

INSECTA MUNDI

A Journal of World Insect Systematics

0347

Updated list of *Pinnaspis* armored scales (Hemiptera: Diaspididae)
of Korea

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Date of Issue: February 7, 2014

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Insecta Mundi 0347: 1–9

ZooBank Registered: urn:lsid:zoobank.org:pub:3F9D4643-F0C3-47F7-BC03-03E8D56C08B4

Published in 2014 by

Center for Systematic Entomology, Inc.

P. O. Box 141874

Gainesville, FL 32614-1874 USA

<http://centerforsystematicentomology.org/>

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Updated list of *Pinnaspis* armored scales (Hemiptera: Diaspididae) of Korea

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Abstract. *Pinnaspis chamaecyparidis* Takagi, *Pinnaspis hikosana* Takagi and *Pinnaspis uniloba* (Kuwana), occurring on *Chamaecyparis obtusa* Endl., *Styrax japonica* S. et Z. and *Cleyera japonica* Thunb. are newly documented in the Korean fauna of armored scales (Diaspididae). The characters of these species are here redescribed with illustrative photographs and information on distribution and hosts along with a dichotomous key to the species of *Pinnaspis* for correct species identification. In addition, the paper discusses the current status of *Pinnaspis buxi* (Bouché) and *Pinnaspis strachani* (Cooley) which are known as native armored scale insects of Korea by analyzing information on the result of the survey.

Key words. *Pinnaspis chamaecyparidis*, *Pinnaspis hikosana*, *Pinnaspis uniloba*, New Record, Diaspididae, Korea

Introduction

Species in the genus *Pinnaspis* Cockerell (Hemiptera: Diaspididae) have a more or less slender, fusiform and elongate body, the metathorax distinctly or slightly protruding lateral lobes and the pygidium triangular or roundish. The most distinctive feature is the pair of median lobes, which are united at the base by an elongate zygois; the inner edges of the median lobes are parallel and very close together at the apices, appearing to be fused (Takagi 1970; Williams and Watson 1988). According to the ScaleNet database, 46 species have been documented around the world (Ben-Dov et al. 2013); of these, 41 species and 12 species were reported to be originated from Oriental (89%) and Palaearctic (26%) regions, respectively. Between 1963 and 2003, Takagi discovered and described 14 *Pinnaspis* species from eastern Asia, thus this illustrates the abundance and diversity of the genus in the eastern Asia (Ben-Dov et al. 2013).

Species of the genus *Pinnaspis* species were first time recorded in Korea by Nakayama and Kanda in 1933 and 1942 (cited from the publication of Paik (2000) who documented the presence of *Pinnaspis aspidistrae* (Signoret), *Pinnaspis buxi* (Bouché) and *Pinnaspis strachani* (Cooley)). Since that time, no species have been added to the Korean armored scale fauna (Paik 1978; Paik 2000; Lee 2010), although some species of the genus have been found in other eastern Asian countries including Japan and China. As the result of the Korean Diaspididae project survey initiated in 2006, the following three additional *Pinnaspis* species occurring on *Chamaecyparis obtusa* Endl. (Cupressaceae), *Styrax japonica* S. et Z. (Styracaceae) and *Cleyera japonica* Thunb. (Theaceae), respectively were found: *Pinnaspis chamaecyparidis* Takagi, *Pinnaspis hikosana* Takagi and *Pinnaspis uniloba* (Kuwana) and represent the first records of the occurrence of these species in Korea. All three species were collected on leaves and twigs and no damage to their host plants was observed.

Regarding the economic importance of *Pinnaspis*, *P. aspidistrae* and *P. strachani* are known for polyphagous and worldwide pests. The fern scale, *P. aspidistrae* is probably native to the Oriental region (Miller and Davidson 2005) and is considered to be one of the principal armored scale pests of the world (Beardsley and González 1975). Also the fern scale is regarded as serious pest of fern, foliage, citrus, oil palm and rubber trees in the USA, Brazil, Chile, Japan and Malaysia (Miller and Davidson 2005). In Korea, it was reported to occur only on *Asplenium nidus* (Aspleniaceae), *Aspidistra elatior* (Asparagaceae) and undetermined Orchidaceae in greenhouses (Paik 1978). During the recent survey, it was often collected not only in greenhouses but also on outside plants. Based on the material in the PQTC's collection, it was found on *Liriope platyphylla* (Asparagaceae) and *Rhaphis humilis* (Arecaceae) outdoors in Korea. The lesser snow scale, *P. strachani*, described from Nigeria, is a serious and wide-

spread pest as well. It occasionally causes serious damage to hibiscus, tamarind, citrus, black pepper, arecanut, olives and several wild plants (Miller and Davidson 2005).

