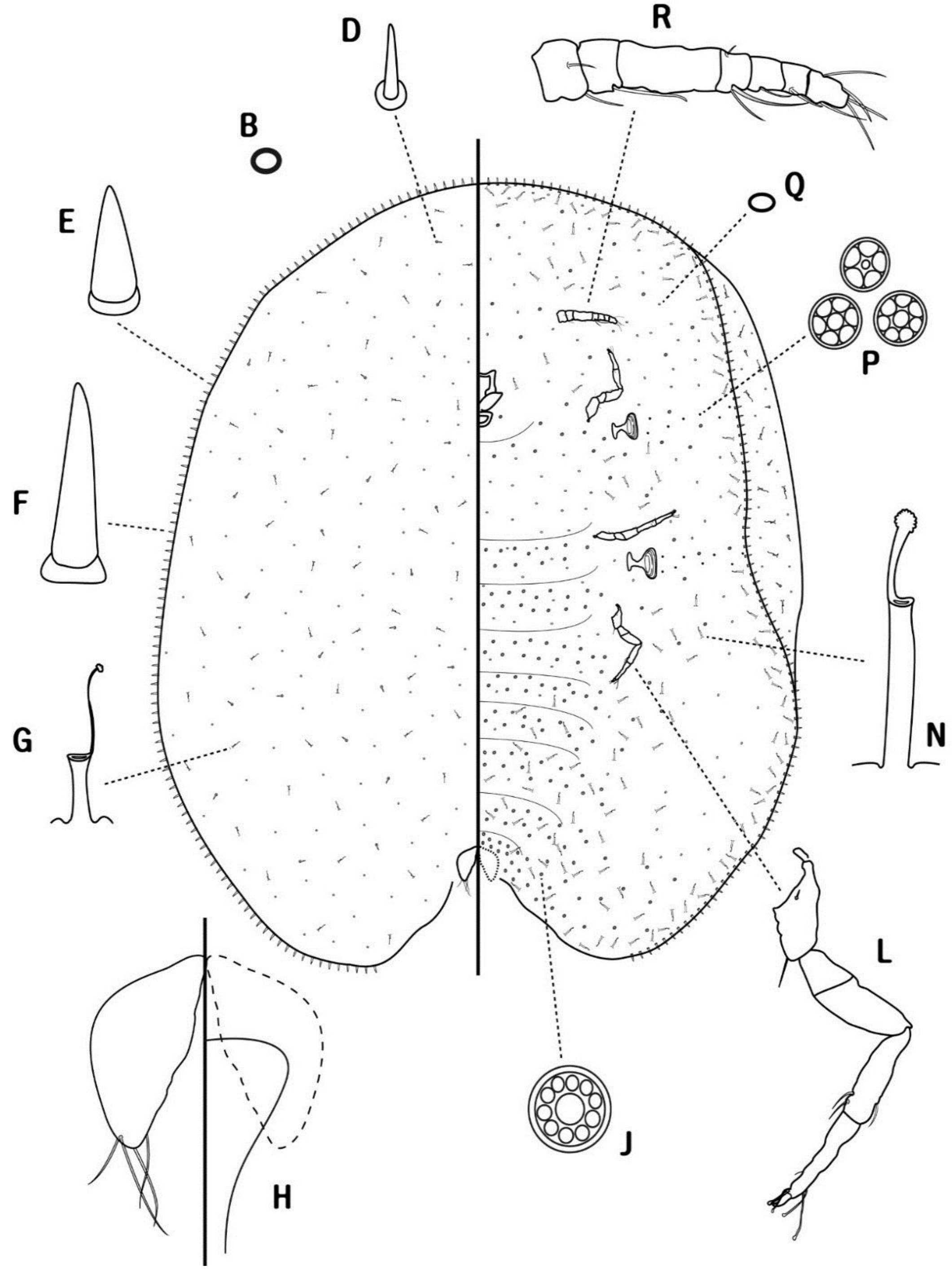

Fig. 55. *Takahashia japonica* (Cockerell, 1896)

Appendix III. Tables of Biometric Data

Table 10. *Ceroplastes ceriferus* (Fabricius, 1798) and *C. floridensis* Comstock, 1881

