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ORIGINAL ARTICLE

# Taxonomic review of the genus *Xenolecanium* Takahashi and description of the new genus *Takahashilecanium* Kondo (Hemiptera: Coccidae; Coccinae, Paralecaniini)

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## Abstract

The genus *Xenolecanium* Takahashi is reviewed and transferred from the subfamily Myzolecaniinae to the Coccinae (tribe Paralecaniini). The type species *Xenolecanium mangiferae* Takahashi is redescribed, and *Xenolecanium takahashii* Kondo sp. nov. from Indonesia is described based on the adult female and first instar nymph. A taxonomic key is provided to separate adult females of the two species of *Xenolecanium*. *Xenolecanium rotundum* Takahashi is transferred to become the type species of a new monotypic genus, *Takahashilecanium* Kondo, which is also placed in the Paralecaniini. The morphological justification for placing *Xenolecanium* and *Takahashilecanium* in the Paralecaniini is discussed, and we provide a taxonomic key for separating both genera from all other members of the Paralecaniini.

**Key words:** ant association, Coccoidea, scale insect, taxonomic key.

## INTRODUCTION

The soft scale genus *Xenolecanium* was erected by Takahashi (1942a) for *X. mangiferae* Takahashi, 1942, collected in Thailand on the branches of a mango tree. Takahashi later added a second species from Indonesia, *X. rotundum* Takahashi, found on an undetermined host and tended by ants (Takahashi 1951). We revise the taxonomy of the genus *Xenolecanium* in comparison with the genus *Paralecanium* Cockerell. A new species from Indonesia, *Xenolecanium takahashii* Kondo, is added to the genus, and a new genus, *Takahashilecanium* Kondo, is erected for *Xenolecanium rotundum*. The adult females of the three species are described or redescribed. The first instar nymph (crawler) is known only for *X. takahashii*, and is described here for the first

time. We speculate that certain morphological features of *Takahashilecanium rotundum* (Takahashi) are adaptations to a mutualistic association with *Crematogaster* ants.

## MATERIALS AND METHODS

The microscope slide-mounted specimens are deposited in the following institutions: Auburn University Coccoidea Collection, Alabama, USA (AUCC); the Bohart Museum of Entomology, Department of Entomology, University of California, Davis, California, USA (BME); Brunei Museum, Jalan Kota Batu, Brunei Darussalam (BMKB); the Natural History Museum, London, UK (BMNH); the Systematic Entomology Collection, Faculty of Agriculture, Hokkaido University, Sapporo, Hokkaido, Japan (SEHU); the Insect Museum, Taiwan Agricultural Research Institute, Taiwan (IMZT); and the National Museum of Natural History Coccoidea Collection, Beltsville, Maryland, USA (USNM).

Terms for morphological features follow chiefly those of Hodgson (1994). Measurements of specimens were made using an ocular micrometer on an Olympus

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(Japan) BX40 and a Zeiss (Germany) standard RA phase-contrast microscope.

### Material of other taxa studied for comparison

Adult ♀, *Paralecanium paradeniyense* Green, 1904, labeled as Metatype, Sri Lanka (as Ceylon), Paradeniya, specimens received from E. E. Green, ex *Piper nigrum*, two slides two specimens (BME). First instar nymph, *P. paradeniyense*, same data as adult ♀, one slide four specimens (BME). First instar nymph, *P. planum* (Green, 1896), labeled as Metatype, Sri Lanka (as Ceylon), Paradeniya, specimens received from E. E. Green, one slide one specimen (BME). Adult ♀, *Paralecanium* sp., determined by T. Kondo, West Malaysia, S. G., Terkala, 13.v.1995, coll. A. Weissflog, host not given, tended by *Camponotus* sp., AL-105-99, one slide one specimen, AL-094-99, two slides two specimens (AUCC).

## TAXONOMY

The genus *Xenolecanium* Takahashi was placed in the subfamily Myzolecaniinae by Hodgson (1994). The Myzolecaniinae consist mostly of myrmecophilous soft scale insects that are characterized by their lack of dorsal tubular ducts and eyespots, and the presence of anal plates with numerous setae on the dorsal surface, particularly large spiracles with broad bands of spiracular disc pores between the margin and spiracles, ventral tubular ducts of one type and frequently restricted to each side of the genital opening, bands of setae replacing the normal pairs of long pregenital setae, reduced legs with fine claw digitules, reduced antennae and a short anal tube (Hodgson 1994). Recently, it was suggested that the subfamily Myzolecaniinae is composed of several unrelated lineages, and that the morphology of first instar nymphs indicates that several genera in the Myzolecaniinae, including *Xenolecanium*, are not related to the *Myzolecanium* group, which is a group composed of *Cribrolecanium* Green, *Cryptostigma* Ferris, *Halococcus* Takahashi, *Houardia* Marchal and *Myzolecanium* Beccari (Kondo & Williams 2002).

*Xenolecanium* is here transferred to the tribe Paralecaniini of the subfamily Coccinae. The Paralecaniini contains genera characterized by possessing a pair of eyespots on the dorsal surface of the head situated some distance from the margin and with stigmatic clefts noticeably sunken and well sclerotized (Williams 1969). The Paralecaniini was revised by Hodgson (1994: 48) who listed four additional characteristics for the tribe: '(i) lack of dorsal tubular ducts; (ii) restriction of ventral tubular ducts, if present, to a group on either side of

genital opening; (iii) lack of pocket-like sclerotizations (except in *Perilecanium*); and (iv) restriction of pregenital disc-pores to segments immediately anterior to genital opening' (when present). The genus *Xenolecanium* keys out as a member of the Myzolecaniinae in the keys to subfamilies, tribes and genera of the Coccidae provided by Hodgson (1994). This is probably because *Xenolecanium* shares the following characteristics with the Myzolecaniinae: (i) lack of dorsal tubular ducts; (ii) lack of eyespots; (iii) ventral tubular ducts of one type, frequently restricted to a group each side of the genital opening; (iv) reduced legs with fine claw digitules; (v) reduced antennae; and (vi) a short anal tube. The distribution of ventral tubular ducts and the lack of dorsal tubular ducts occur in both the Myzolecaniinae and the Paralecaniini (Coccinae). Furthermore, although not listed as characteristics of the Paralecaniini, the tribe includes members with reduced antennae and legs; for example, *Saccharolecanium krugeri* (Zehntner, 1897) (Hodgson 1994), *Platylecanium cribrigerum* (Cockerell and Robinson, 1915) (Hodgson 1994) and *Paralecanium hainanense* Takahashi, 1942 (Takahashi 1942b). *Xenolecanium* fulfills all of the characteristics listed above for the tribe Paralecaniini, except for the presence of eyes well onto the dorsum. Although the presence of eyes displaced well onto the dorsum has been considered a character defining the Paralecaniini, this character may appear to be absent or not detectable in some species in the Paralecaniini; for example, *Xenolecanium* spp. and *Paralecanium* sp. (AL-105-99), and it is also not found in *P. trifasciatum* Green, 1922 (Green 1922). In *Takahashilecanium rotundum*, the eyespots become visible only in mature specimens, but are not detectable in most young adult female specimens.