While updating the list of the *Pinnaspis* armored scales of Korea, the presence of *P. buxi* and *P. strachani* in Korea could not be confirmed because no specimens could be found from collections made from 2006 to the present time, although according to the literature (Paik 1978; Paik 2000; Lee 2010), both species have been found in greenhouses in Korea.

The purpose of this paper is: 1) to update the list of the *Pinnaspis* species that occur in Korea, 2) to provide an identification key to species of *Pinnaspis* in Korea, 3) to provide photos, redescriptions for the three species newly documented in Korea, and information on the plant hosts and distribution of species, and 4) to review the current status of *P. buxi* and *P. strachani* in Korea.

Materials and Methods

All slide-mounted specimens used for this paper are deposited in the Collection of Plant Quarantine Technology Center (PQTC), QIA (Figure 3F). The dichotomous key mentioned below was based on specimens of adult females collected on leaves and twigs of their plant hosts. Terminology for morphological structures used in descriptions and an identification key follows that of Miller and Davidson (2005). Photographs were taken using an AxioCam MRC5 camera through ZEISS Axio Imager M2 Microscope and a Leica M165C microscope with Delta pix camera. An asterisk(*) is used to indicate a new distribution record. The following *Pinnaspis* species: *P. aspidistrae*, *P. buxi* and *P. strachani* were well described in the book of Paik (1978), and are not addressed here.

Description

Pinnaspis chamaecyparidis Takagi, 1961

(Figures 1A–F)

Pinnaspis chamaecyparidis Takagi, 1961: 72–73. Type data: Japan, on *Chamaecyparis obtusa*, 8-i-1955 and 16-iv-1956.

Field Characters. Adult female cover narrowly to broadly oyster-shell shaped, light to dark brown; shed skins margin, yellow brown to brown. Male cover smaller, felted, white, elongate, with slight median carina; shed skin yellowish.

Slide-mounted Characters. Adult female with 2 pairs of well developed lobes, third lobes inconspicuous; paraphyses attached to medial margin of median lobules of second lobe. Median lobes small in size, closely appressed together, slightly elongate with 1–2 deeply lateral notches, the basal zygosis robust, and distinctly produced anteriorly into apex of pygidium; second lobes with 2 lobules, medial lobules slightly expanded apically, with a pair of slender basal scleroses. Gland spine formula 1–1–1, with about 14 gland spines near each body margin from segments 5 to 7. Macroducts of 2 sizes, larger size in marginal areas on segments 4 to 7, in submarginal areas on segments 1 to 3, smaller size in submarginal and marginal areas from metathorax to segment 3. Perivulvar pores in 5 groups, 38–48 pores. Perispiracular pores usually with 3 loculi, anterior spiracles each with 3–6 pores, posterior spiracles with 1–2 pores. Anal opening located about middle of pygidium. Antennae each with 1 conspicuous seta. Body elongated fusiform with prepygidial segments each slightly convex laterally. Preanal scars absent.

Affinities. This species is most similar to *Pinnaspis juniper* Takahashi which is not known to occur in Korea, from which it differs mainly by the second lobes which are well developed, with the inner lobule slightly expanded apically.

Material examined. Korea. Gyeongsangnamdo (GN): Dadaepo-dong, Saha-gu, Busan-si, 5 adult females, on *Chamaecyparis obtusa* (Cupressaceae) leaf, 13-xii-2007 (S.J. Suh); Dongbaekseom, 2 adult