Part		*C. ceriferus* (n =13)		*C. floridensis* (n =7)	
		mean	range	mean	range
Body (mm)	Length of body	2.3	1.2-3.8	1.5	1.3-1.9
	Width of body	2.0	0.9-3.6	1.0	0.9-1.3
Dorsal (μm)	Length of Setae	7.8	5.4-10	4.0	3.4-4.3
	Length of Anal plates	122.0	88.4-173.7	106.1	99.3-126.1
	Width of Anal plates	114.3	90.5-154.5	107.8	94.2-124.8
	Width of monolocular pores	4.8	4.0-6	3.3	2.8-4.0
	Width of bilocular pores	6.3	5.6-7.3	4.1	3.9-4.5
	Width of trilocular pores	6.9	6.0-8.2	5.1	3.7-6.0
	Width of quadrilocular pores	7.6	6.6-8.6	3.7	3.4-4.0
Margin	Length of Marginal setae (conical)	-	-	12.3	9.9-14.1
	Length of Marginal setae (spinose)	16.5	11.3-22.9	18.5	16.8-20.0
	Length of stigmatic setae	25.2	17.0-35.5	19.0	15.4-22.2
Venter	Length of Submarginal setae	8.7	6.3-11.1	7.5	6.8-8.1
	Width of Multilocular pores	7.4	6.8-7.9	6.8	6.7-6.9
	Width of Clypeolabral shield	141.8	117.2-168.7	119.7	109.1-152.7
	Length of Coxa	83.7	56.8-102.3	100.7	86.1-137.2
	Length of trochanter+femur	103.5	77.3-126.1	133.1	118.0-173.2
	Length of tibia+tarsus	109.4	84.4-125.1	144.7	130.2-199.7
	Length of claw	12.8	9.8-16.3	13.0	11.1-14.5
	Total length of leg	309.4	234.9-368	407.7	351.2-524.0
	Length of Antennae	168.5	130.1-211.9	215.5	201.3-275.3
	Width of peritreme (Anterior)	58.6	23.3-90.5	24.5	20.3-39.3
	Width of peritreme (Posterior)	62.4	25.3-92.6	27.4	21.6-45.0
	Width of Spiracular pores	4.7	3.2-6	3.6	3.4-3.9
	Length of Setae (Spinose)	8.2	6.6-12.4	6.0	5.0-8.4
	Length of Tubular ducts	33.3	28.7-39.6	20.1	18.9-21.3
	Length of Microducts	3.2	2.3-4	1.8	1.1-2.6

Appendix III. Tables of Biometric Data

Table 11. *Ceroplastes japonicas* Green, 1921

Part		*C. japonicus* (n=10)	
		mean	range
Body (mm)	Length of body	2.5	1.7-3.5
	Width of body	1.9	1.1-3.1
Dorsal (μm)	Length of Setae	6.1	5.1-8.3
	Length of Anal plates	147	138.6-160.4
	Width of Anal plates	122.1	109.9-137.0
	Width of monolocular pores	4.4	3.9-5.3
	Width of bilocular pores	4.9	4.1-5.3
	Width of trilocular pores	5.1	4.0-7
	Width of quadrilocular pores	5.5	4.0-6.6
Margin	Length of Marginal setae (conical)	15.1	11.9-17.5
	Length of Marginal setae (spinose)	24.6	12.2-30.3
	Length of stigmatic setae	22.9	19.5-27.8
Venter	Length of Submarginal setae	9.5	7.0-12.1
	Width of Multilocular pores	6.5	5.3-7.8
	Width of Clypeolabral shield	154.4	141.8-163.1
	Length of Coxa	145.5	131.3-160.2
	Length of trochanter+femur	202.7	182.7-222.7
	Length of tibia+tarsus	211.6	200.3-230
	Length of claw	20.8	15.7-23.2
	Total length of leg	580.5	543.2-635.7
	Length of Antennae	310.2	285.3-327.7
	Width of peritreme (Anterior)	47.8	41.9-53.4
	Width of peritreme (Posterior)	56.6	50.8-60.8
	Width of Spiracular pores	4	3.4-5.7
	Length of Setae (Spinose)	7.4	4.4-9.6
	Length of Tubular ducts	28.3	21.1-41.4
	Length of Microducts	2.5	1.6-3.6

Appendix III. Tables of Biometric Data

Table 12. *Ceroplastes rubens* Maskell, 1893

Part		*C. rubens* (n =10)	
		mean	range
Body (mm)	Length of body	2.6	1.7-3.8
	Width of body	2.1	1.3-3.2
Dorsal (μm)	Length of Setae	5.5	4.4-6.4
	Length of Anal plates	151.1	140.8-160.3
	Width of Anal plates	130.8	117.8-149.2
	Width of monolocular pores	4.8	4-5.3
	Width of bilocular pores	5.9	4.8-7.2
	Width of trilocular pores	7.1	6.1-9
Margin	Length of Marginal setae (dorsal)	6.4	4.5-7.6
	Length of Marginal setae (ventral)	8.1	5.9-9.6
	Length of stigmatic setae (conical)	55.3	39.9-66.6
	Length of stigmatic setae (round)	29.9	26.1-35.6
	Length of stigmatic setae (others)	13	10.1-16.1
Venter	Width of Multilocular pores	7.3	6.3-8.6
	Width of Clypeolabral shield	165.4	151.5-181.1
	Length of Coxa	64.6	56.2-71.9
	Length of trochanter+femur	54.0	37.0-64.6
	Length of tibia+tarsus	62.5	47.7-73.6
	Length of claw	10	6.4-12.9
	Total length of leg	191.2	156.2-212.8
	Length of Antennae	173.8	155.9-199.4
	Width of peritreme (Anterior)	63.4	55.6-70.6
	Width of peritreme (Posterior)	69.6	55.6-75.3
	Width of Spiracular pores	5.6	5-6.6
	Length of Setae (Spinose)	8.3	7.7-9.4
	Length of irregular ducts	23.6	-
	Length of Microducts	4	3.1-4.6

