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SYSTEMATIC STUDIES ON THE *ANTONINA CRAWI* COCKERELL (HEMIPTERA: COCCOIDEA: PSEUDOCOCCIDAE) COMPLEX OF PEST MEALYBUGS

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Abstract.–Careful analysis of specimens identified as *Antonina crawi* Cockerell has shown that three very similar species are involved, i.e., *A. crawi*, ***A. nakaharai* Williams and Miller, new species**, and *A. socialis* Newstead (**reinstated status**). A key is provided for 11 species reported on bamboos and a description is given for a bamboo-infesting species from Taiwan, i.e., ***A. maai* Williams and Miller, new species**. *Antonina crawi* is reported from China, Japan, and the U.S. (California) but is suspected to have disappeared from the latter country.

Key Words: Coccoidea, Pseudococcidae, new species, *Antonina maai, Antonina nakaharai,* redescribed species, *Antonina crawi* Cockerell, *Antonina socialis* Newstead, bamboo, key

As part of a study on the mealybugs of southern Asia, the first author noted an unusually large amount of morphological variation in *Antonina* specimens determined as *A. crawi* Cockerell. After careful analysis of these specimens it is evident that what had originally been considered a single taxon is actually three different species. Because mealybugs in the Crawi complex are primarily bamboo feeders and because bamboos are frequently used as ornamentals, we examined as many *Antonina* specimens as possible from that host and provide a key to all of the species that occur on bamboo.

Antonina includes 17 valid species, all of which are native to the Old World (Ben-Dov et al. 2001), particularly Asia. They are: *A. australis* Froggatt (Australia), *A. bambusae* Khalid and Shafee (India), *A. crawi* Cockerell (probably native to Japan and China), *A. elongata* Tang (China), *A. graminis* (Maskell) (possibly native to India), *A. maritima* Ramakrishna Ayyar (India and Sri Lanka), *A. meghalayaensis* Khalid and Shafee (India), *A. natalensis* Brain (possibly Africa), *A. pretiosa* Ferris (Asia), *A. purpurea* Signoret (Europe), *A. tesquorum* Danzig (northeastern Asia), *A. thaiensis* Takahashi (Malaysia and Thailand), *A. transcaucasica* (Borchsenius) (Armenia and Azerbaijan), *A. transvaalensis* Brain (South Africa), *A. vera* Borchsenius (northeastern Asia), and *A. zonata* Green (southern Asia). *Antonina indica panica* Hall recently has been considered a valid species (Williams 2001), i.e., *A. panica.*

Several species have become invasive pests in various parts of the world, particularly *A. crawi* (actually *A. nakaharai* Williams and Miller, n. sp. and *A. socialis* Newstead), *A. graminis,* and *A. pretiosa*

(Miller et al. 2002). A comprehensive book was written by Hendricks and Kosztarab (1999) on the legless mealybugs including detailed morphological treatments and a key for the adult females of all but 4 species of *Antonina.* They were unable to locate specimens of *A. bambusae, A. elongata, A. meghalayaensis,* and *A. transcaucasica.* The immature stages of several species were treated by Yang and Kosztarab (1967), and adult males were described by Afifi and Kosztarab (1967) and Beardsley (1965).

We have found 11 species that occur on bamboo including: *A. bambusae* (*Bambusa*), *A. crawi* (see later description for list of bamboo hosts), *A. graminis* (*Bambusa* sp.), *A. maai* Williams and Miller, n. sp. (see later description for list of bamboo hosts), *A. meghalayaensis* (*Bambusa* sp.), *A. nakaharai* Williams and Miller, n. sp. (see later description for list of bamboo hosts), *A. pretiosa* (*Arundinaria, Bambusa, Phyllostachys, Pleioblastus, Sasa,* and *Yushania*), *A. purpurea* (*Phyllostachys*), *A. socialis* (see later description for list of bamboo hosts and corrected status), *A. thaiensis* (*Bambusa*), *A. zonata* (*Bambusa, Indocalamus, Semiarundinaria, Teinostachyum*). It is interesting that 9 of these species are specific to bamboos and only 2 species are incidental on bamboo. The latter 2 species (*A. graminis* and *A. purpurea*) are more general feeders occurring on a wide range of grass hosts.

The three species encompassing the Crawi complex are here determined as *A. crawi, A. nakaharai,* and *A. socialis.* These species are considered a complex because they have so frequently been confused. There are no characters unique to this group that do not also occur in other species of *Antonina.* Although *Antonina maai* is similar to species in the Crawi complex, it is most similar to *A. pretiosa.*

Materials and Methods

Depositories of specimens are: The Natural History Museum, London (BMNH); California Department of Food and Agriculture, Sacramento (CDFA); Florida State Collection of Arthropods, Gainesville (FSCA); Muséum National d'Histoire Naturelle, Paris (MNHN); Taiwan Agricultural Research Institute, Entomology Collection, Taichung, Taiwan (TARI); National Museum of Natural History, Beltsville, MD (USNM); R. M. Bohart Museum, University of California, Davis, CA (UCD).

Abbreviations used in the Specimens Examined sections are: ad. = adult; imm. = immature; sl. = slide.