Hodgson (1994) subdivided the tribe Paralecaniini into four groups according to their morphological similarities. *Takahashilecanium* falls into Hodgson's Group C, composed of *Melanesicoccus* Williams and Watson, *Neosaissetia* Tao and Wong, and *Platylecanium* Cockerell and Robinson. Adult females of the group have setose or spinose marginal setae and possess pregenital disc pores, but lack ventral tubular ducts. *Xenolecanium* falls into Hodgson's Group A, composed of *Maacoccus* Tao and Wong, and *Saccharolecanium* Williams, in which adult females have very short dorsal setae (normal in *Xenolecanium*) and lack pregenital disc pores but have ventral tubular ducts. The placement of *Xenolecanium* in the Paralecaniini is supported also by the morphology of first instar nymphs. The first instar nymph of *X. takahashii* is similar to those of *Paralecanium* (T. Kondo, unpubl. data, 2004); for example,

*P. paradeniyense* Green, 1904 and *P. planum* (Green, 1896) in which a seta is present next to each mesothoracic and metathoracic coxa, and the spiracular setae are positioned submarginally on the dorsum on the sides of a deep stigmatic cleft (see Fig. 3C). We conclude that *Xenolecanium* is a genuine member of the Coccinae: Paralecaniini and not a member of the Myzolecaniinae. The similarity of *Takahashilecanium* Kondo gen. nov. and *Xenolecanium* to members of the Myzolecaniinae may be explained by the convergence of some features (e.g. absence of eyespots, dorsal tubular ducts and dorsal tubercles; reduction of legs, antennae, and anal tube; numerous setae on the anal plates) due to these taxa sharing the habit of living in close association with tending ants.

*Takahashilecanium* Kondo gen. nov. and *Xenolecanium* Takahashi can be incorporated into Hodgson's (1994) key to the tribe Paralecaniini (Coccinae) as follows.

#### Key to the genera of the tribe Paralecaniini (Coccinae)

- 1 Dorsum with subcircular, quadrate or irregularly shaped sclerotic plates..... 2
- Dorsum without sclerotic plates..... see Hodgson (1994): 78, subfamily Coccinae, tribe Paralecaniini (*Anthococcus* Williams and Watson, *Maacoccus* Tao and Wong, *Marsipococcus* Cockerell and Bueker, *Megalocryptes* Takahashi, *Melanesicoccus* Williams and Watson, *Neoplatylecanium* Takahashi, *Neosaissetia* Tao and Wong, *Paralecanium* Cockerell, *Perilecanium* da Fonseca, *Platylecanium* Cockerell and Robinson, *Podoparalecanium* Tao and Wong, *Pseudalichtensia* Hempel, *Saccharolecanium* Williams).
- 2 Mid-dorsum with a subcircular cribriform plate; without preopercular pores..... *Xenolecanium* Takahashi
- Mid-dorsum without a cribriform plate; preopercular pores present in two distinct groups laterad to anal plates..... *Takahashilecanium* Kondo gen. nov.

#### Genus *Xenolecanium* Takahashi

*Xenolecanium* Takahashi (1942): 26; Tang (1991): 144; Hodgson (1994): 607.

Type species: *Xenolecanium mangiferae* Takahashi, 1942. By original designation and monotypy.

*Diagnosis of adult female.* Dorsal derm with subcircular sclerotic plates, abundant near body margin. A single subcircular cribriform plate present on mid-dorsum of thoracic region. Dorsal body setae slender. Dorsal

tubercles and preopercular pores absent. Dorsal microducts present. A sclerotized area present around anal plates. Anal plates together quadrate, slightly pyriform, located at approximately one-fifth to one-fourth of body length from posterior margin, each plate with approximately four setae on dorsal surface. Eyespots absent. Margins crenulated. Marginal setae slender, with apex of setae variable. Stigmatic clefts deep, forming a sclerotic plate; with three stigmatic setae of subequal length. Ventral tubular ducts present in a small group around vulvar opening. Pregenital disc pores absent. Spiracular disc pores mostly five-locular, found within a stigmatic furrow. Antennae reduced, one- or two-segmented. Legs greatly reduced; claw present. Spiracles located closer to legs than to body margin.

#### Key to the species of *Xenolecanium* Takahashi

- 1 Legs with all segments fused; some marginal setae with a branched apex..... *Xenolecanium mangiferae* Takahashi
- Legs showing incomplete segmentation; some marginal setae with a flat and broad apex  
..... *Xenolecanium takahashii* Kondo sp. nov.

#### *Xenolecanium mangiferae* Takahashi

(Fig. 1)

*Xenolecanium mangiferae* Takahashi (1942a): 27–28; Tang (1991): 144–145; Hodgson (1994): 607–609.

*Diagnosis of adult female.* Unmounted material: Insects blackish brown, shining, yellowish brown in some dried specimens, irregular in shape, generally ovate, slightly longer than wide, slightly convex dorsally; body margin, area around anal plates, and stigmatic area particularly sclerotized; body segments not discernible (modified from Takahashi 1942a).