Appendix III. Tables of Biometric Data

Table 13. *Coccus hesperidum* Linnaeus, 1758 and *C. pseudomagnoliarum* (Kuwana, 1914)

Part		*C. hesperidum* (n =20)		*C. pseudomagnoliarum* (n=2)	
		mean	range	mean	range
Body (mm)	Length of body	2.9	2.0-3.8	4.3	4.2-4.5
	Width of body	2	1.6-2.8	3.6	3.5-3.6
Dorsal (μm)	Length of Setae	7.7	5.5-9.4	10.5	10.3-10.7
	Length of Anal plates	154	135.2-175.4	162.8	157.2-168.4
	Width of Anal plates	136.9	110.9-152.7	182.5	179.1-185.8
	Length of Anterolateral margin	97.8	86.2-109.7	114.9	109.9-119.9
	Length of Posterolateral margin	107.5	91.7-122.5	4.9	4.7-5.2
	With of Disc pores	4.8	3.9-6.5	-	-
	With of Preopercular pores	4.1	3.2-4.7	4.9	4.7-5.2
	Width of Dorsal microducts	-	-	3.1	-
Margin	Length of Marginal setae	25.7	18.5-36.6	28.9	27.7-30.1
	Length of Median stigmatic setae	54.3	38.2-73.8	71.7	67.9-75.5
	Length of Lateral stigmatic setae	19.4	4.9-44.2	30.4	25.1-35.7
Venter	Width of Multilocular pores	6.1	4.7-7.3	6.1	5.7-6.5
	Width of Clypeolabral shield	116.8	102.2-142.5	265.7	162.8-368.5
	Length of Coxa	116.8	89.8-137	142.3	140.6-144
	Length of trochanter+femur	156.6	127.7-183.9	186.8	177.5-196.1
	Length of tibia+tarsus	179.2	146-213.0	217.4	212.1-222.7
	Length of claw	17.3	11.8-20.1	23.7	21.6-25.9
	Total length of leg	461	273.8-548.6	570.2	551.7-588.8
	Length of Antennae	288.3	237.8-329	344	341.4-346.6
	Width of peritreme (Anterior)	29.6	22.4-36.1	52.1	47.7-56.6
	Width of peritreme (Posterior)	37.2	28-49.2	66.7	61.8-71.7
	Width of Spiracular pores	3.8	3.6-4.5	4.4	4.4-4.5
	Length of Setae (Spinose)	9.8	6.5-13.9	12.1	10.6-13.6
	Width of Microducts	-	-	2.7	2.3-3.1

Appendix III. Tables of Biometric Data

Table 14. *Leptopulvinaria kawaii* Tanaka & Amano, 2008 and *Nipponpulvinaria horii* (Kuwana, 1902)

	Part	*L. kawaii* (n =18)		*N. horii* (n=10)	
		mean	range	mean	range
Body (mm)	Length of body	3.8	3.2-4.3	5.9	4.3-8.4
	Width of body	2.8	2.3-3.2	5.8	4.0-8.2
Dorsal (µm)	Length of Setae	7.5	5.5-10.2	12.2	8.0-19.6
	Length of Anal plates	134.3	121.6-145.1	226.7	200.6-247.1
	Width of Anal plates	132.9	119.9-151.1	222.3	164.6-276.2
	Length of Anterolateral margin	89	79.8-100.9	156.8	129.6-187.6
	Length of Posterolateral margin	91.5	82.0-102.8	145.6	120.7-158.8
	With of Disc pores	-	-	6.2	5.3-7.3
	With of Preopercular pores	5.0	3.4-6.5	-	-
	Width of Dorsal microducts	-	-	6.2	5.3-7.3
Margin	Length of Marginal setae	33.3	24.1-41.7	34.1	24.8-42.5
	Length of Median stigmatic setae	43.9	32.0-53.8	106.8	77.2-122.2
	Length of Lateral stigmatic setae	24.8	17.1-30.9	52.7	27.2-65.7
Venter	Width of Multilocular pores	6.7	5.0-8.2	8.7	8.2-9.5
	Width of Clypeolabral shield	156	142.5-183.5	269.5	225.4-316.3
	Length of Coxa	179.5	144.2-209.5	143.6	129.4-166.9
	Length of trochanter+femur	256.6	214.9-291.4	192.6	166.2-207.5
	Length of tibia+tarsus	339.5	304.4-366.2	244.0	225.4-262.7
	Length of claw	34.2	29.7-39.4	28.9	22.4-32.7
	Total length of leg	809.2	703.3-879.7	824.7	604.0-946.0
	Length of Antennae	452.6	398.3-481.0	455.3	420.0-485.9
	Width of peritreme (Anterior)	41.7	32.3-49.3	89.3	66.0-113
	Width of peritreme (Posterior)	44	36.6-54.0	114.4	77.9-142.2
	Width of Spiracular pores	4.4	3.7-5.3	6.1	5.3-7
	Length of Setae (Spinose)	12.6	10.1-19.1	15.8	12.3-18.9
	Length of Tubular ducts	21.5	11.4-44.7	42.9	34.0-49.4
	Width of Microducts	-	-	3.1	2.4-3.6