Measurements of the labium are the longest dimension of the anterior to the posterior edges of the structure as it appears on slide-mounted specimens. In some instances the labium is oriented with the apex pointing directly at the microscope slide (ventrally) rather than pointing posteriorly, as is the case for most mealybugs. Thus, the measurement in these instances is not always taken of the lateral profile of the labium but instead is of the largest diameter of the structure. Measurements of the anal tube are taken on the dorsal surface from the anterior end of the anal ring to the opening of the anal tube nearest to the anal ring; this measurement is the shortest length. Also note that there is a band of pores and tubular ducts internally near the entrance of the anal tube. These structures are not shown in the illustrations.

Inclusion of *Antonina bambusae* and *A. meghalayaensis* in the key to *Antonina* species that occur on bamboo is based on examination of the original descriptions only; we have been unable to locate specimens of these species. Hendricks and Kosztarab (1999) questioned the validity of some of the statements made by Khalid and Shafee (1988) in their descriptions of these species, including the presence of a circulus in *A. bambusae.*

Results

Antonina crawi Cockerell (Fig. 1)

Antonina crawi Cockerell 1900:70.

Antonina crawii: Ferris 1918:77 (misspelling).

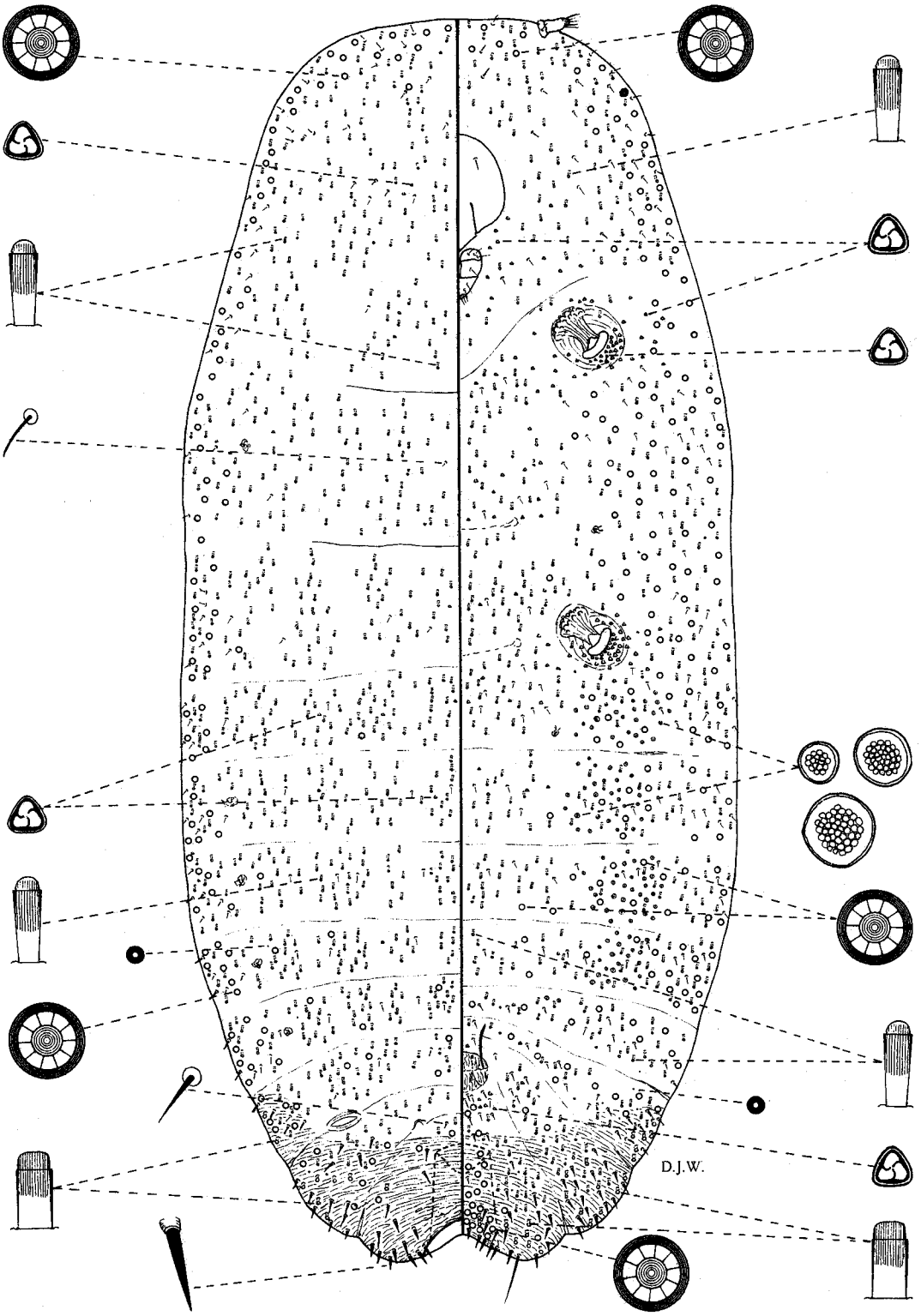

Fig. 1. *Antonina crawi.* Specimen from Japan, near Tokyo, on *Arundinaria fastuosa.*

Antonina bambusae: Borchsenius 1934:13 (misidentification).