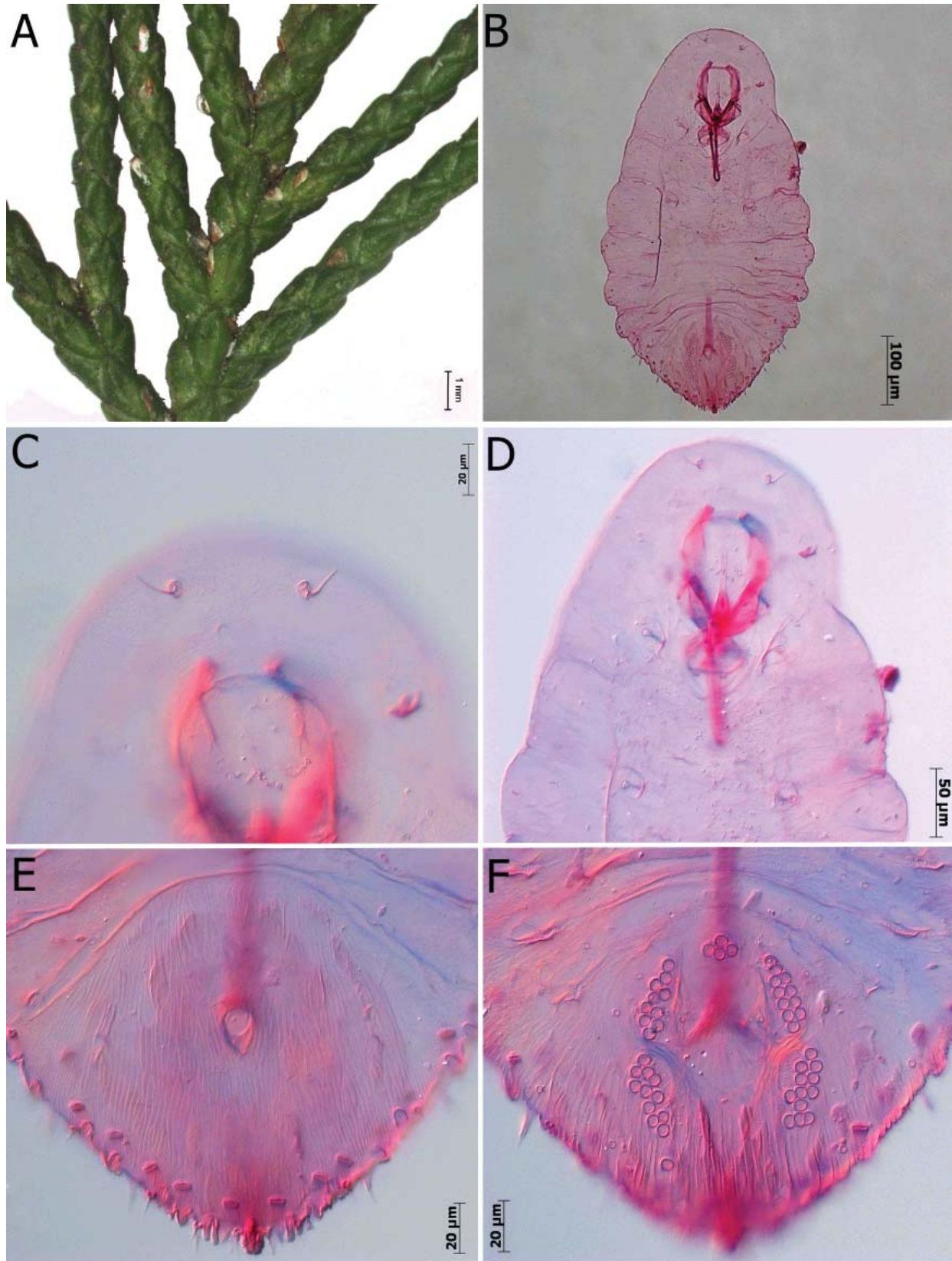


Figure 1. *Pinnaaspis chamaecyparidis* Takagi. A) Habitus. B) Female. C) Antennae. D) Anterior and posterior spiracles. E) Median lobes. F) Perivulvar pores.

females, on *Juniperus chinensis* (Cupressaceae) leaf, 14-viii-2008 (S.J. Suh); Dongbaek park, 3 adult females and 2 nymphs, on *Juniperus chinensis* (Cupressaceae) leaf, 24-ix-2008 (S.J. Suh); Tongdosa, 7 adult females, on *Chamaecyparis obtusa* (Cupressaceae) leaf, 8-ix-2009 (S.J. Suh). Jeollabukdo (JB): Gyeongwon-dong, Wansan-gu, Jeonju-si, 5 adult females, on *Chamaecyparis obtusa* (Cupressaceae) leaf, 17-iii-2006 (S.J. Suh). Jeollanamdo (JN): Gatbawi, 7 adult females, on *Juniperus chinensis* (Cupressaceae) leaf, 23-vii-2012 (S.J. Suh).

