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External morphology of the first and second instars of *Lecanodiaspis tingtunensis* (Coccoidea: Lecanodiaspididae)

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Abstract. The first and second instars of *Lecanodiaspis tingtunensis* are described and illustrated. First instars are distinguished from other species of *Lecanodiaspis* by the arrangement of dorsal 8-shaped pores in six complete longitudinal rows and a partial row in the thoracic region and the number of labial, anal plate, and spiracular setae. Second instars are dimorphic with males possessing well developed 5-segmented legs, dorsal tubular ducts, and long hair-like setae on the venter between the antennae and on the abdominal segments. Females have fewer 8-shaped pores in transverse rows on the dorsum, as well as legs reduced to stubs and only one pair of hair-like medial setae on the venter.

Key Words. *Lecanodiaspis tingtunensis*, Coccoidea, Lecanodiaspididae, scale insect.

Introduction

Of the 62 recognized species of *Lecanodiaspis* represented in the Australian, Ethiopian, Nearctic, Neotropical, and Palearctic regions (Howell and Kosztarab 1972, Howell et al. 1973, Lambdin et al. 1973), first instars for 29 species have been described and illustrated (Williams and Kosztarab 1970, Morrison and Morrison 1927, Lambdin and Podsiadlo 2001). Because of their cryptic appearance, small size, and period of development throughout the season, the immature stages are seldom available for study and comparisons. One such rare species is *Lecanodiaspis tingtunensis* (Borchsenius), which was originally described and placed in the genus *Prosopophora* (Borchsenius 1960) and later transferred to the genus *Lecanodiaspis* (Lambdin et al. 1973). This species was placed into the *Quercus* group (Howell et al. 1973) based on the presence of lateral reticulated anal plates and non-bifid posterior spiracular furrows on the adult female. At present, 13 species from the Australian, eight from the Oriental, and three from the Palearctic regions are assigned to this group.

The morphology of immatures differs from that of the adults providing the opportunity to establish a more stable classification for the species. Since control efforts against these pests are more effective when applied against emerging first instars, identification

of the immature stages is essential to properly identify the species and to determine the time of development to protect the host plant from damage. The objective of this study was to describe and illustrate the first and second instars of *L. tingtunensis* from available specimens to distinguish them from the immatures of similar species.

Material and Methods

The type material studied consisted of eight first instar specimens collected by Borchsenius in the Yunnan Province, China. An additional seven specimens obtained from dry material collected by D. Murphy in the Nee Soon Swamp Forest, Singapore were mounted on slides for study. Second instars were represented by seven female and two male specimens. Measurements (in micrometers) of structures for these specimens are presented as averages followed by ranges in parentheses. The illustrations were developed using Adobe Photoshop®. Enlargements of the various structures in the margin of each figure are not proportional, but illustrate the general appearance of the specific structure. Terminology in the descriptions follows that of Williams and Kosztarab (1970). The gender of the first instar was not determined.