Appendix III. Tables of Biometric Data

Table 15. *Pulvinaria nipponica* Lindinger, 1933 and *P. hydrangeae* Steinweden, 1946

	Part	*P. nipponica* (n =7)		*p. hydrangeae* (n=10)	
		mean	range	mean	range
Body (mm)	Length of body	3.7	2.8-4.4	2.5	2-3.4
	Width of body	2.9	2.1-3.6	2.1	1.6-2.9
Dorsal (μm)	Length of Setae	7.7	6.1-10.2	10.4	8.7-13
	Length of Anal plates	134.7	113.4-145.4	145.1	133.7-155
	Width of Anal plates	142.5	124.3-164.4	157.2	138.6-172.8
	Length of Anterolateral margin	86.7	71.0-100.6	99.5	89-111.2
	Length of Posterolateral margin	100.8	91.3-113.8	110.8	98.4-120
	With of Disc pores	4	3.2-5	-	-
	Length of Tubular ducts	-	-	20.9	18.1-23.1
	With of Preopercular pores	-	-	4.2	3.6-5.4
	Width of Dorsal microducts	-	-	2.9	2.1-3.9
Margin	Length of Marginal setae	36.6	24.2-48.5	43.2	29-54.4
	Length of Median stigmatic setae	77.2	69.3-89	80.1	71.4-83.7
	Length of Lateral stigmatic setae	29.2	20.8-37	38.0	27.8-59.5
Venter	Length of Submarginal setae	17	11.1-24.3	18.1	11.4-26.4
	Width of Multilocular pores	6.8	6.0-7.9	7.2	6.5-7.9
	Width of Clypeolabral shield	175.1	158.8-188.2	174.6	158-190.8
	Length of Coxa	223.2	206.7-232.9	222.5	195.2-245.7
	Length of trochanter+femur	293.8	283.2-310.5	308.7	281.4-334.3
	Length of tibia+tarsus	275.7	269.9-285.4	299.0	269-325.9
	Length of claw	33.3	29.8-39.2	31.5	27.6-35.9
	Total length of leg	825.9	794.4-868	861.6	796.4-922.1
	Length of Antennae	388.7	353.8-424.8	442.1	408.4-497.4
	Width of peritreme (Anterior)	52.7	42.2-61	52.2	46.6-60.2
	Width of peritreme (Posterior)	61.3	52.7-69.2	61.2	54.4-68.2
	Width of Spiracular pores	5.5	4.9-6.6	5.1	4.2-6
	Length of Setae (Spinose)	10.9	8.4-13.9	11.8	7.6-14.8
	Length of Tubular ducts	24.8	19.9-28.3	31.2	27-38.5
	Width of Microducts	2.7	2.4-3.1	2.6	1.9-3.2

Appendix III. Tables of Biometric Data

Table 16. *Pulvinaria idesiae* Kuwana, 1914 and *P. photiniae* Kuwana, 1914

Part		*P. idesiae* (n =5)		*p. photiniae* (n=9)	
		mean	range	mean	range
Body (mm)	Length of body	4.7	3.7-5.8	2.9	2.5-3.7
	Width of body	3.9	3.2-5	2.2	1.8-3
Dorsal (μm)	Length of Setae	7.9	6.3-9.9	7.6	6.1-9.1
	Length of Anal plates	194.7	169.5-214.2	133.6	125.4-141.1
	Width of Anal plates	197.3	163.8-216.3	126.1	104.1-142.7
	Length of Anterolateral margin	125.2	104.6-142.9	82.1	63.9-97.6
	Length of Posterolateral margin	151.3	124.7-173.3	92.2	82.4-104.5
	With of Preopercular pores	5.3	4.5-6	4.1	3.6-4.5
Margin	Length of Marginal setae	43.1	34.8-47.9	42.6	30.8-55.2
	Length of Median stigmatic setae	97.2	80.4-108	74.2	55.9-88.8
	Length of Lateral stigmatic setae	42.1	34.1-50	31.0	21.7-38.6
Venter	Width of Multilocular pores	6.8	6.3-7.9	6.5	5.3-7.1
	Width of Clypeolabral shield	194.1	180.3-204.5	163.9	138.6-187.3
	Length of Coxa	293.8	204.5-356.4	192.9	165.1-210.3
	Length of trochanter+femur	404.8	280.9-478.5	271.0	241.4-293.4
	Length of tibia+tarsus	403.4	280.9-508.7	264.0	230-289.3
	Length of claw	40.7	34.8-48.2	29.9	23.2-35.6
	Total length of leg	1142.7	880.7-1380	757.7	680.6-820.9
	Length of Antennae	559.0	399.2-625.6	356.6	319.4-395.5
	Width of peritreme (Anterior)	62.7	56.4-70.9	56.2	48.2-65.6
	Width of peritreme (Posterior)	74.7	49.9-91.6	62.9	56.3-71.8
	Width of Spiracular pores	4.9	4.2-5.3	5.3	4.1-6.2
	Length of Setae (Spinose)	16.6	12-20.5	13.1	9.1-17.7
	Length of Tubular ducts	29.8	23.3-36.7	26.5	20.6-31.2