Mounted material: Body outline oval to elongate oval. Dorsal derm membranous, with subcircular sclerotic plates (Fig. 1B) scattered evenly on dorsum, except for a small area on mid-dorsum. (Enlargement of dorsal derm shown in Fig. 2A.) A large subcircular cribriform plate (Fig. 1D) present on mid-dorsum. Simple disc pores (Fig. 1E) present evenly on dorsum. Dorsal body setae (Fig. 1H) slender, straight or slightly bent, evenly distributed over dorsum. Dorsal microducts (Fig. 1G) evenly distributed on dorsum. A sclerotized area present around anal plates. Anal plates (Fig. 1I) together slightly pyriform, located at approximately one-fifth of body

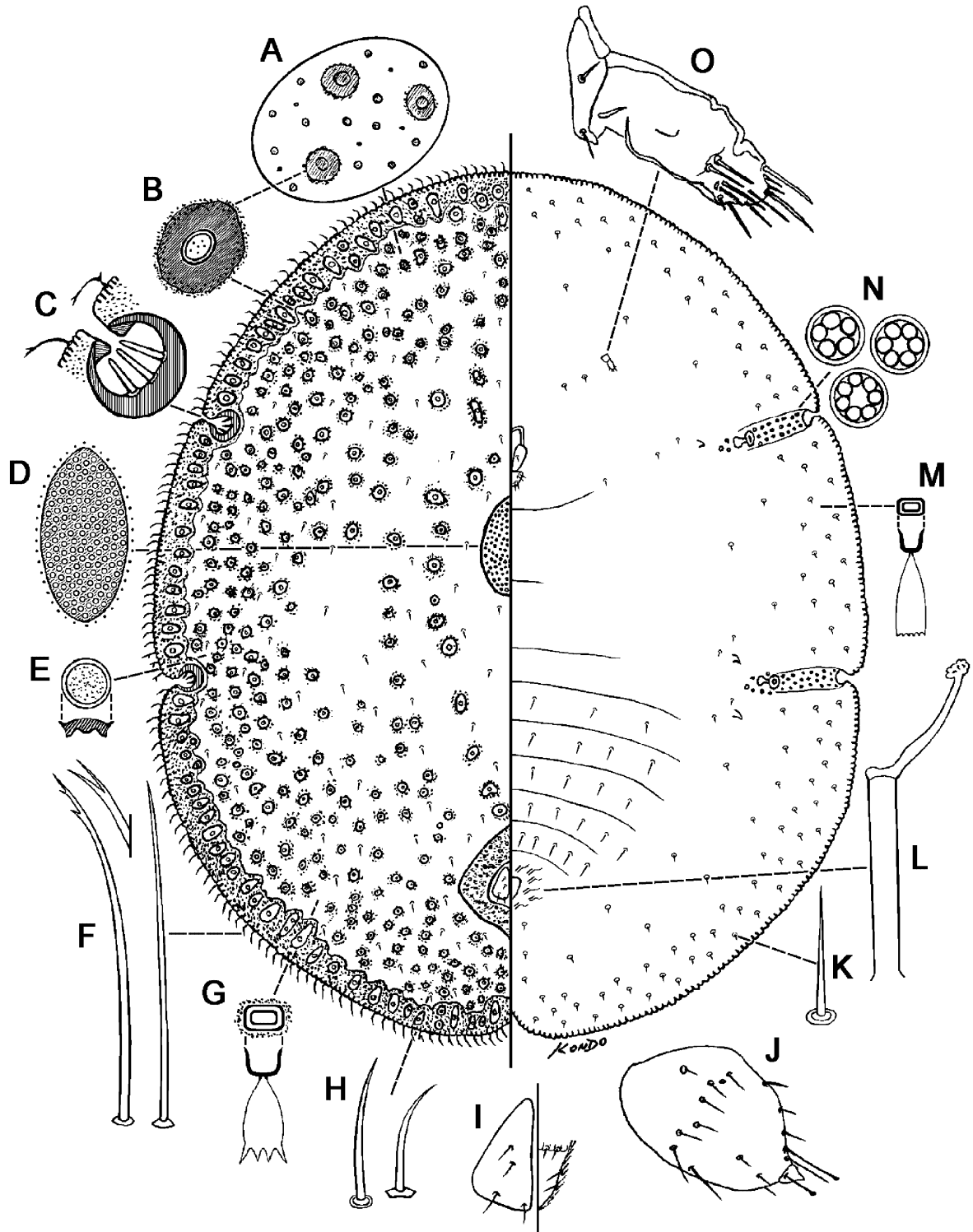


Figure 1 *Xenolecanium mangiferae* Takahashi, adult female. (A) Enlargement of dorsal derm, (B) sclerotic plate, (C) stigmatic cleft, (D) cribriform plate, (E) simple disc pore, (F) marginal setae, (G) dorsal microduct, (H) dorsal setae, (I) anal plates, (J) leg, (K) ventral seta, (L) ventral tubular duct, (M) ventral microduct, (N) spiracular pores and (O) antenna.