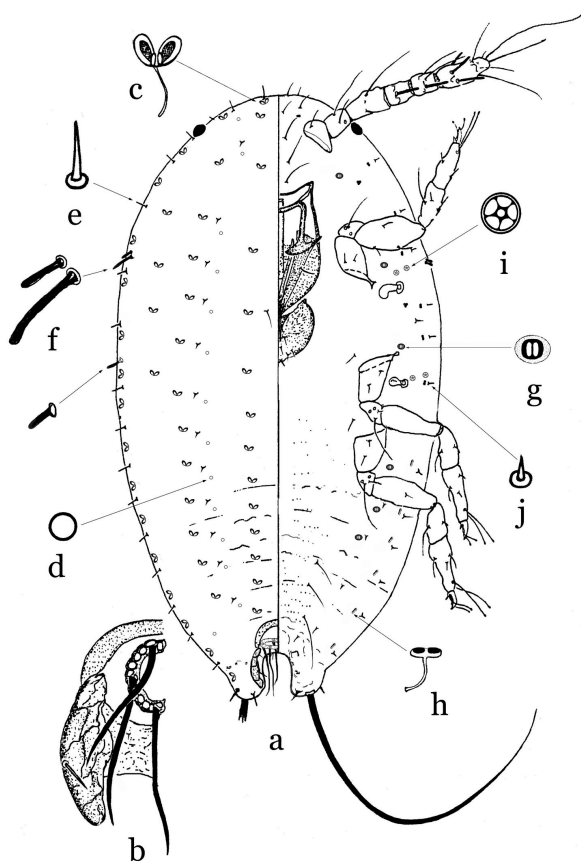


Figure 1. *Lecanodiaspis tingtunensis* (Borchsenius), first instar (sex undetermined). a) dorsoventral view; b) anal ring, anal plate, and arched plate; c) figure 8-shaped pore; d) simple disc pore; e) marginal spine-like seta; f) fleshy spiracular setae; g) bilocular pore (dark rimmed); h) flat 8-shaped pore; i) quinquelocular pore; j) tack-like seta.

Descriptions

Lecanodiaspis tingtunensis (Borchsenius)

First Instar (Fig. 1a-j)

Body of slide-mounted specimens ovoid (Fig. 1a), 481 (400-630) long, 247 (200-280) wide.

Dorsal surface (left half). Anal lobe (Fig. 1a) with apical seta 151 (120-182) long, 1 seta on inner margin 6.8 (6-8) long, and 1 stout seta on outer margin 9.8 (9-12) long. Anal ring (Fig. 1b) elliptical, slightly open anteriorly, 18.8 (16.0-20.0) diam.; with 6 fleshy setae, each 42.0 (32.0-45.0) long. Anal plates (Fig. 1b) deltoid, margins reticulated, each 33.5 (25.0-40.0) long, 18.8 (15.0-21.5) wide; 1 seta on inner margin, each 5 (5) long, and a pair of setae on medial bar, 2 (2) long. Arched plate (Fig. 1b) slightly curved, 8.0 (6.0-10.0) long, 32.8 (30.0-38.0) wide. Anal cleft (Fig. 1a) short.

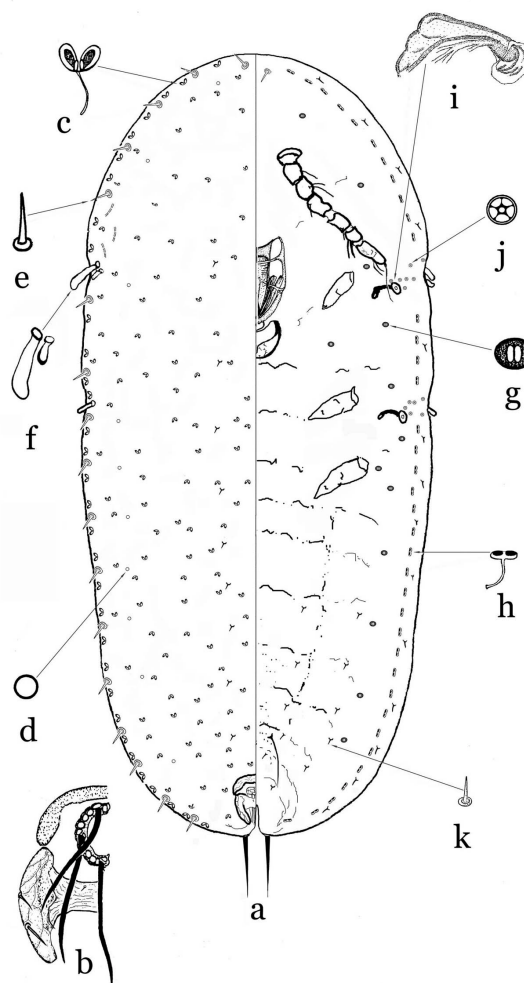


Figure 2. *Lecanodiaspis tingtunensis* (Borchsenius), second instar female. a) dorsoventral view; b) anal ring, anal plate, and arched plate; c) figure 8-shaped pore; d) simple pore; e) marginal spine-like seta; f) fleshy spiracular setae; g) bilocular pore (dark rimmed); h) flat 8-shaped pore; i) spiracle; j) quinquelocular pore; k) tack-like seta.