Appendix III. Tables of Biometric Data

Table 17. *Pulvinaria* sp. (misreported as *Pulvinaria torreyae* Takahashi, 1956)

Part		*P.* sp. (n =2)	
		mean	range
Body (mm)	Length of body	5.8	5.4-6.3
	Width of body	4.4	4.3-4.4
Dorsal (μm)	Length of Setae	10.6	9.2-12.1
	Length of Anal plates	207.1	203.9-210.3
	Width of Anal plates	187.5	182.3-192.7
	Length of Anterolateral margin	116.4	108.5-124.3
	Length of Posterolateral margin	163.9	161.4-166.3
	Length of Dorsal tubular ducts	28.1	27.8-28.5
	Width of Disc pores	6.3	5.7-7
	With of Dorsal microducts	3.4	3.2-3.6
Margin	Length of Marginal setae	58.0	54.6-61.4
	Length of Median stigmatic setae	91.8	86.7-97
	Length of Lateral stigmatic setae	36.5	31.6-41.4
Venter	Width of Multilocular pores	7.4	6.6-8.2
	Width of Clypeolabral shield	197.5	196-198.9
	Length of Coxa	330.3	328.9-331.8
	Length of trochanter+femur	385.3	363.5-407.1
	Length of tibia+tarsus	465	449.7-480.2
	Length of claw	32.5	30.9-34.2
	Total length of leg	1312.5	1209.7-1415.4
	Length of Antennae	513.7	430-597.4
	Width of peritreme (Anterior)	69.4	69.4-69.4
	Width of peritreme (Posterior)	81.3	77.6-85
	Width of Spiracular pores	5.7	5.3-6
	Length of Setae (Spinose)	22.4	21-23.8
	Length of Tubular ducts (TypeI)	31.2	29.7-32.6
	Length of Tubular ducts (TypeII)	30.1	28.7-31.5
	Length of Tubular ducts (TypeIII)	19.6	16.2-23
	Width of Microducts	3.7	3.6-3.9

Appendix III. Tables of Biometric Data

Table 18. *Parthenolecanium corni* (Bouché, 1844) and *P. fletcheri* (Cockerell, 1893)

Part		*P. corni* (n =10)		*P. fletcheri* (n=10)	
		mean	range	mean	range
Body (mm)	Length of body	4.5	2.9-6	2.7	2.3-3.3
	Width of body	4.1	2.4-5.4	2.2	1.8-2.9
Dorsal (μm)	Length of Setae (large)	10.1	7.4-13.9	21.5	18.2-26.9
	Length of Setae (small)	6	3.4-7.8	8.5	5.6-10.9
	Length of Anal plates	132.2	96.5-153.3	123.3	111.9-127.7
	Width of Anal plates	129.7	106.4-160	150.2	127.3-169
	Length of Anterolateral margin	83.9	53.2-104	96.1	85.8-105.7
	Length of Posterolateral margin	94.1	69.7-112.5	87.4	76.8-94.1
	Width of Dorsal tubercles	16.9	12.1-21.3	-	-
	Width of Pocket-like sclerotisations	9.3	7.1-19.7	-	-
	Width of Preopercular Pores	6.9	4.9-9.7	6	4.1-7.4
	Length of Dorsal tubular ducts	27.4	17.1-37.1	-	-
	With of Dorsal microducts	2.9	2.1-3.4	2.8	2.3-3.2
Margin	Length of Marginal setae	21.9	17.4-26.1	18.6	14.7-22.1
	Length of Median stigmatic setae	51.2	47.8-54.1	34.1	26.2-45.8
	Length of Lateral stigmatic setae	26.3	19.9-31.6	20.6	13.6-26.7
Venter	Length of Ventral submarginal setae	14.1	10-17.9	13.9	10.8-17.6
	Width of Multilocular pores	7.5	6.3-7.9	7.2	5.7-8.9
	Width of Clypeolabral shield	158.1	126.4-180.2	166.4	146.6-180.4
	Length of Coxa	123.3	107.8-133.7	112.1	106.7-118.6
	Length of trochanter+femur	169.8	149.1-184.6	137.4	130-144.1
	Length of tibia+tarsus	192.1	62.4-224.7	165	153.7-179.5
	Length of claw	22.9	20.3-25.1	19.2	12.7-23.1
	Total length of leg	508.1	374.9-554.9	433.7	414.5-455.8
	Length of Antennae	269.1	242.6-289.7	236.5	129.5-265.6
	Width of peritreme (Anterior)	44.2	26.1-55.2	42.8	34.9-48.1
	Width of peritreme (Posterior)	58.5	33.4-69.3	51.2	44.9-56.1
	Width of Spiracular pores	4.9	4.4-5.7	5.3	4.7-6.3
	Length of Setae (Spinose)	9.9	7.7-14.6	9.4	7.4-11.9
	Length of Tubular ducts	32.7	25.1-39	35.5	26-49.8
	Width of Microducts	2.8	2.1-3.7	3	2.4-3.9