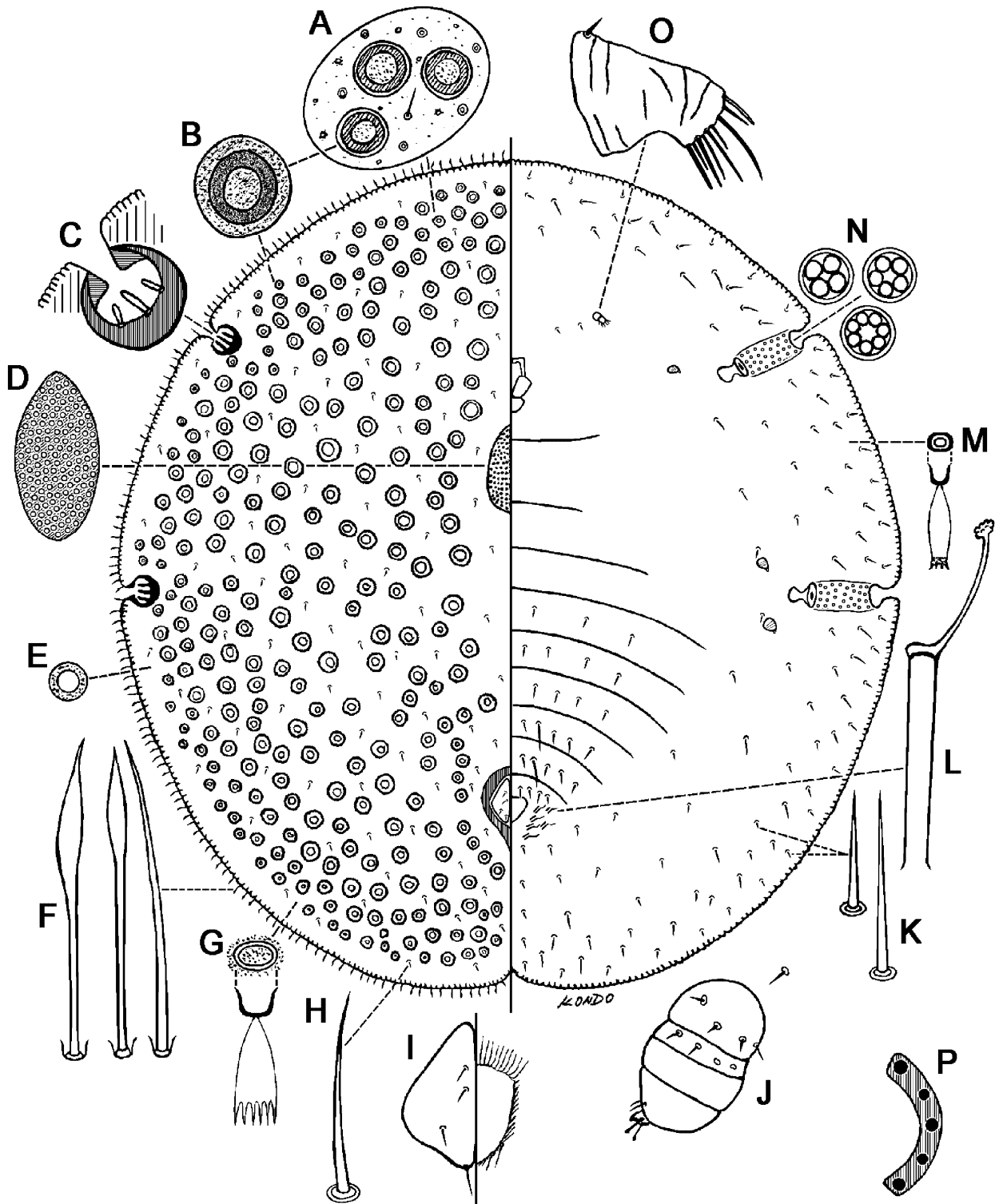


Figure 2 *Xenolecanium takahashii* Kondo sp. nov., adult female. (A) Enlargement of dorsal derm, (B) sclerotic plate, (C) stigmatic cleft, (D) cribriform plate, (E) simple disc pore, (F) marginal setae, (G) dorsal microduct, (H) dorsal setae, (I) anal plates, (J) leg, (K) ventral seta, (L) ventral tubular duct, (M) ventral microduct, (N) spiracular pores, (O) antenna and (P) anal ring.

length from posterior margin, with four setae on dorsal surface. Anal ring not visible due to derm sclerotization. Eyespots absent.

**Margin:** Body margin crenulated. Marginal setae (Fig. 1F) slender, simple or branched, arranged in one row, 24–27 between anterior and posterior stigmatic areas. Stigmatic cleft deep, forming a sclerotic plate (Fig. 1C), with three stigmatic setae of subequal length.

**Venter:** Derm membranous. Ventral setae (Fig. 1K) slender, abundant around submargin and abdominal segments; those closer to margin shorter. Ventral microducts (Fig. 1M) distributed evenly on venter. Ventral tubular ducts (Fig. 1L) present in a small group around vulvar opening. Pregonital disc pores absent. Spiracular disc pores (Fig. 1N) with five to seven (mostly five) loculi, found around each spiracle and extending to body margin; pores found within a stigmatic furrow. Antennae (Fig. 1O) reduced, segments fused, approximately two-segmented. Interantennal setae two next to each antennal scape. Legs (Fig. 1J) greatly reduced, all segments fused except for claw. Spiracles located closer to legs than to body margin.

**Distribution.** Thailand.

**Biology.** Insects were collected on a branch of *Mangifera indica* (Anacardiaceae).

**Lectotype.** Adult ♀, Thailand (Siam), Bangkok, 30.iii.1940, coll. R. Takahashi, ex mango, one slide one specimen, labeled as *Ctenochiton mangiferae* (IMZT). Paralectotypes: Adult ♀, same data, 11 slides 11 specimens (IMZT), two slides two specimens (BMNH).

**Paralectotype.** Adult ♀, one slide one specimen (BMNH).

**Remarks.** Features that separate *X. mangiferae* from *X. takahashii* Kondo, sp. nov. are discussed in the Remarks section for the latter species.

### *Xenolecanium takahashii* Kondo, sp. nov.

(Figs 2,3)

*Xenolecanium eugeniae*; Hodgson (1995): 49–53 (nomen nudum).

**Adult female.** (Fig. 2) Unmounted material: Not available during present study.

**Mounted material:** Body outline oval to elongate oval, 2.8–3.0 mm long, 2.3–3.0 mm wide ( $n = 2$ ).

**Dorsum:** Derm membranous, with circular sclerotic plates (Fig. 2B), each plate 11–75 mm wide, evenly distributed on dorsum, absent from a small area on mid-dorsum; those closer to body margin smallest. (Enlargement of dorsal derm shown in Fig. 2A.) A subcircular cribriform plate (Fig. 2D) present on mid-dorsum, plate

length 243–286  $\mu\text{m}$ , width 135–146  $\mu\text{m}$ . Simple disc pores (Fig. 2E) approximately 2.7–3.6  $\mu\text{m}$  wide evenly distributed on dorsum. Dorsal body setae (Fig. 2H) slender, 5.3–10.7  $\mu\text{m}$  long, evenly distributed over dorsum. Dorsal microducts (Fig. 2G) approximately 3.6  $\mu\text{m}$  wide evenly distributed on dorsum. A small sclerotized area present around anal plates. Anal plates (Fig. 2I) together slightly pyriform, located at approximately one-fifth of body length from posterior margin, each plate 126–136  $\mu\text{m}$  long, 75–79  $\mu\text{m}$  wide, anterolateral margin 100–107  $\mu\text{m}$  long, posterolateral margin 85–90  $\mu\text{m}$  long, with four setae on dorsal surface. Anal ring (Fig. 2P) with 10 setae. Eyespots absent.