Hosts. This species has a restricted host range occurring on conifers. Cupressaceae: *Chamaecyparis obtusa*, *Chamaecyparis pisifera*, *Cryptomeria japonica*, *Juniperus chinensis* (Kawai 1980; Ben-Dov et al. 2013).

Distribution. Japan and Korea* (Ben-Dov et al. 2013).

Remarks. This species has two generations per year and hibernates as an adult female in Japan (Kawai 1980).

***Pinnaspis hikosana* Takagi, 1961**

(Figures 2A–F)

Pinnaspis hikosana Takagi, 1961: 73–74. Type data: Japan, on *Viburnum* sp., 10-v-1957.

Field Characters. Adult female cover narrowly to broadly oyster-shell shaped, dark brown; shed skins marginal, yellow brown to brown. Male cover smaller, felted, white, elongate, with tricarinate (Kawai 1980).

Slide-mounted Characters. Adult female with 2 pairs of lobes, third lobes inconspicuous; paraphyses usually absent. Median lobes prominent, large in size, closely appressed together, a half circle shaped with 1–2 deeply lateral notches, the basal zygotis small, and slightly produced anteriorly into apex of pygidium; second lobes present and represented by a small, apically pointed process and lateral lobules by a small inconspicuous process. Gland spine formula 1–1–1, with about 16–18 gland spines near each body margin from segments 2 to 7. Macroducts of 2 sizes, larger size in marginal areas on segments 4 to 7, smaller size in submarginal and marginal areas from metathorax to segment 3. Perivulvar pores in 5 groups, 48–58 pores. Perispiracular pores usually with 3 loculi, anterior spiracles each with 5–6 pores, posterior spiracles with 1–2 pores. Anal opening located about middle of pygidium. Antennae each with 1 conspicuous seta. Body elongated fusiform with prepygidial segments each moderately convex laterally. Preanal scar present and represented by slender crescent shaped scars.

Affinities. This species is very similar to *P. strachani* from which it differs mainly by the basal zygotis of medial lobes which are small and slightly produced anteriorly into apex of pygidium and the second lobes present and represented by a small, apically pointed process.

Material examined. Korea. Chungcheongnamdo (CN): Gyeryosan, 7 adult females, on *Styrax japonica* (Styracaceae) twig, 26-iv-2013 (S.J. Suh).

Hosts. Anacardiaceae: *Lannea coromandelica*. Aquifoliaceae: *Ilex crenata*, *Ilex integra*. Caprifoliaceae: *Viburnum dilatatum*, *Viburnum plicatum*, *Viburnum sieboldii*, *Viburnum* sp. Cornaceae: *Cornus controversa*, *Cornus macrophylla*, *Cornus* sp. Clethraceae: *Clethra barbinervis*. Daphniphyllaceae: *Daphniphyllum macropodum*. Styracaceae: *Styrax japonica*. Theaceae: *Camellia japonica*, *Cleyera japonica*, *Eurya japonica* (Kawai 1980; Ben-Dov et al. 2013).

Distribution. Japan and Korea* (Ben-Dov et al. 2013).