Appendix III. Tables of Biometric Data

Table 19. *Parthenolecanium persicae* (Fabricius, 1776)

Part		*P. persicae* (n =9)	
		mean	range
Body (mm)	Length of body	3.7	2.2-8.1
	Width of body	2.6	1.1-6.4
Dorsal (μm)	Length of Setae (large)	14.7	9.7-22.4
	Length of Setae (small)	7.4	6.8-8.6
	Length of Anal plates	161.2	142.7-174.8
	Width of Anal plates	149.2	123.1-178.6
	Length of Anterolateral margin	108.1	104.5-110.7
	Length of Posterolateral margin	125.2	114.4-129.7
	Width of Dorsal tubercles	26.1	22.7-28.6
	Width of Pocket-like sclerotisations	11.4	11.4-11.4
	Width of Preopercular Pores	7.8	6.1-9.5
	Length of Dorsal tubular ducts	-	-
	With of Dorsal microducts	-	-
Margin	Length of Marginal setae	48.9	41.6-62.3
	Length of Median stigmatic setae	53.3	45.7-61.7
	Length of Lateral stigmatic setae	42.5	31.3-51.2
Venter	Length of Ventral submarginal setae	13.6	10.6-18.5
	Width of Multilocular pores	6.8	5.2-7.8
	Width of Clypeolabral shield	176.5	161.1-189.6
	Length of Coxa	163.5	144.5-177.1
	Length of trochanter+femur	239.9	221.8-258.1
	Length of tibia+tarsus	308.0	243.3-337.3
	Length of claw	25.3	19.2-29.6
	Total length of leg	736.8	645.2-795.7
	Length of Antennae	443.1	404.8-521.8
	Width of peritreme (Anterior)	68.8	54.9-86.1
	Width of peritreme (Posterior)	83.9	69.6-93.1
	Width of Spiracular pores	4.5	3.1-5.2
	Length of Setae (Spinose)	9.5	7.1-10.9
	Length of Tubular ducts	26.9	23-33.3
	Width of Microducts	2.9	2.3-3.6

Appendix III. Tables of Biometric Data

Table 20. *Saissetia coffeae* (Walker, 1852) and *Saissetia miranda* (Cockerell & parrott, 1899)

Part		*S. coffeae* (n =11)		*S. miranda* (n=2)	
		mean	range	mean	range
Body (mm)	Length of body	2.6	2-3.1	2.3	1.8-2.9
	Width of body	2.2	1.7-2.9	2.0	1.4-2.5
Dorsal (μm)	Length of Setae	7.2	5.6-8.9	16.1	13.5-18.7
	Length of Anal plates	144.7	135.1-158.6	179.9	175.6-184.2
	Width of Anal plates	165.8	145.8-197.8	141.8	89.5-194.1
	Length of Anterolateral margin	97.6	84.1-106.7	108.4	105.5-111.2
	Length of Posterolateral margin	108.9	86.4-129.2	136.8	136.6-137
	Width of Disc pores	2.2	1.9-2.8	2.4	2.4-2.4
	Width of Preopercular Pores	4.4	3.7-5.7	6.3	4.9-7.8
	With of Dorsal microducts	2.5	1.8-3.2	1.8	1.7-1.9
Margin	Length of Marginal setae	48.8	31.2-64.5	54.9	54.1-55.6
	Length of Median stigmatic setae	73.7	61.9-82.6	-	-
	Length of Lateral stigmatic setae	23.2	14.2-36.2	29.1	29.1-29.1
Venter	Length of Ventral submarginal setae	13.6	9.2-24.2	17.0	14.3-19.7
	Width of Multilocular pores	6.4	5.5-7.5	8.1	8-8.2
	Width of Clypeolabral shield	173.2	154.4-190.2	169.1	168.6-169.7
	Length of Coxa	193.0	169.8-210.3	139.5	130.8-148.2
	Length of trochanter+femur	230.8	221.8-246.1	204.9	198.4-211.4
	Length of tibia+tarsus	248.2	226.2-273.8	255.7	243.2-268.2
	Length of claw	23.5	18.7-31.2	20.9	17.3-24.5
	Total length of leg	693.1	662.2-749.2	705.8	627.6-784.1
	Length of Antennae	357.6	343-382.6	329.1	297-361.3
	Width of peritreme (Anterior)	47.1	36.8-56.3	45.7	42.3-49
	Width of peritreme (Posterior)	52.1	44.7-59.5	51.0	47.6-54.5
	Width of Spiracular pores	4.4	3.7-5.3	4.4	3.7-5.2
	Length of Setae (Spinose)	10.2	6.9-13.2	-	-
	Length of Tubular ducts	27.5	19.4-38	29.3	24.6-34.1
	Width of Microducts	2.4	1.9-2.9	2.0	1.6-2.3