Type material.–Lectotype adult female single specimen on slide labeled as follows: left label "Antonina/crawi Ckll/TYPE/ Bamboo/Japan (Craw) 1900/Ckll. Coll.;" right label "*LECTOTYPE*/Desig. H. Hendricks/1992/Antonina crawi Ckll./Remounted: Balsam." In addition there is an additional slide containing 2 adult female paralectotypes (all in USNM). The lectotype was designated by Hendricks and Kosztarab (1999).

Description.—*Adult female* on microscope slide, elongate oval, 1.4–4.5(3.2) mm long, 0.7–2.9(1.8) mm wide; posterior apex of last 2 or 3 abdominal segments sclerotized (more mature paratypes sometimes with more sclerotization); lateral margins of abdominal segments VII–VIII convex, rarely segment VI slightly convex, others straight sided. Antenna 2- or 3-segmented, 45–62(54) μ long. Legs usually represented by inconspicuous sclerotized area or small dermal pocket, sometimes absent. Labium 55–90(80) μ long, between 2 and 3 times shorter than clypeolabral shield. Ostioles present on abdomen only. Circulus absent. Spiracles with 2 sizes of trilocular pores in sclerotized area surrounding atrium. Cerarii absent, but posterior abdominal setae enlarged, subconical. Anal ring invaginated in anal tube, 145–175(162) μ long; ring diameter 88–130(105) μ; anal tube internally with ring of multilocular pores and tubular ducts. With 28–66(42) multilocular pores on each side of body in area delimited by posterior edges of each anterior and posterior spiracle.

Dorsal surface with short setae, decreasing in length and width anteriorly; longest seta on posterior apex 32–40(36) μ long. Trilocular pores of 1 size, absent from posterior 3 or 4 segments, absent along body margin except near spiracles, scattered over remainder of surface. Discoidal pores of same distribution pattern as triloculars, less abundant. Multilocular pores forming longitudinal band along body margin; with 0–7(3) pores on segment VII near intersegmental line between VII and VIII. Oral-collar tubular ducts of 1 variable size, absent or rare on segment VIII except in anal tube, abundant over remainder of surface.

Ventral surface with setae similar to those on dorsum. Multilocular disc pores present in band along body margin, with 6–24(14) pores on abdominal segment IV within area delimited by lateral margin of disc-like pore clusters on each side of segment; with multilocular pores on segment VIII often spanning space between vulva and posterior apex of body, occasionally restricted to half or three-fourths of distance between vulva and posterior apex of body; dermal surface surrounding opening of anal tube with cluster of multilocular pores and oral-collar tubular ducts. Disc-like pores present in mediolateral areas from metathorax to segments IV, V, or rarely VI. Trilocular pores of 2 or 3 sizes, smaller size in plate outside of spiracular atrium; larger size scattered around mouthparts, medium size scattered over remainder of surface except absent or rare on posterior 3 or 4 segments, most abundant near body margin. Oral-collar tubular ducts present over surface. Vulvar area with 1 pair of lateral apophyses and 1 pair of weakly indicated posterior apophyses.

Notes.—This species is similar to *Antonina nakaharai* and *A. socialis* but differs by having: 6–24(14) multilocular pores on abdominal segment IV within the area delimited by the lateral margins of disc-like pore clusters on each side of the segment; disc-like pores present from abdominal segment II to segments IV, V, or VI; the row of dorsal multilocular pores on segment VII, adjacent to the intersegmental line between segments VII and VIII, with 0–7(3) pores on each side of body. *Antonina nakaharai* has: 0–4(1) multilocular pores on abdominal segment IV within the area delimited by lateral margins of disc-like pore clusters on each side of the segment; disc-like pores present from abdominal segment II to seg-

ments IV, V, or VI; the row of dorsal multilocular pores on segment VII, adjacent to the intersegmental line between segments VII and VIII, with 0–3(0) pores on each side of body. *Antonina socialis* has: 0–7(2) multilocular pores on abdominal segment IV within the area delimited by the lateral margins of disc-like pore clusters on each side of the segment; disc-like pores present from abdominal segment II to VII or VIII; the row of dorsal multilocular pores on segment VII, adjacent to the intersegmental line between segments VII and VIII, usually with 1–12(6) pores on each side of body.

Although this species previously was reported to be widespread (Ben-Dov 1994), the species concept presented here limits its distribution to China, Japan, and the U. S. (California). The latter record is based on a single adult female that was collected in San Jose, California, in 1900; it has not been collected in the U. S. since and is assumed to have disappeared in the intervening period.

Specimens examined.—CHINA: Bamboo gardens, Lingnan University, Canton, on *Phyllostachys nigra,* date ?, F. A. McClure (1 ad. ♀, 2 imm. on 1 sl.) (USNM). JAPAN: Kagoshima, on *Phyllostachys* sp., I-11-1923, B. M. Broadbent (1 ad. ♀) (USNM); Kuro, Chiku, Hotel Chiku, on *Bambusa* sp.,? -?-1889, collector ? (2 ad. ♀ on 1 sl.) (USNM); Shinohana-machi, Kohoku-ku, Kanagawa-ken, Yokohama, on *Sasa* sp., X-19-1941, K. Sato (9 ad. ♀ on 2 sl.) (USNM); Near Tokyo, on *Arundinaria fastuosa* cultivar Hasimoto, III-18-1917, collector ? (1 ad.♀) (USNM); locality ?, on bamboo, XI-?-1909, E. M. Ehrhorn (1 ad. ♀) (USNM); locality ?, on bamboo, ?-?-1900, Craw (1 lectotype ad. ♀, 2 lectotype ad. ♀ on 2 sl.) (USNM); [Authors' note: An additional slide containing 1 ad. ♀ from E. E. Green's collection may also be from the type series, but associated information only indicates, Japan, from bamboo (BMNH)]. UNITED STATES: CALIFORNIA: San Jose, Japanese Nursery, on bamboo, II-?-1900, collector ? (1 ad. ♀, 12 first instars on 2 sl.) (USNM).