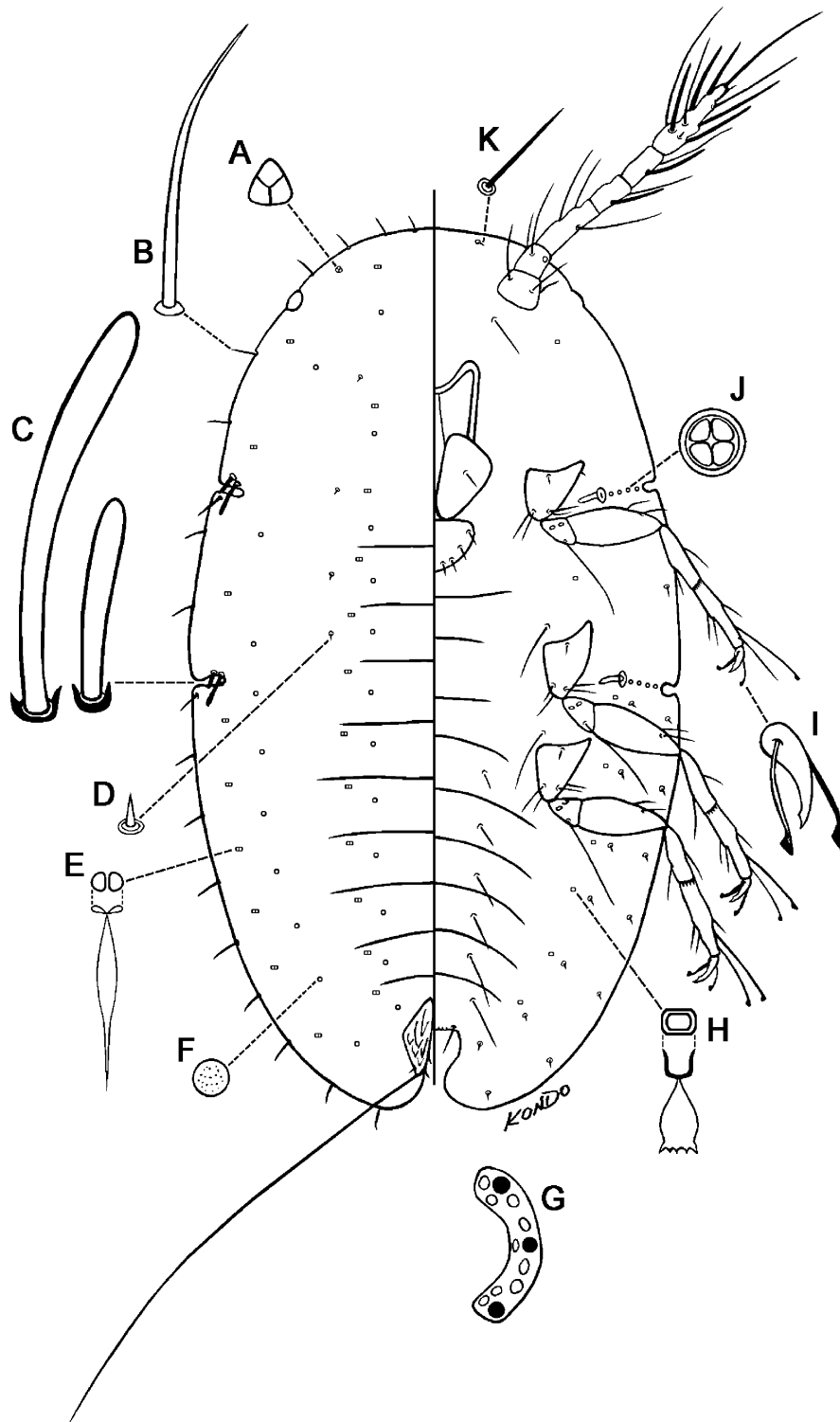
**Margin:** Body margin crenulated. Marginal setae (Fig. 2F) slender, straight or with a bent apex, simple or with a broad and flattened apex, somewhat lanceolate, 12–52  $\mu\text{m}$  long, arranged in one row, numerous, 25–30 between anterior and posterior stigmatic areas. Stigmatic cleft deep, forming a sclerotized plate (Fig. 2C). With three stigmatic setae, subequal in length, 12–23  $\mu\text{m}$  long.

**Venter:** Derm membranous. Ventral setae (Fig. 2K) slender, 5–24  $\mu\text{m}$  long, abundant around submargin and abdominal segments; those closer to margin shorter. Ventral microducts (Fig. 2M) scattered evenly on venter, each duct approximately 1.8  $\mu\text{m}$  wide. Ventral tubular ducts (Fig. 2L) present in a small group around vulvar opening. Clypeolabral shield 151–167  $\mu\text{m}$  wide. Pregonital disc pores absent. Spiracular disc pores (Fig. 2N) with four to seven (mostly five) loculi; each pore 2.7–4.4  $\mu\text{m}$  wide, found anterior to each spiracle and extending to body margin; pores within a stigmatic furrow. Antennae (Fig. 2O) reduced, with segments fused, one-segmented, small, 43–51  $\mu\text{m}$  long. Interantennal setae two pairs. Legs (Fig. 2J) greatly reduced, total length 21–45  $\mu\text{m}$ , with four segments, probably tibia and tarsus fused; tarsal digitules similar, spiniform; claw digitules similar, knobbed; claw without a denticle. Spiracles closer to legs than body margin; anterior spiracular peritremes 66–75  $\mu\text{m}$  wide, posterior spiracular peritremes each 64–81  $\mu\text{m}$  wide.

**First instar nymph.** (Fig. 3) Unmounted material: Not available during present study.

**Mounted material:** Slide-mounted specimens elongate oval, 539–615  $\mu\text{m}$  long, 313–388  $\mu\text{m}$  wide ( $n = 6$ ).

**Dorsum:** Dorsal derm membranous, with segmentation delineated by membranous folds. Dorsal setae (Fig. 3D) short, 2.5–3.6  $\mu\text{m}$  long, present in two submedial longitudinal rows of four setae on anterior part of body. A trilocular pore (Fig. 3A) present on each side of head region near margin. Microducts (Fig. 3E) appear-



**Figure 3** *Xenolecanium takahashii* Kondo sp. nov., first instar nymph. (A) trilocular pore, (B) marginal seta, (C) stigmatic setae, (D) dorsal seta, (E) dorsal microduct, (F) simple disc pore, (G) anal ring, (H) ventral microduct, (I) claw, (J) spiracular pore and (K) ventral cephalic seta.



ing bilocular, very small, approximately 0.9  $\mu\text{m}$  wide, present submarginally and in two submedial longitudinal rows. Most microducts associated with simple disc pores (Fig. 3F), each simple disc pore approximately 1.8  $\mu\text{m}$  wide. Anal plates of a shingled texture, each triangular, 49–60  $\mu\text{m}$  long, 19–23  $\mu\text{m}$  wide, with three subapical setae, one long apical seta, one hypopygial seta and one fringe seta (not illustrated). Anal ring (Fig. 3G) with six setae and one irregular row of translucent wax pores. Eyes located at approximately same level as antennal scape.