Figure 8-shaped pores (Fig. 1c) slightly bent; arranged in 3 complete and 1 partial longitudinal rows; marginal row with 17 pores, one per segment, partial submarginal row of 4-5 pores in spiracular region associated with submarginal row of 11 (11-12) pores, and medial row of 13 (13) pores; each 4.5 (4.0-5.0) long, 2.8 (2.0-3.0) wide. Simple disc pores (Fig. 1d) sparse, 8 (7-11) arranged one per segment in longitudinal row between submarginal and submedial rows of 8-shaped pores, each 2 (2) in diam.; simple disc pores associated with tack-like setae. Setae variable, marginal setae (Fig. 1e) spine-like, 18 setae arranged one per segment, each 6.4 (5.0-8.0) long except for 2 pair of stout setae at apex of cephalic region, larger 14.0 (10.0-16.0) long, smaller 8.0 (6.0-8.5) long; other dermal setae

located submedially, 7 (6-8) setae associated with simple pores and 8-shaped pores, tack-like, each 2 (2) long; pair of medial setae above mouthparts 5.0 (4.0-6.0) long. Spiracular setae (Fig. 1f) on margin; 2 anterior setae at apex of spiracular furrows, unequal in size, larger one 32.0 (29.0-35.0) long, smaller one 12.4 (7.0-14.0) long, posterior seta 6.4 (6.0-8.0) long.

Ventral surface (right half). Antennae (Fig. 1a) well-developed, 6-segmented, length 124 (115-141). Segments I-VI: 14.1 (10.0-15.0), 19.7 (15.0-25.0), 21.9 (20.0-27.0), 20.8 (17.0-25.0), 17.7 (13.0-21.0), and 30.1 (25.0-37.0) long, respectively. Bilocular pores (Fig. 1g) rare, 1-2 in cephalothorax and in submarginal row of 3 pores mesad of flat 8-shaped pores on abdomen, each 2.5 (2.0-3.0) diam. Clypeolabral shield 89.3 (70.0-104.0) long, 67.2 (55.0-78.0) wide; with a pair of hair-like setae in anteriodorsal region 10 (10). Labium deltoid, 31.5 (25.0-35.0) long, 47.7 (40.0-60.0) wide; with 10 slender setae, each 8.0 (5.0-10.0) long. Flat 8-shaped pores (Fig. 1h) in submarginal row of 14 (13-15) pores; each 2.8 (2.0-3.0) long. Legs 5-segmented, similar in size, prothoracic 130.0 (120.0-140.0) long, mesothoracic 135.0 (125.0-145.0) long, and metathoracic 138 (125.0-145.0) long; claw curved without denticle, each 13.3 (10.0-17.0) long; each tibial digitule 29.8 (26.0-32.0) long, and each tarsal digitule 19.3 (15.0-25.0) long. Spiracles on submargin, each 14.5 (11.0-16.0) long, peritreme 7.0 (5.0-9.0) in diam., aperture 2.4 (2.0-3.0) in diam.; with 2 quinquelocular pores (Fig. 1i) near each spiracle, each 2.5 (2.0-4.0) in diam. Posterior furrows not bifid. Setae variable, submarginal row of segmental setae between marginal row of 8-shaped pores and submarginal row of flat 8-shaped pores, each tack-like (Fig. 1j), 2 (2) long; 4 pairs of submedial setae on head between antennae, each 23.0 (20.0-24.0), 25 (20-35), 30.0 (25.0-35.0), and 25.0 (20.0-35.0) long, respectively; row of 3 hair-like medial setae on posterior abdominal segments, each 22.4 (18.0-25.0), 24.5 (23.0-25.0), and 46.7 (40.0-56.0) long, respectively.

Material Studied: on *Pasania* sp., 8(4); Yunnan Province, China, 11 Jun. 1957, N. Borchsenius, Coll.; on *Quercus* sp., 7(2); Nee Soon Swamp Forest, Singapore, 8 Aug. 1972, D. H. Murphy Coll.

Female Second Instar (Fig. 2a-k)

Body of slide-mounted specimens ovoid (Fig. 2a), 712 (625-815) long, 337 (345-405) wide.