Antonina maai Williams and Miller, new species
(Fig. 2)

Antonina pretiosa: Hendricks and Kosztarab 1999:115 (misidentification, in part)

Type material.–Holotype adult female mounted alone on a slide labeled as follows: left label "Taiwan/Hsinkien, Taipeh/Hsien/Ex Bambusa/Oct 9, 1951/T Maa/Ferris No M331" right label "*Antonina maai*/Williams & Miller/HOLOTYPE, UCD." In addition there are 55 paratypes deposited in the following museums: BMNH, CDFA, FSCA, MNHN, TARI, UCD, USNM.

Description.—*Adult female* holotype on microscope slide, elongate oval, 1.5 mm long (paratypes 1.0–2.7(1.6) mm), 0.8 mm wide (paratypes 0.7–1.8(1.1) mm); posterior apex of last 3 abdominal segments sclerotized, lateral margins of all abdominal segments sclerotized (more mature female paratypes sclerotized completely); without convex lateral margins of abdominal segments; sometimes margin of segment VIII convex in very mature adults. Antenna 2-segmented, basal segment small, with 3 setae, apical segment larger with 5 sensory setae and 2 or 3 thinner setae, antenna 62 μ long (paratypes 52–70(61) μ). Legs absent. Labium profile 70 μ long (paratypes 48–75(66) μ), about 3 times shorter than clypeolabral shield. Ostioles present on abdomen only. Circulus absent. Spiracles only with smaller size of trilocular pore in atrium. Cerarii absent, but posterior abdominal setae slightly enlarged. Anal ring invaginated in anal tube, 142 μ long (paratypes 135–168(150) μ); ring diameter 88 μ long (paratypes 85–100(92) μ); anal tube internally with ring of small trilocular pores near entrance. With 5 multilocular pores on each side of body in area delimited by posterior edges of each anterior and posterior spiracle (paratypes 0–10(4) pores).