Margin: Outline smooth. Marginal setae (Fig. 3B) sharply spinose, straight or with slightly bent tips, total 36, numbering eight anteriorly between eyes, two between each eye and anterior stigmatic setae, three between each anterior and posterior stigmatic setae, and nine between each posterior stigmatic cleft and body apex. Stigmatic cleft deep. Stigmatic setae (Fig. 3C) numbering two, well differentiated from marginal setae, found on dorsum on anterior part of cleft, bluntly spinose, tips usually slightly swollen, with one stigmatic setae longer than other, longer seta 13–20  $\mu\text{m}$  long, shorter seta 9–15  $\mu\text{m}$  long.

Venter: Derm membranous. Submedial abdominal setae in six pairs, seven pairs of submarginal setae on abdomen, a single submarginal seta between each anterior and posterior spiracle, and one pair near apex of head (Fig. 3K). Long seta present anteromedially to each mesothoracic and metathoracic coxa. Six ventral microducts (Fig. 3H) present next to each inner submarginal seta on abdomen, one between anterior and posterior spiracle, and one near base of each antennal scape. Spiracular disc pores (Fig. 3J) with four loculi, approximately 2.7  $\mu\text{m}$  wide, numbering four between each spiracle and stigmatic cleft. Clypeolabral shield 79–96  $\mu\text{m}$  wide, with four pairs of labial setae. Legs well developed, trochanter plus femur 75–85  $\mu\text{m}$  long, tibia plus tarsus 87–107  $\mu\text{m}$  long, microctenidia present on tibial apex. Prothoracic tarsal digitules dissimilar, one knobbed and one spiniform; mesothoracic and metathoracic tarsal digitules similar, knobbed. Claw (Fig. 3I) with a denticle, claw digitules similar, knobbed. Antennae six-segmented, total length 183–194  $\mu\text{m}$  long, with third antennal segment longest; fleshy setae present on last three apical segments. One pair of interantennal setae present.

*Etymology.* The species is named in honor of its collector Dr Ryoichi Takahashi.

*Distribution.* Indonesia (Rempang, Riau Islands).

*Biology.* Unknown.

*Type material studied.* Adult ♀, *Xenolecanium takahashii* Kondo sp. nov. Indonesia (Rempang, Riau Islands, near Singapore), i.1946, coll. R. Takahashi, one slide two specimens, labeled as *Xenolecanium eugeniae* Takahashi, holotype on left side, paratype on right side of the slide when labels are in reading position (USNM). Other paratypes: first instar nymphs, one slide six specimens, same data (USNM).

*Remarks.* There are no data concerning its specific host, but, judging from the specific epithet ‘*eugeniae*’ written on the slide label, it is fair to assume that its host is a species in the genus *Eugenia* (Myrtaceae). *Xenolecanium takahashii* is morphologically similar to *X. mangiferae*, but it can be distinguished from it by the presence of broad-tipped marginal setae, by the discernible segmentation of the legs, by having a non-sclerotized body margin, and dorsal sclerotic plates with a smooth margin. Hodgson (1995) gives a detailed description of the spiracles of the adult female (as *Xenolecanium eugeniae* Takahashi).

### *Takahashilecanium* Kondo, gen. nov.

Type species: *Xenolecanium rotundum* Takahashi, 1951.

*Diagnosis of adult female.* (Fig. 4) Dorsal derm of mature specimens with large quadrate, triangular to irregular shaped sclerotic plates. Dorsal setae present, slender. Dorsal tubercles absent. Dorsal microducts present, with a long terminal filament. Preopercular pores present in two groups located laterad to anal plates. Anal plates together quadrate to slightly pyriform. Eyespots present, located far from body margin. Margin crenulated. Marginal setae sharply spinose, numerous, with well-developed bases. Stigmatic clefts deep, forming a sclerotic plate. Stigmatic setae three or four in number, all subequal in length. Ventral tubular ducts absent. Pregenital disc pores with five to seven loculi, present in a small group posterior to vulvar opening on each side of anal cleft. Spiracular disc pores with four to six loculi. Antennae six- or seven-segmented.

*Etymology.* The generic name is given in honor of its collector Dr Ryoichi Takahashi. The suffix ‘*lecanium*’ is commonly used in coccid names.

### *Takahashilecanium rotundum* (Takahashi), comb. nov.

(Figs 4,5)

*Xenolecanium rotundum* Takahashi (1951): 105; Tang (1991): 145.