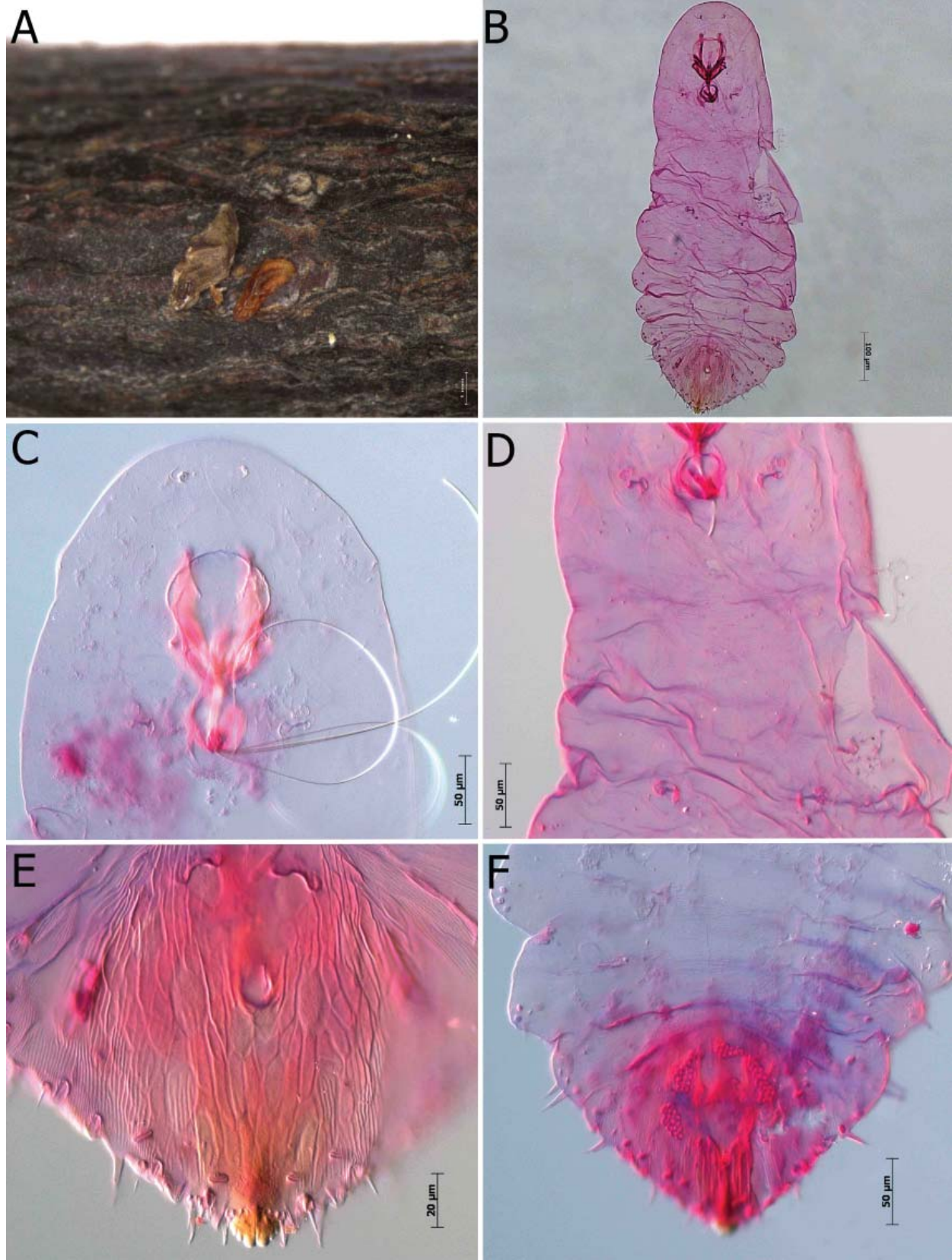


Figure 2. *Pinnaspis hikosana* Takagi. **A)** Habitus. **B)** Female. **C)** Antennae. **D)** Anterior and posterior spiracles. **E)** Median lobes and preanal scars. **F)** Perivulvar pores.

Remarks. This species has two generations per year, hibernates as an adult female and the first generation appears in mid-May to early June in Japan (Kawai 1980).

***Pinnaspis uniloba* (Kuwana), 1909** (Figures 3A–E)

Mytilaspis (*Lepidosaphes*) *uniloba* Kuwana, 1909: 156. Type data: Japan, on *Osmanthus* sp., ?-iii-1907.

Field Characters. Adult female cover elongate oyster-shell shaped, dark brown (Takagi 1970). Male not observed during the survey.

Slide-mounted Characters. Adult female with one lobe, the second lobes absent. Median lobes fused throughout their entire length, thus forming a single median lobe with 2–3 lateral notches, the basis zygotis prominent, small and slightly produced anteriorly into apex of pygidium, the basal sclerites heavily sclerotized patches. Gland spine formula 1–1–1, with about 16–18 gland spines near each body margin from segments 3 to 7. Macroducts of 2 sizes, larger size in marginal areas on segments 4 to 7, smaller size in marginal areas from metathorax to segment 3 and in submarginal area of segment 4. Perivulvar pores in 5 groups, 42–60 pores. Perispiracular pores usually with 3 loculi, anterior spiracles each with 2–4 pores, posterior spiracles nothing or 1 pore. Anal opening located about middle of pygidium. Antennae each with 1 conspicuous seta. Body elongated fusiform, almost parallel on the lateral margins through the thorax and prepygidial abdominal segments, with prepygidial segments each slightly convex laterally, with pygidium triangular. Preanal and poster lateral to the anus scars present and represented by a slender sclerotized bar.

Affinities. This species is distinct among species of *Pinnaspis* that occur in Korea by having a wholly fused median lobe.