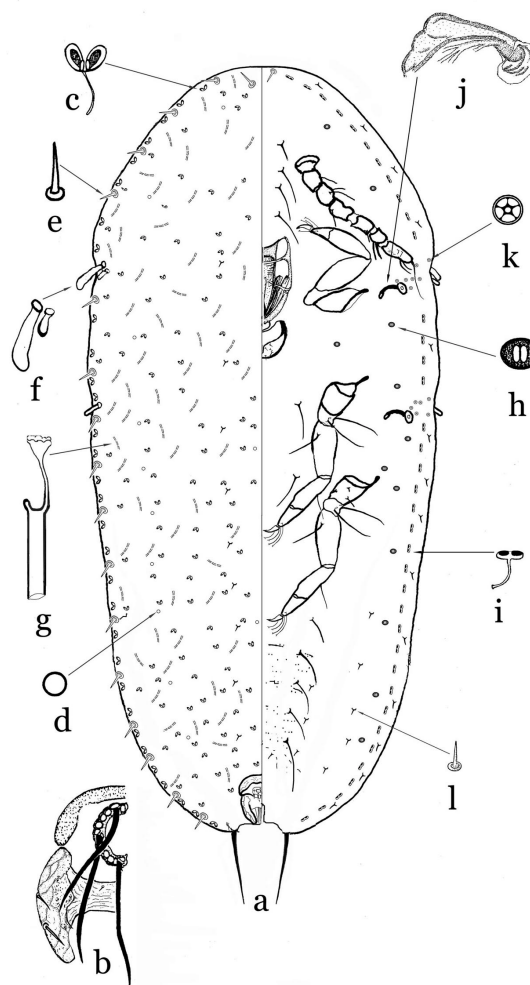


Figure 3. *Lecanodiaspis tingtunensis* (Borchsenius), second instar male. a) dorsoventral view; b) anal ring, anal plate, and arched plate; c) figure 8-shaped pore; d) simple disc pore; e) marginal spine-like seta; f) fleshy spiracular setae; g) tubular duct; h) bilocular pore (dark rimmed); i) flat 8-shaped pore; j) spiracle; k) quinquelocular pore; l) tack-like seta.

Dorsal surface (left half). Anal lobe (Fig. 2a) with spine-like apical seta 91.2 (85.0-100) long. Anal ring (Fig. 2b) subcircular, slightly anterior to anal plates, 21.3 (15.0-27.0) long, 19.7 (16.0-21.0) wide; with 6 fleshy setae, each 56.2 (50.0-64.0) long. Anal plates (Fig. 2b) deltoid, attached anteriomedially by wide plate, margins reticulated, 43.9 (35.0-50.0) long, 40.0 (40.0) wide; each half with 2 stout setae, each 7.5 (6.0-9.0) long, and a pair of minute setae on medial bar, 2 (2) long. Arched plate (Fig. 2b) slightly curved and scalloped, 40.4 (32.0-46.0) long and 10.6 (8.0-15.0) wide. Figure 8-shaped pores (Fig. 2c) in a marginal row and in transverse segmental rows with medial

and submarginal areas void of pores that provide a swirl-like appearance; marginal pores 5.9 (5.2-6.0) long, 2.9 (2.5-3.0) wide, segmental pores 4.2 (4.0-5.0) long, 2.2 (2.0-3.0) wide. Simple disc pores (Fig. 2d) sparse, each 2 (2) in diam. with spine-like marginal setae (Fig. 2e), 1 seta per segment, each 8.3 (7.0-10.0) long, other setae on derm rare. Spiracular setae (Fig. 2f) on thoracic margin; 2 anterior fleshy setae at apex of anterior spiracular furrows, unequal in size; larger one 37.0 (30.0 - 46.0) long, smaller one 16.4 (11.0-22.0) long; posterior spiracular furrows each with one fleshy seta 24.8 (22.0-28.0) long.