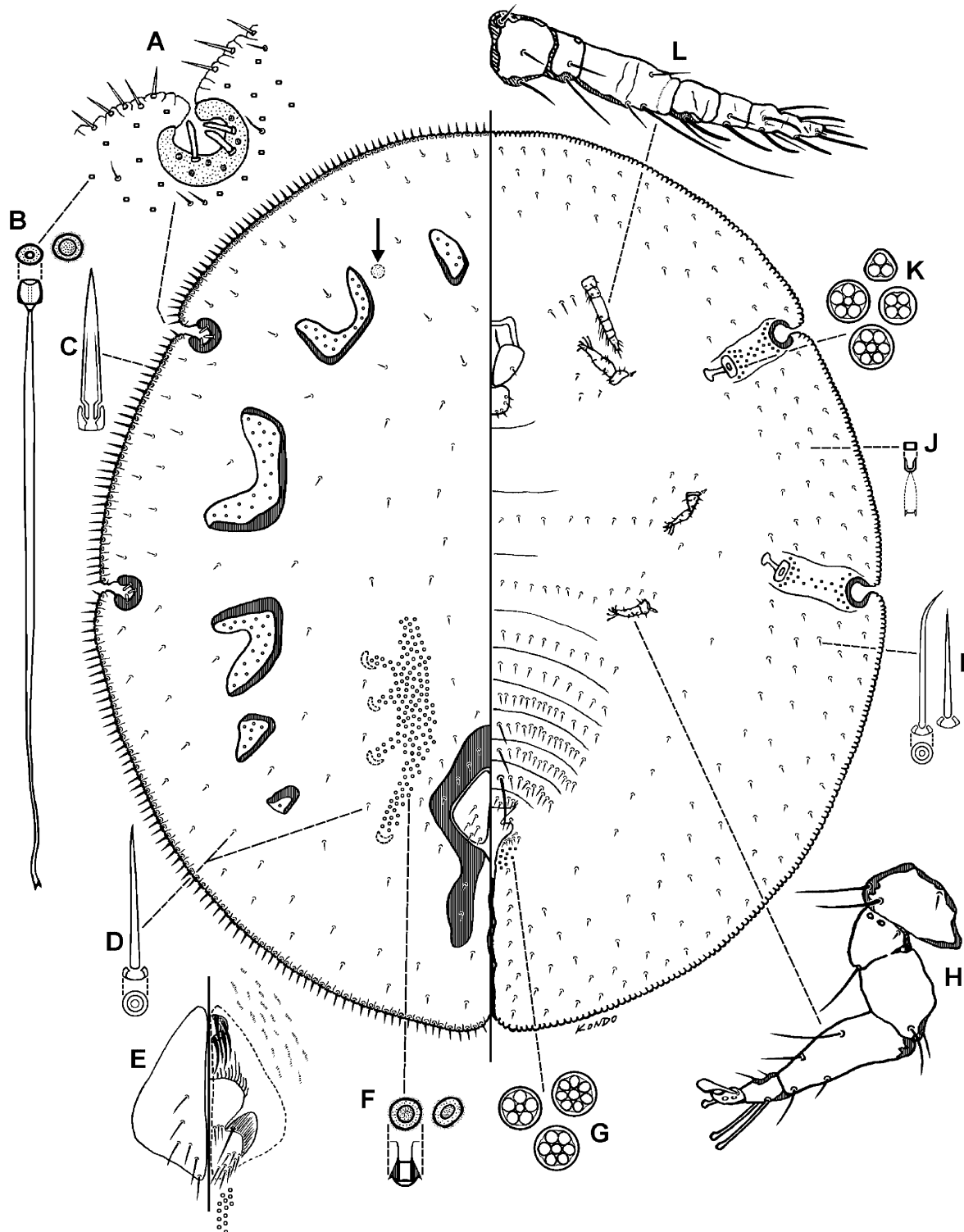
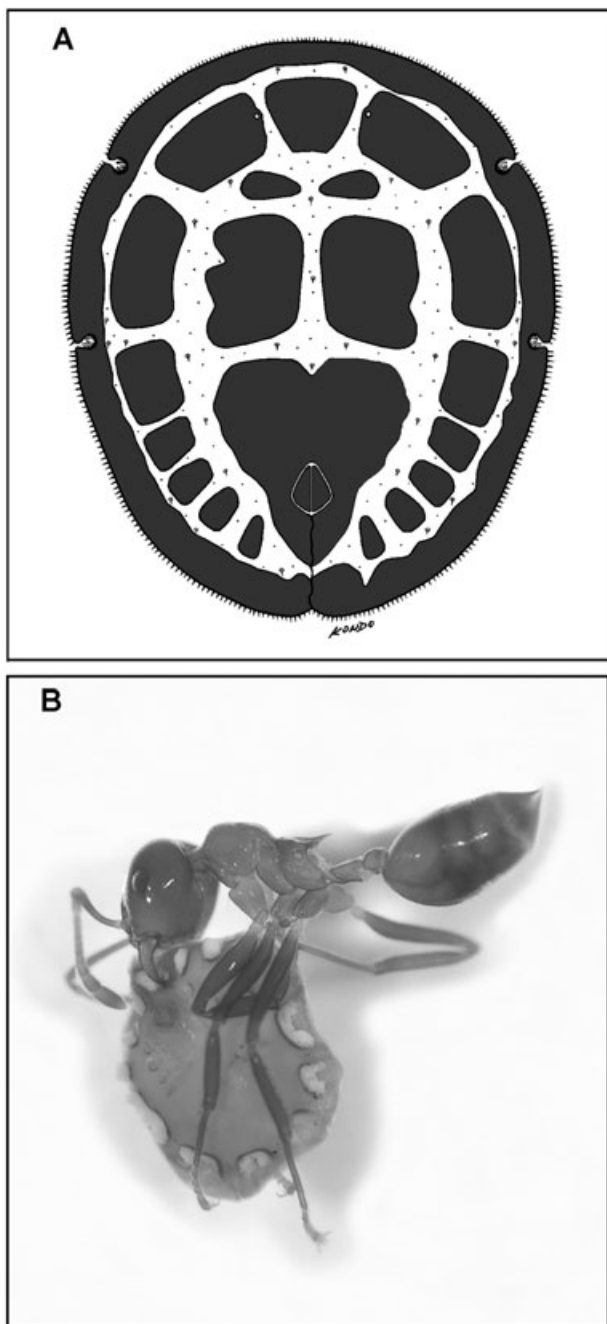


Figure 4 *Takahashilecanium rotundum* (Takahashi), young adult female. (A) enlargement of stigmatic area, (B) dorsal microduct, (C) marginal seta, (D) dorsal seta, (E) anal plate and anal ring, (F) prepericular pores, (G) pregenital disc pores, (H) leg, (I) ventral setae, (J) ventral microduct, (K) spiracular disc pores and (L) antenna.



**Figure 5** (A) Dorsal view of a fully mature adult female of *Takahashilecanium rotundum* (Takahashi), showing distribution of sclerotic plates and marginal sclerotization; and (B) a *Crematogaster* ant carrying a coccid by holding a submarginal sclerotic plate of *T. rotundum*.

*Description of adult female.* Live insects: Adult female oval to elongate oval, somewhat bottlecap-shaped, submargins elevated, with various ridges, these associated with submarginal sclerotic plates seen on slide-mounted specimens; mid-dorsum forming a depression, slightly corrugated, with elevated areas forming a cross on mid-dorsum. Eyespots present or absent, visible as dark spots when detectable; located far from body margin. Insects pink to purplish red in color, mid-dorsum and margin colorless, almost translucent, submargin often mottled in brown in older specimens; parasitized specimens orange, yellowish brown, yellowish gray to dark, parasitoids visible through derm.

Mounted material: Body outline circular to subcircular, 2.2–2.7 mm long, 1.9–2.5 mm wide ( $n = 36$ ).