Appendix III. Tables of Biometric Data

Table 21. *Eriopeltis festucae* (Fonscolombe, 1834)

Part		*E. festucae* (n =8)	
		mean	range
Body (mm)	Length of body	3.8	3.4-4.5
	Width of body	2.3	1.8-2.6
Dorsal (μm)	Length of Setae	26.9	16.2-37.4
	Length of Anal plates	161.6	140-191.3
	Width of Anal plates	182.3	133.4-244.6
	Length of Anterolateral margin	105.3	86.7-128.7
	Length of Posterolateral margin	139.8	97-167.9
	Width of Bilocular pores	4.7	4-5.8
	Width of Dorsal simple pores	2.9	2.5-3.4
	Width of Dorsal disc pores	6.4	5.3-7.3
Margin	Length of Marginal setae	13.1	9.8-16.8
	Length of Median stigmatic setae	22.5	15.5-29.5
Venter	Width of Multilocular pores	7	5.7-7.9
	Width of Clypeolabral shield	154.4	129.1-190.1
	Length of Coxa	42.0	34-65.3
	Length of trochanter+femur	42.9	27.4-63
	Length of tibia+tarsus	59.8	27.5-106.1
	Length of claw	16.1	10.8-26
	Total length of leg	150.1	86.2-252.3
	Length of Antennae	131.5	113.1-156.4
	Width of peritreme (Anterior)	62	52.8-72.1
	Width of peritreme (Posterior)	66.4	56.8-75
	Width of Spiracular pores	6.1	4.7-7.4
	Length of Tubular ducts	38.6	29.1-45.1

Appendix III. Tables of Biometric Data

Table 22. *Ericerus pela* (Chavannes, 1848)

Part		*E. pela* (n =10) mean	range
Body (mm)	Length of body	4.6	4-5.3
	Width of body	4.4	3.5-5
Dorsal (μm)	Length of Setae	8.5	7.4-11
	Length of Anal plates	189.6	160.9-208.4
	Width of Anal plates	170.7	149-193
	Length of Tubular ducts	20	14.5-24.5
	With of Dorsal microducts	2.7	1.7-3.4
Margin	Length of Marginal setae	33.7	27.5-42.2
	Length of Median stigmatic setae	43.9	31.8-59.7
	Length of Lateral stigmatic setae	37.0	29.5-46.7
Venter	Length of Ventral submarginal setae	14.5	10-19
	Width of Multilocular pores	9.1	8.1-11.2
	Width of Clypeolabral shield	229.6	200.3-257
	Length of Coxa	106.6	96.8-119.4
	Length of trochanter+femur	127.2	108.4-144.6
	Length of tibia+tarsus	145.5	132.7-155.6
	Length of claw	18.9	13.6-24.9
	Total length of leg	466.2	360.7-642.4
	Length of Antennae	218.6	181.9-242.2
	Width of peritreme (Anterior)	176.8	162.2-195.1
	Width of peritreme (Posterior)	184.4	162.1-218.2
	Width of Spiracular pores	5.8	5.3-6.5
	Length of Setae (Spinose)	12.7	7.3-17.4
	Length of Tubular ducts	34.1	26-39.8
	Width of Microducts	2.5	1.1-3.4

Appendix III. Tables of Biometric Data

Table 23. *Metaceronema japonica* (Maskell, 1897) and *Takahashia japonica* (Cockerell, 1896)

