ORIGINAL ARTICLE

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

Takumasa KONDO1, Michael L. WILLIAMS2 and Penny J. GULLAN1
1Department of Entomology, University of California, Davis, California and 2Department of Entomology and Plant Pathology, Auburn University, Auburn, Alabama, USA

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
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 genera in the ural unrelated lineages, and that the morphology of first instar nymphs indicates that several genera in the Myzolecaniinae share 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, *Xenolecanium* krugeri (Zehntner, 1897) (Hodgson 1994), *Platylecanium cribigerum* (Cockerell and Robinson, 1915) (Hodgson 1994) and *Paralecanium bainanense* 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* Cockrell 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 *Maacococcus* 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,
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.

Genus *Xenolecanium* Takahashi

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

**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 cribleiform 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 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 subaequal length. Ventral tubular ducts present in a small group around vulvar opening. Pre-genital 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.

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Figure 1 *Xenolecanium mangiferae* Takahashi, adult female. (A) Enlargement of dorsal derrm, (B) sclerotic plate, (C) stigmatic cleft, (D) cribiform 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) cribiform 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.
Remarks. Features that separate X. mangiferae from X. takahashii Kondo, sp. nov. are discussed in the Remarks section for the latter species.

**Xenolecanium eugeniae** Kondo, sp. nov. (Figs 2, 3)


**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 μm, width 135–146 μm. Simple disc pores (Fig. 2E) approximately 2.7–3.6 μm wide evenly distributed on dorsum. Dorsal body setae (Fig. 2H) slender, 5.3–10.7 μm long, evenly distributed over dorsum. Dorsal microducts (Fig. 2G) approximately 3.6 μm 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 μm long, 75–79 μm wide, anterolateral margin 100–107 μm long, posteroventral margin 85–90 μm 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, 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) distributed on dorsum. Spiracular disc pores (Fig. 2N) with five to seven (mostly five) loculi; each pore 2.7–3.6 μm long, present in two submedian 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.
X. eugeniae 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)

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) preopercular pores, (G) pregenital disc pores, (H) leg, (I) ventral setae, (J) ventral microduct, (K) spiracular disc pores and (L) antenna.
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 μm 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 μm wide, numerous, scattered evenly on dorsum. Preopercular pores (Fig. 4F) invaginated, 2.5–5.0 μm 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 μm long, 75–93 μm wide, anterolateral margin 113–163 μm long, posterolateral margin 94–125 μm 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-

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

Margin: Margins crenulated. Marginal setae (Fig. 4C) present, sharply spine, with well-developed bases, 17–27 µm 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 spine, clavate or truncate, usually three in number, occasionally four, all subequal in length, 15–40 µm long.

Venter: Derm membranous. Ventral body setae (Fig. 4I) slender, length of setae divided into three categories, shorter setae present around submargin, 8–18 µm long, thicker and longest setae present in pairs in a mid longitudinal line on segments V, VI and VII, 30–118 µm long, those elsewhere and on abdominal segments where segmentation is distinct, 18–33 µm long. Ventral microducts (Fig. 4J) approximately 2.0 µm wide, scattered evenly on venter. Clypeolabral shield 74–98 µm wide. Labium 42–62 µm wide, with four pairs of setae. Pregenital disc pores (Fig. 4G) with five to seven loculi, 3.9–4.9 µm 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 µm wide; found in a lateral line extending from area anterior to each spiracular peritreme toward stigmatic cleft. Antennae (Fig. 4L) well developed, 160–240 µm 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 µm, tibia plus tarsus 58–95 µm. 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 µm wide, posterior peritreme, 60–78 µm 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, 1.xi.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). Paratypotypes: 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.x.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. Takahashiclecanium 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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