Dorsum: Derm membranous, with quadrate, triangular to irregular shaped sclerotic plates (Figs 4,5) present submarginally around insect body: three or four plates between anterior stigmatic areas, one large plate between each anterior and posterior stigmatic area; and three to five small to medium sized plates between posterior stigmatic area and body apex. Anal plates surrounded by a narrow sclerotic area. In heavily sclerotized mature specimens (Fig. 5A), the area surrounding the anal plates becomes quite large, entirely covering the area of the preopercular pores and most of the anal cleft; with two large additional irregular quadrate plates on mid-dorsum, and two small triangular plates on head region just posterior to submarginal plates. Sclerotic plates completely absent in newly moulted specimens; derm becoming totally sclerotized in old specimens. Dorsal body setae (Fig. 4D) slender, 17–22  $\mu\text{m}$  long, scattered throughout dorsum, abundant in submarginal areas. Dorsal microducts (Fig. 4B) with a very long terminal filament (not visible in most type material), 1.5–2.0  $\mu\text{m}$  wide, numerous, scattered evenly on dorsum. Preopercular pores (Fig. 4F) invaginated, 2.5–5.0  $\mu\text{m}$  wide, occurring in two groups, present laterad to anal plates and extending anteriorly onto area dorsad to hind legs; pores incorporated into sclerotic area around anal plates in mature specimens. Anal plates (Fig. 4E) together quadrate, located at approximately one-fourth of body length from posterior margin, each plate 168–213  $\mu\text{m}$  long, 75–93  $\mu\text{m}$  wide, anterolateral margin 113–163  $\mu\text{m}$  long, posterolateral margin 94–125  $\mu\text{m}$  long, with four to six setae on dorsal surface, and with seven to nine ventral subapical setae on each plate. Anal ring with four pairs of setae. Eyespots (see arrow on main Fig. 4) not detected in newly moulted specimens, but present in most young and mature specimens, located far from margin, incorpo-

rated into submarginal sclerotic plates in older specimens (see Fig. 5A).

**Margin:** Margins crenulated. Marginal setae (Fig. 4C) present, sharply spinose, with well-developed bases, 17–27  $\mu\text{m}$  long, arranged in a single row, numerous, 37–48 between anterior and posterior stigmatic areas. Stigmatic cleft deep, forming a sclerotic plate. Stigmatic setae (Fig. 4A) bluntly spinose, clavate or truncate, usually three in number, occasionally four, all subequal in length, 15–40  $\mu\text{m}$  long.

**Venter:** Derm membranous. Ventral body setae (Fig. 4I) slender, length of setae divided into three categories, shorter setae present around submargin, 8–18  $\mu\text{m}$  long, thicker and longest setae present in pairs in a mid longitudinal line on segments V, VI and VII, 30–118  $\mu\text{m}$  long, those elsewhere and on abdominal segments where segmentation is distinct, 18–33  $\mu\text{m}$  long. Ventral microducts (Fig. 4J) approximately 2.0  $\mu\text{m}$  wide, scattered evenly on venter. Clypeolabral shield 74–98  $\mu\text{m}$  wide. Labium 42–62  $\mu\text{m}$  wide, with four pairs of setae. Pregenital disc pores (Fig. 4G) with five to seven loculi, 3.9–4.9  $\mu\text{m}$  wide, present in a small group of approximately 10–14 pores on each side of anal lobes posterior to vulvar area. Spiracular disc pores (Fig. 4K) with four to six (mostly five or six) loculi, 3.9–4.9  $\mu\text{m}$  wide; found in a lateral line extending from area anterior to each spiracular peritreme toward stigmatic cleft. Antennae (Fig. 4L) well developed, 160–240  $\mu\text{m}$  long, six-segmented, rarely seven-segmented; third segment longest; fleshy setae present on last three segments. Interantennal setae in a group of three or four setae near/medial to each antennal scape. Legs (Fig. 4H) well developed, but small, trochanter partially fused with femur, length of trochanter plus femur 53–68  $\mu\text{m}$ , tibia plus tarsus 58–95  $\mu\text{m}$ . Tarsal digitules similar, slender, knobbed. Claw digitules knobbed, broad, one digitule broader than other. Claw with a swollen base, without a denticle. Spiracles located between legs and body margin. Anterior spiracular peritreme 63–75  $\mu\text{m}$  wide, posterior peritreme, 60–78  $\mu\text{m}$  wide.

**Distribution.** Indonesia (Riau Islands), Brunei.

**Biology.** Host plants not identified. Soft scales collected in Borneo were found covered in cartons of *Crematogaster* ants. Despite the protection given by the ants, a high parasitization rate was observed, with many specimens infested with either larvae or pupae of an unidentified parasitoid wasp. When the nests were disturbed to collect the specimens, several ants were found actively carrying the coccids in their mandibles taking the coccids away from the disturbed twigs (P. J. Gullan, unpublished data, 1995). In the alcohol material, ants were found

holding the coccids in the same position as they were collected. A photo of a *Crematogaster* ant carrying an adult female of *T. rotundum* (Fig. 5B) clearly shows the ant holding the coccid in her mandibles by biting into a submarginal sclerotic plate. A thick layer of wax, usually secreted in an inverted U-shape on the sclerotic plates appears to cushion the biting grip of the ant mandibles. The dorsum of the soft scale is thus unharmed, but the membranous ventral area is damaged by the strong bite of the ant that must pull the scale insect (including its stylets) off its host stem. The wax on the sclerotic plates is probably produced by the dorsal microducts because no other secretory structure is present in that region. Although numerous dorsal microducts are scattered evenly throughout the dorsum, only those on the submarginal sclerotic plates and the small crescentic plates at the outermost borders of the preopercular pores appear to be actively secreting wax. Ants have been reported to carry away dead coccids onto dumping grounds (Heckroth *et al.* 2001), and several other records of coccid transport have been reported (reviewed by Gullan 1997). However, this is the first example of a coccid apparently showing morphological adaptation for ant transport. The length of the mandibles of the tending ants closely match the position of the submarginal sclerotic plates of *T. rotundum*, and it is possible that the carrying behavior of the ants, and the morphological traits of the coccids, have resulted from a long mutualistic association.

**Type material studied.** Adult ♀, *Xenolecanium rotundum* Takahashi, Indonesia, Riau (=Riouw) Islands, Rempang, i.1946, coll. R. Takahashi, host not given, one slide three specimens. Lectotype here designated, closest to original label, location clearly indicated on left side label (SEHU). Paralectotypes: four slides 19 specimens (18 adult ♀ and one third instar nymph) including specimens on slide with lectotype, same data (SEHU).

**Other material studied.** Adult ♀, Borneo, Brunei, Batu Apoi Forest Reserve, Ashton Trail ridge, 4°33'N, 115°9'E, 1.xi.1995, coll. P. J. Gullan, PJG-B66, on trunk of small tree under carton cover of *Crematogaster* sp., 17 slides 17 specimens (seven, BME; three, BMKB; three, BMNH; four, USNM).

**Remarks.** *Takahashilecanium rotundum* is a monotypic genus known from two localities in the South China Sea, Rempang Island in Indonesia, and from Brunei on the island of Borneo. It is a typical member of the tribe Paralecaniini, with eyes being far from the body margin, the stigmatic cleft forming a sclerotic plate, and the preopercular pores distributed in two groups on each side of the anal plates.

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