Ventral surface (right half). Antennae (Fig. 2a) well-developed, 7-segmented, third and fourth segments often appearing fused, length 135 (124-140). Segments I-VII: 16.6 (12.0-22.0), 16.9 (12.0-21.0), 25.0 (15.0-35.0), 19.6 (12.0-28.0), 19.1 (17.0-22.0), 18.7 (16.0-20.0) and 19.3 (17.0-22.0) long, respectively. Bilocular pores (Fig. 2g) in single row on cephalothorax and abdomen mesad of flat 8-shaped pores, each 2.6 (2.0-3.0) diam. Clypeolabral shield 112.4 (95.0-125.0) long, 81.8 (75.0-100.0) wide. Labium deltoid, 48.0 (34.0-50.0) long, 53.7 (36.0-66.0) wide; with 10 slender setae, each 6.7 (4.0-9.0) long. Flat 8-shaped pores (Fig. 1h) in submarginal row, each 3.5 (3.0-4.0) long. Legs rudimentary, nonfunctional, prothoracic 35.3 (25.0-40.0) long, mesothoracic 55.1 (40.0-90.0) long, and metathoracic 62.2 (45.0-94.0) long. Spiracles (Fig. 2i) on submargin, each 32.7 (30.0-35.0) long, peritreme 13.1 (11.0-15.0) in diam., aperture 4.8 (4.0-6.0) in diam.; with 6-7 quinquelocular pores (Fig. 2j) near each spiracle, each 2.8 (2.0-3.0) in diam. Posterior furrows not bifid. Setae variable, no setae between antennae, submarginal row of segmental setae between marginal row of figure 8-shaped pores and submarginal row of flat 8-shaped pores, each tack-like (Fig. 2k), 4.0 (4.0) long; 1 pair of hair-like submedial setae on 7th abdominal segment, each 55.0 (50.0-70.0), long; about 4 tack-like setae in transverse abdominal rows, each ca. 2.0 (2.0); and a pair at apex of anal cleft ca. 3.0 (3.0) long.

Material Studied: on *Pasania* sp., 6(3); Yunnan Province, China, 11 Jun. 1957, N. Borchsenius, Coll.; on *Quercus* sp., 1(1); Nee Soon Swamp Forest, Singapore, 8 Aug. 1972, D. H. Murphy Coll.

Male Second Instar (Fig. 3a-l)

Body of slide-mounted specimens with sides more parallel than in females, ca. 690 long and 360 wide.

Dorsal surface (left half). Males differ from females by having numerous figure 8-shaped pores (Fig. 3c) on the body; these pores arranged in transverse rows with areas void of pores in median and submarginal areas, alternate rows often oriented toward each other, each 4.0 (4.0) long, 2.2 (2.0-2.5) wide; tubular ducts (Fig. 3g) irregularly spaced over derm, each 22.8 (18.0-26.0) long and 2.0 (2.0) wide; and 8-9 tack-like setae in longitudinal submedial row, each 3.0 (3.0) long.

Ventral surface (right half). Males differ from females by having well-developed 5-segmented legs, prothoracic ca. 265 long (245-277) long. Setae more numerous and variable than on female, stout medial pair of setae near vertex 10-16 long; 4 pairs of hair-like setae between antennae, each 60-80 long, and 5 pairs of hair-like submedial setae on posterior abdomen segments 40-100 long.

Material Studied: on *Quercus* sp., 2(2); Nee Soon Swamp Forest, Singapore, 8 Aug. 1972, D. H. Murphy Coll.

Discussion

Marginal area of first instars is distinguished by having a row of figure 8-shaped pores and tack-like setae slightly dorsad, a row of flat 8-shaped pores and bilocular pores on the venter. The anterior spiracular furrows have a pair of unequal size, fleshy setae at apex, while the unbranched posterior spiracular furrows terminate with a stout fleshy seta. The thoracic segments are demarked by the legs, spiracles, and marginal setae. The abdominal segments are delimited by transverse to crescent-shaped creases. This species is also differentiated from 24 of the 26 species described by Williams and Kosztarab (1970) by the number of labial setae (10 rather than 6 or 8) as well as the shape and size of the anal plates, the number and position of the anal plate setae, and the reticulated anal plates. Of those species described, *L. tingtungensis* has the closest affinity to *L. quercus* based on the reticulated anal plates, the type of spiracular setae, the number and position of the bilocular or dark-rimmed pores on the abdomen. The second instars exhibit sexual dimorphism. Males differ from females by the presence of transverse rows of figure 8-shaped pores, tubular ducts, and large spine-like marginal setae on dorsum. In addition, males have four pairs of setae between the antennae, five pairs of submedial setae on abdomen, and well developed legs. No setae were noted between the antennae of available female

specimens, and they had only one pair of long setae on posterior abdominal segment. The lack of tubular ducts in the second instar female is consistent with immatures in other scale insect families. For example, dorsal tubular ducts were reported to be absent in *Pseudophilippia quaintancii* Cockerell (Ray and Williams 1980). Additional studies are needed to obtain immature specimens of other species in the genus to compare similarities and possible relationships among the species.

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