Dorsal surface with short setae, decreas-

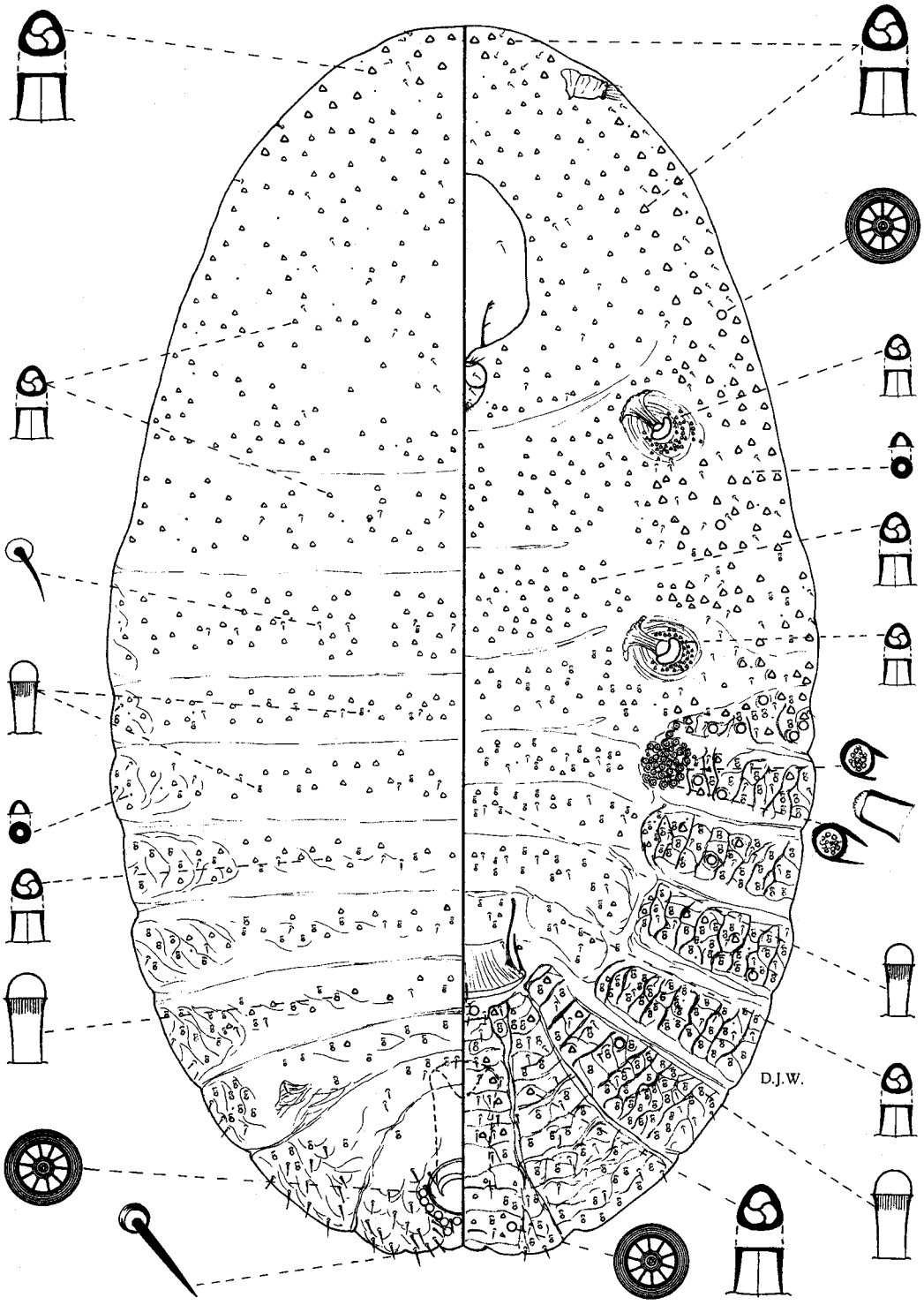

Fig. 2. *Antonina maai.* Specimen from Taiwan, Taipeh, Hsien, on *Bambusa* sp.

ing in length and width anteriorly; longest seta on posterior apex 28 μ long (paratypes 25–31(28) μ). Trilocular pores of 2 sizes, smaller size scattered over most of surface, increasingly abundant anteriorly, absent on posterior 2 or 3 abdominal segments; larger size restricted to marginal areas of anterior thorax and head. Discoidal pores of same distribution pattern as triloculars, less abundant. Multilocular pores present in cluster near entrance of opening to anal tube, multilocular pores absent elsewhere on holotype, variable on paratypes from relatively abundant near body margin of abdominal segments, thorax, and head to only 1 or 2 along any area of body margin; without pores on segment VII near intersegmental line between VII and VIII (paratypes 0–1(0) pores). Oral-collar tubular ducts of 2 sizes, larger size restricted to marginal areas of abdomen, usually absent from segment VIII, smaller size in medial and mediolateral areas of abdomen and posterior thorax, absent from head (most paratypes with some small ducts along body margin of thorax and head).

Ventral surface with setae similar to those on dorsum. Multilocular disc pores present in diffuse band along body margin, without pores in medial and mediolateral areas of segment IV; usually without multilocular pores on segment VIII, rarely with 1 or 2; dermal surface near anal tube surrounded by cluster of multilocular pores. Disc-like pores restricted to mediolateral cluster on abdominal segments I and II; often tubular in structure. Trilocular pores scattered over surface, most abundant anteriorly. Oral-collar tubular ducts of 2 sizes, larger size present laterally from metathorax or abdominal segment I to abdominal apex, smaller size in medial and mediolateral area, sometimes present laterally on head and thorax. Vulvar area with 1 pair lateral apophyses, 1 pair lateral apodemes, and 1 medial apophysis.

First-instar (based on numerous embryos from Taiwan and 1 first instar from Canton, China) are not in sufficient condition to allow a complete description, but some diagnostic characters are as follows. Antenna 6-segmented. Mesosternal apophysis absent. Small round circulus present on intersegmental line between segments III and IV. Ostioles restricted to posterior pair. Trilocular pores of 3 sizes: larger size present around body margin, usually with 17 on each side of body (1 on lateral margin of each abdominal segment, 2 on lateral margin of each thoracic segment, and 3 on lateral margin of head); medium-sized triloculars usually associated with ventral mediolateral setae on each side of segment VII and with 1 or 2 near mouthparts, about 1/3 of specimens with 4 such pores forming longitudinal line associated with ventral mediolateral setae of abdominal segments IV–VII; small-sized triloculars forming marginal line around body, associated with larger marginal triloculars, also with 2 in each sclerotized area associated with spiracular atrium, 1 associated with each leg, 1 associated with each ostiole, and sometimes with 1 or 2 in ventral mediolateral areas of segments II and III. Discoidal pores associated with ventral sublateral setae, with 1 on each side of each body segment. Cerarii present on lateral margins of segments V or VI to VIII, those on segment V and VI with 1 conical seta, those on segments VII and VIII with 2 conical setae. Dorsal setae arranged in 4 longitudinal lines on each side of body (1 submedial, 1 mediolateral, and 2 lateral) with 1 seta in each position on each body segment except without mediolateral setae on segments II and III; ventral setae arranged in 3 longitudinal lines on each side of body (1 submedial, 1 mediolateral, and sublateral) with 1 seta in each position on each abdominal segment. Posterior abdominal segments with slight lobe laterally. Posterior seta 56–65(65) μ long.

Notes.—Adult females of this species are most similar to the adult females of *Antonina pretiosa* in possessing abdominal segments which are plate-like and sclerotized. *Antonina maai* differs by having disc-like

pores confined to a single submedian group behind each posterior spiracle and having a few multilocular pores scattered along body margin including near opening to anal tube; *A. pretiosa* has disc-like pores forming a band from abdominal segment II posteriorly around entire abdomen and lacks pores along the body margin except near opening to anal tube.