Material examined. Korea. Jeollanamdo (JN): Wando arboretum, 13 adult females, on *Cleyera japonica* (Theaceae) leaf, 10-v-2007 (S.J. Suh).

Hosts. Apocynaceae: *Alyxia olivaeformis*, *Alyxia* sp. Fabaceae: *Bauhinia racemosa*. Magnoliaceae: *Michelia* sp. Oleaceae: *Osmanthus fortunei*, *Osmanthus fragrans*, *Osmanthus* sp. Rutaceae: *Aegle marmelos*. Theaceae: *Adinandra milletti*, *Adinandra ryukyuensis*, *Adinandra* sp., *Camellia japonica*, *Cleyera japonica*, *Cleyera ochracea*, *Eurya japonica*, *Thea japonica* (Kawai 1980; Ben-Dov et al. 2013).

Distribution. Hawaiian Islands, India, Taiwan, China, Japan and Korea* (Ben-Dov et al. 2013).

Remarks. This species has one generation per year, hibernates in the egg stage and the first generation appears in May in Japan. It lacks males and is parthenogenetic (Kawai 1980).

Key to species of *Pinnaspis* from Korea (slide mounted adult female)

1. Found only on conifers. ***P. chamaecyparidis* Takagi**
- Not found on conifers. **2**
2. Median lobes fused throughout their length, thus forming a single median lobe. ***P. uniloba* (Kuwana)**
- Median lobes although usually very closely appressed together, separate for at least some distance from the apex, if not to the base. **3**
3. Median lobes protrude less than or about the same distance as second lobes. **4**
- Median lobes protrude beyond or about the same distance as second lobes. **5**
4. With submarginal ducts on dorsum of 5th abdominal segment. ***P. aspidistrae* (Signoret)**
- Without submarginal ducts on dorsum of 5th abdominal segment. ***P. buxi* (Bouché)**
5. Basal zygotis of median lobes slender, scarcely produced anteriorly beyond bases of the lobes. ***P. hikosana* Takagi**
- Basal zygotis of median lobes robust, distinctly produced anteriorly beyond bases of the lobes. ***P. strachani* (Cooley)**