	Part	*M. japonica* (n =10)		*T. japonica* (n =6)	
		mean	range	mean	range
Body (mm)	Length of body	2.2	1.6-3	7.2	5.2-9.2
	Width of body	1.4	1.1-1.8	5.8	4.5-7.6
Dorsal (μm)	Length of Setae	15.0	11.9-17.1	12.0	10.9-14.9
	Length of Anal plates	135.5	104.6-154	192.7	180.7-204
	Width of Anal plates	144.0	108.1-180	177.9	155-194.6
	Length of Anterolateral margin	100.3	84.8-114.8	122.4	114.1-136.5
	Length of Posterolateral margin	78.9	69.6-94.9	132.8	116.6-139.4
	Length of Dorsal tubular ducts	30.2	25.3-35.7	24.2	21.2-29.7
	Width of Dorsal pores	-	-	5.4	4.2-6.5
	Width of Dorsal pores (elongate oval)	3.4	3.1-4.1	-	-
	Width of Dorsal pores (microduct)	2.6	1.9-2.9	-	-
	Width of Dorsal pores (tubercle like)	7.3	6.3-8.1	-	
	Width of Dorsal pores (small convex)	3.7	3.2-4.3	-	-
	Width of Dorsal pores (minute pore)	2.2	1.9-2.6	-	-
Margin	Length of Marginal setae	43.4	31.4-56.7	22.8	17.4-28
	Length of Median stigmatic setae	95.5	30.2-117	19.0	15.9-22.1
	Length of Lateral stigmatic setae	70.1	24.5-95.5	15.4	12.4-18.3
Venter	Length of Ventral submarginal setae	9.8	6.8-13.7	-	-
	Width of Multilocular pores	7.9	7-8.9	9.2	7-10.5
	Width of Clypeolabral shield	175.0	128.4-209.4	211.0	113.3-289.2
	Length of Coxa	195.5	111.5-234.5	80.5	54.2-104.3
	Length of trochanter+femur	254.8	145.8-286.8	114.1	87.1-137.1
	Length of tibia+tarsus	265.4	156.2-297.8	175.0	128.4-208.9
	Length of claw	26.3	19.9-31.9	20.8	13.9-32.6
	Total length of leg	742.0	433.4-830.1	390.5	308.6-482.8
	Length of Antennae	372.9	219.2-436.4	208.7	163-252.1
	Width of peritreme (Anterior)	51.4	21.6-64.4	119.3	95.1-131.6
	Width of peritreme (Posterior)	60.9	22.5-83.5	132.4	114.6-155.5
	Width of Spiracular pores	5.5	4.4-6.1	6.5	6-7.1
	Length of Setae (Spinose)	8.9	7-12.6	12.8	10.2-15.6
	Length of Tubular ducts	27.2	24.9-29.3	48.9	40.4-60
	Width of Microducts	2.5	1.9-3.2	4.3	3.9-4.7

국문초록

밀깍지벌레과(노린재목: 깍지벌레상과)의 계통분류학적 연구

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본 연구는 한반도산 밀깍지벌레과에 대한 계통분류학적 연구로써, 세가지 주요 주제를 가지고 연구를 수행하였다. 첫 번째, 한반도산 밀깍지벌레의 분류학적 검토, 두 번째, 밀깍지벌레의 분자계통학적 연구, 세 번째, 무화과깍지벌레의 유전적 다양성과 잠재종에 대한 분자학적 연구이다.

첫 번째 연구에서는 총 19속 39종의 밀깍지벌레류에 대한 분류학적 검토가 수행되었다. 이를 통하여 7종이 국내에서 처음으로 보고되었으며, 이 전에 기록된 종 중 주목솜깍지벌레로 기록된 종이 오동정으로 보고된 종임을 확인하였다.

두 번째 연구에서는 mitochondrial DNA (COI)와 nuclear ribosomal RNA genes (18S and 28S), elongation factor 1**α** (EF-1α)의 분자마커를 이용한 밀깍지벌레과에 대한 계통학적 연구를 수행하였다. 분석결과 Ceroplastinae를 제외한 모든 아과는 측계통을 형성하였으며, Coccinae에 속하는 4개의 족의 경우에는 ML tree 상의 Saissetiini를 제외하고 모두 단계통을 나타내지 않았다. 특히, Coccini와 Pulvinariini는 불규칙한 분기 형태를 보였으며, *Paralecanium*과 *Megapulvinaria*는 Coccinae의 주요 분기군에서 뚜렷하게 분리되어 Cardiococcinae와 Filippiinae에 근연으로 나타났다. 그리고 *Didesmococcus*가 Coccinae의 분기군 내에서 나타남에 따라 Eulecaniinae는 측계통을 형성하는 그룹임을 확인하였다.

세 번째 연구에서는 무화과깍지벌레의 유전자 분석을 통하여 COI haplotype의 높은 다양성과 2종의 잠재종을 확인하였다. Maximum Likelihood (ML)의 계통수와 haplotype network에서 무화과깍지벌레의 모든 haplotype은 3개의 분리된 분기군을 형성하였고, K2P-distance를 통하여 분기군간 유전적인 차이 정도가 크게 나타남을 확인하였다.

검색어: 밀깍지벌레과, 밀깍지벌레류, 계통분류학, 분류학적 검토, 분자계통학, 유전적 다양성, 잠재종, 한반도