Based on the descriptions and key presented by Yang and Kosztarab (1967) the first instar of this species also seems to be most similar to *A. pretiosa.* However, we discovered a discrepancy in their description that merits correction. All specimens of *A. pretiosa,* including those examined by Yang and Kosztarab contain a very small, but definite circulus. *Antonina maai* and *A. pretiosa* share the following characters: 3 sizes of trilocular pores; no longitudinal lines of triloculars on dorsum; cerarii with conical setae; body margin of posterior abdominal segments lobed; a small circulus. *Antonina maai* differs by having: line of small-sized trilocular pores around body margin and trilocular pore associated with each ostiole. *Antonina pretiosa* has: no line of small-sized trilocular pores around body margin and no trilocular pore associated with ostioles.

Etymology.—This species is named after Tsing-chao Maa, the collector, formerly of the Agricultural Research Institute, Taipeh, Taiwan, who also collected many scale insects in China and other areas in South East Asia. His help during G. F. Ferris' expedition to China in 1948–1949 was much appreciated by Ferris (see Ferris 1950).

Other specimens examined (not paratypes).—CHINA: Foochow (= Fuzhou), on, ?-?-1976, M. S. Yang (8 ad. ♀, on 3 sl.) (BMNH); Lingnan University, Canton, on *Bambusa multiplex,* IX-18-1948 (Ferris Collection # 97) (11 ad. ♀, 1 first instar, on 6 sl.) (UCD).

Antonina nakaharai Williams and Miller, new species
(Fig. 3)

Type material.–Holotype adult female center specimen on slide with 2 adult female paratypes labeled as follows: left label "Glendale, MD/V-18-77 on/*Phyllostachys* sp./leaf sheath by S./Nakahara 6-77-3/" right label "*Antonina nakaharai*/Williams & Miller/HOLOTYPE/PARATYPE" the right label also gives a map of the position of the holotype. In addition there are 111 adult female paratypes, 7 immature paratypes (excluding first instars), and 155 first instar paratypes.

Description.—*Adult female* holotype on microscope slide, elongate oval, 1.7 mm long (paratypes 1.4–3.7(2.6) mm), 0.7 mm wide (paratypes 0.4–1.8(1.1) mm); posterior apex of last 3 abdominal segments sclerotized (more mature paratypes sometimes with more sclerotization); lateral margins of abdominal segments VI–VIII convex, others straight sided. Antenna 2-segmented (paratypes with 2 or 3 segments), 65 μ long (paratypes 52–85(62) μ). Legs usually represented by inconspicuous sclerotized area, sometimes with associated seta. Labium 60 μ long (paratypes 70–100(80) μ), 2–3 times shorter than clypeolabral shield. Ostioles present on abdomen only. Circulus absent. Spiracles with 2 sizes of trilocular pores in atrium. Cerarii absent, but posterior abdominal setae enlarged, subconical. Anal ring invaginated in anal tube, 150 μ long (paratypes 120–170(139) μ); ring diameter 85 μ long (paratypes 88–100(95) μ); anal tube internally with ring of small multilocular pores and tubular ducts. With 14 & 19 multilocular pores on each side of body in area delimited by posterior edges of each anterior and posterior spiracle (paratypes 10–50(25) pores).

Dorsal surface with short setae, decreasing in length and width anteriorly; longest seta on posterior apex 42 μ long (paratypes 30–52(40) μ). Trilocular pores of 1 size, absent from posterior 2 or 3 segments, scattered over remainder of surface, least abundant posteriorly. Discoidal pores of same distribution pattern as triloculars, less abundant. Multilocular pores forming longitudinal band along body margin; without pores on segment VII near intersegmental