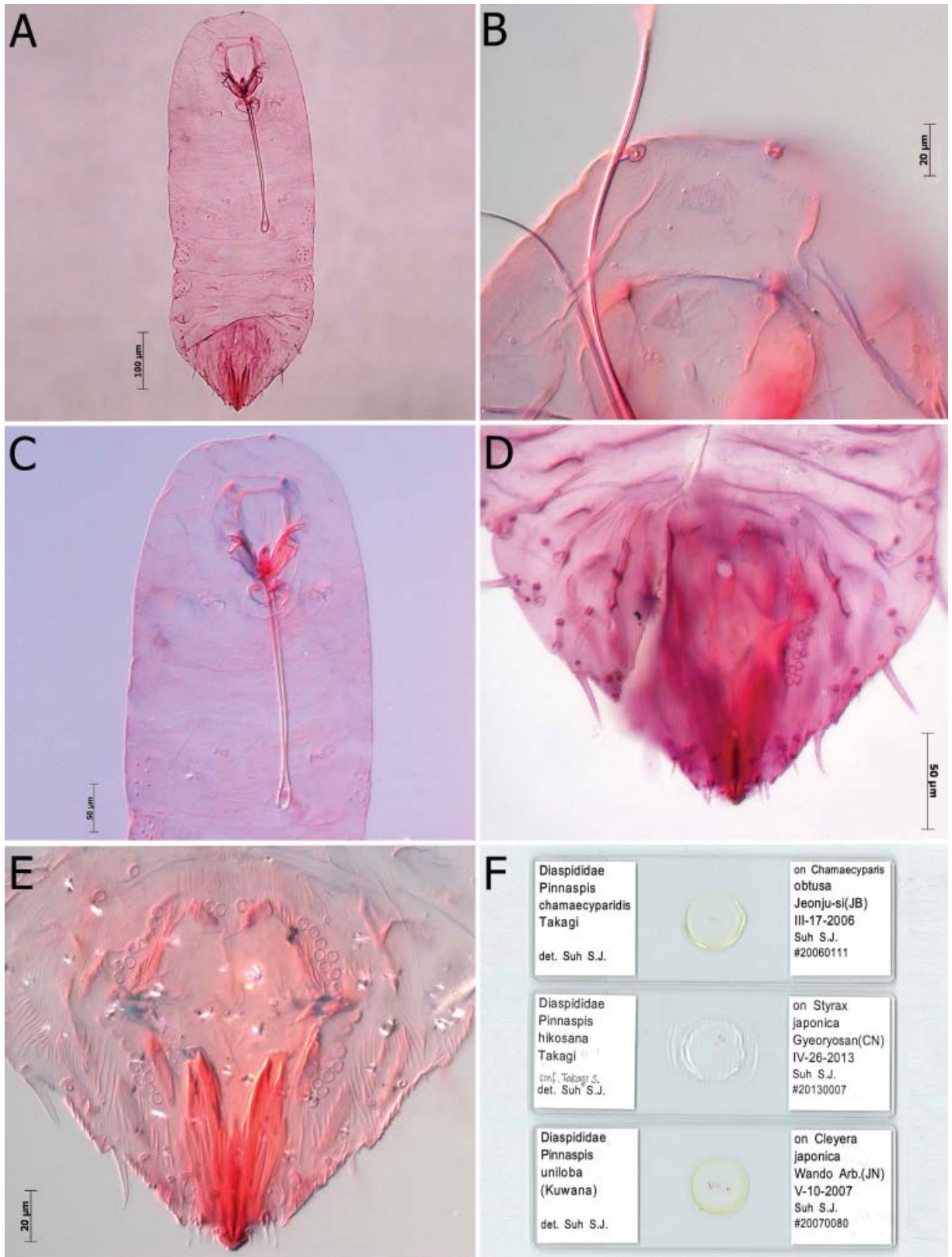


Figure 3. Three species of *Pinnaaspis*. **A)** *P. uniloba* (Kuwana), female. **B)** *P. uniloba* (Kuwana), antennae. **C)** *P. uniloba* (Kuwana), anterior and posterior spiracles. **D)** *P. uniloba* (Kuwana), median lobes and preanal scars. **E)** *P. uniloba* (Kuwana), perivulvar pores. **F)** Slide-mounted specimens.

Discussion

The list of Korean *Pinnaspis*, including *Pinnaspis chamaecyparidis* Takagi, *Pinnaspis hikosana* Takagi and *Pinnaspis uniloba* (Kuwana) which are newly recorded, is updated through the survey conducted recently. The information provided in the paper will be helpful in better understanding Korean *Pinnaspis* species. Such research should be considered to be an integral part of more appropriate and cost-effective preventative quarantine procedures to overcome the challenge from exotic species.

Of these, *P. buxi* and *P. strachani* which have been reported to occur in Korea should be reviewed by analyzing information on their morphological affinities and the results of the survey. First, *P. buxi* is very near *P. aspidistrae* and can only be separated on the basis of the laterally produced metathoracic lobes of *P. aspidistrae* and fewer submarginal ducts of *P. buxi*. It is likely that this record represents a misidentification of *P. aspidistrae*. The other species, *P. strachani* is most similar to *P. aspidistrae*; a few specimens are difficult or impossible to determine using the criteria, the combination of the following characters; the fern scale has small median lobes that protrude less than or about the same distance as the large second lobes, the preanal scars are lacking or represented by light sclerotized patches and the pores around posterior spiracles are present; the lesser snow scale has large median lobes that protrude beyond or about the same distance as the small second lobes, the preanal scars are represented by heavily sclerotized bars and pores around posterior spiracles are absent (Ferris and Rao 1947; Takagi 1963, 1970; Miller and Davidson 2005). The resolution of the taxonomy of the species comprising the *aspidistrae-strachani* complex of *Pinnaspis* has long remained unsettled. *Pinnaspis aspidistrae* has sometimes been misidentified as *P. strachani* and *vice-versa*. Although the two species were recorded in Korea, they are considered to have failed to establish in the exterior environment and greenhouses because they have not been collected in the field and greenhouses during the last 7 years. Therefore, the presence of both of these species in Korea should be regarded as uncertain.

Acknowledgements

I would like to thank Dr. Sadao Takagi (Hokkaido University, Japan) for confirming the identification. I am also grateful to Greg Evans (USDA/APHIS/NIS, Washington, DC, USA) and Greg Hodges (FDACSDPI, Florida, USA) for their useful editorial contributions to early drafts of this paper.

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Received January 3, 2014; Accepted January 30, 2014.