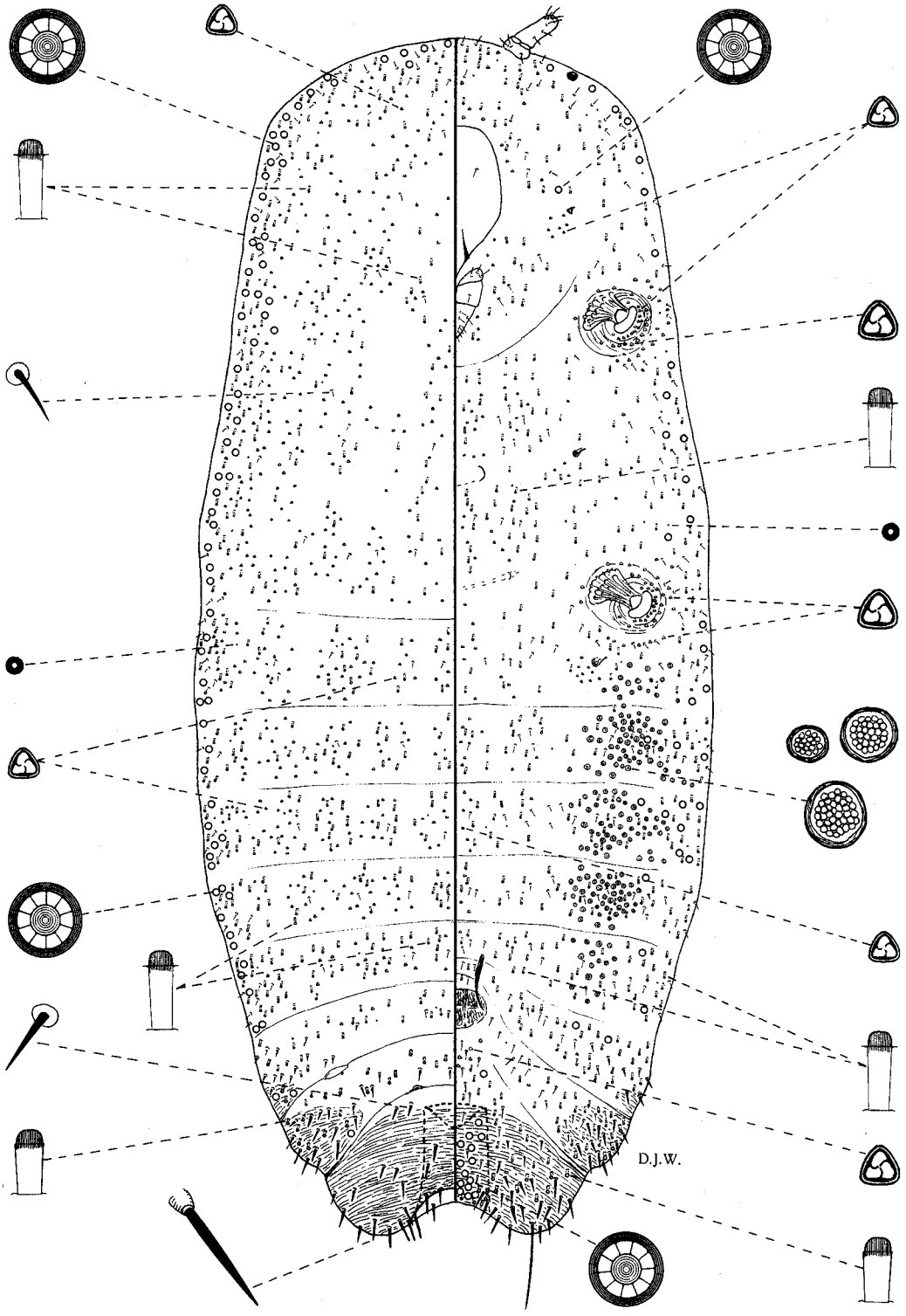

Fig. 3. *Antonina nakaharai.* Specimen from U.S., Maryland, Glendale, on *Phyllostachys* sp.

line between VII and VIII (paratypes 0–3(0) pores). Oral-collar tubular ducts of 1 size, absent from segment VIII except in anal tube, abundant over remainder of surface.

Ventral surface with setae similar to those on dorsum. Multilocular disc pores present in band along body margin, with 1 pore on abdominal segment IV within area delimited by lateral margin of disc-like pore clusters on each side of segment (paratypes with 0–4(1) pores); with multilocular pores on segment VIII restricted to posterior half or third of distance between vulva and posterior apex of body; dermal surface surrounding opening of anal tube with cluster of multilocular pores. Disc-like pores present in mediolateral areas from metathorax to segment VI (paratypes from metathorax to segments IV, V, or VI). Trilocular pores of 2 or 3 sizes, smaller size in plate outside of spiracular atrium and near leg areas; larger size scattered around mouthparts and spiracles, medium size scattered over remainder of surface except absent or rare on posterior 3 or 4 segments, most abundant near body margin. Oral-collar tubular ducts present over surface. Vulvar area with 1 pair of lateral apophyses and 1 pair of weakly indicated posterior apophyses.

Notes.—For a comparison of this species with *A. crawi* and *A. socialis* see the "Notes" section of the former species.

Etymology.—We have named this species after Sueo (Steve) Nakahara who collected some fine specimens of this species in the U.S. He has been an important colleague of both authors for many years.

Specimens examined.—CHINA: Hong Kong, on *Sinobambusa tootsii,* I-30-41, W. B. Wood (2 ad. ♀ on 2 sl.) (USNM) (not part of paratype series); Hong Kong, Botanical Gardens, on *Ixora stricta* (?), VIII-1-1936, R. H. LePelley (1 ad. ♀) (USNM); Koolongue, Fukien, on *Phyllostachys aurea* VII-26-1930, F. A. McClure (2 ad.♀ on 1 slide) (USNM); locality ?, on *Sinobambusa laeta,* Gouldman (1 ad. ♀) (USNM) (not part of paratype series); locality ?, on *Bambusa* sp., IX-1-1936, F. C. Chen (4 ad. ♀ on 4 sl.) (BMNH). RUSSIA: Szocsi (= Sochi), on *Bambusa* sp., IX-5-1985 F. Kozár (1 ad. ♀) (BMNH). JAPAN: Kuro, Chiku, Hotel Chiku, on bamboo, ?-?-1889 (2 ad. ♀, 3 first instars on 2 sl.) (USNM); Mt. Hicko, on bamboo, date and collector ? (1 ad. ♀) (USNM); Sunza Village, on bamboo, XI-6-1980, E. L. Paddock (5 ad. ♀, 1 imm. on 3 sl.) (CDFA); Tokyo on bamboo, date and collector ? (3 ad. ♀ on 1 sl.) (UCD); Yokohama, on bamboo "seeds," I-?-1908, (12 ad. ♀, 7 first instars on 4 sl.) (USNM); Yokohama, on *Arundinaria variegata pygmaea,* VII-11-1911, collector ? (1 ad. ♀) (USNM); Imperial Plant Quarantine Station, Yokohama, on bamboo, date ?, S. I. Kuwana (1 ad. ♀) (UCD); locality ?, on bamboo, XI-?-1909, E. M. Ehrhorn (1 ad.♀) (USNM) (not part of paratype series); locality, host ?, II-?-1912, collector ? (3 ad. ♀ on 1 sl.) (UCD); locality ?, on *Arundinaria japonica,* VIII-14-1933, W. H. Wheeler (1 ad. ♀) (USNM); locality ?, on bamboo stems and leaves, VII-29-1934, W. J. Ehinger (5 ad. ♀, 1 imm. on 2 sl) (USNM); locality ?, on bamboo stems, VIII-2-1934, H. G. Taylor (3 ad. ♀) (USNM); locality ?, on bamboo, I-3-1935, C. V. Scott (1 ad. ♀) (USNM); locality ?, on bamboo, XI-11-1936, O. A. Hardy (2 ad. ♀ on 1 sl) (USNM); locality ?, on bamboo, I-29-1937, A. B. Wells (3 ad. ♀ on 1 sl) (USNM); locality ?, on *Bambusa* sp., X-4-1938, R. F. Wilbur (2 ad. ♀ on 1 sl) (USNM); in quarantine at Seattle, WA, on bamboo, I-17-1946, Young and Smith (1 ad. ♀) (USNM); in quarantine at Encinitas, San Diego Co., CA, on *Sasa kurihensis chabomanba,* III-28-1991, K. Sims (5 ad. ♀ on 3 sl.) (CDFA). TAIWAN: Lo-lin-shan, 2,660 m. elevation, near Arisan, on pygmy bamboo, IX-29-1949, T. Maa (6 ad. ♀ on 3 sl.) (UCD). UNITED STATES: HAWAII: Honolulu, on bamboo, VIII-3-1959, S. Miyake (5 ad.♀ on 1 sl.) (USNM); Honolulu, on bamboo, date and collector ? (1 ad. ♀, 3 first instars on 2 sl.) (USNM); Kawaihae, on bamboo, XII-29-1994, S. Na-

kahara (5 ad.♀, 1 imm. on 1 sl.) (USNM) Oahu, on bamboo, IV-4-1961, J. W. Beardsley (4 ad.♀ on 2 sl.) (USNM). LOUISIANA: New Orleans, on bamboo, IX-29-1924, H. K. Plank (6 ad. ♀ on 1 sl.) (USNM). MARYLAND: Prince George's Co., Glendale, on *Phyllostachys* sp., leaf sheaths, V-18-1977, S. Nakahara (8 ad. ♀, 2 imm. on 3 sl.) (BMNH, USNM). NEW JERSEY: Riverton, on *Bambusa* sp., VII-15-1915, H. B. Weiss (9 ad. ♀, 2 imm. >100 first instars on 7 sl.) (USNM). SOUTH CAROLINA: Aiken, on bamboo, III-8-1911, A. Euctris (2 ad. ♀ on 2 sl.) (USNM). TEXAS: Houston, on bamboo, date ?, N. B. Zuber (5 ad. ♀, 1 imm. on 1 sl.) (USNM); Houston, on bamboo, VIII-?-1918, E. Teas (2 ad. ♀, 4 first instars on 2 sl.) (USNM).

Antonina socialis Newstead, **reinstated status**
(Figs. 4–5)

This species was described by Newstead (1901) but was subsequently treated as a junior synonym of *Antonina crawi* by Williams (1962) based on the illustration of Ferris (1953). Ben-Dov (1994) and Ben-Dov et al. (2001) concurred with Williams' synonymy.

Type material.—Lectotype adult female right specimen on slide with 2 additional adult female paralectotypes labeled as follows: left label "Broxbourne,/Herts; on Arun-/dinaria japonica/Ex Ed. Gard. Chron./26.i.99./E.M.M. vol. XII.p.85"; right label "Antonina/socialis nsp/123 News/Cotype females/3 = lectotype/316" (BMNH). The lectotype was designated by Williams (1985).

Description.—*Adult female* on microscope slide, elongate oval, 1.3–5.0(3.3) mm long, 0.7–2.2(1.7) mm wide; posterior apex of last 2 abdominal segments sclerotized (more mature paratypes sometimes with more sclerotization); lateral margins of abdominal segments VII-VIII convex, others straight sided. Antenna 2- or 3-segmented, 75–105(103) μ long. Legs usually represented by inconspicuous sclerotized area or small dermal pocket, sometimes absent. Labium 88–112(99) μ long, between 2 and 3 times shorter than clypeolabral shield. Ostioles present on abdomen only. Circulus absent. Spiracles with 2 sizes of trilocular pores in sclerotized area surrounding atrium. Cerarii absent, but posterior abdominal setae enlarged, subconical. Anal ring invaginated in anal tube, 127–200(167) μ long; ring diameter 85–132(120) μ); anal tube internally with ring multilocular pores and tubular ducts. With 14–96(50) multilocular pores on each side of body in area delimited by posterior edges of each anterior and posterior spiracle.

Dorsal surface with short setae, decreasing in length and width anteriorly; longest seta on posterior apex 32–47(40) μ long. Trilocular pores of 1 size, absent from posterior 3 or 4 segments, absent along body margin except near spiracles, scattered over remainder of surface. Discoidal pores of same distribution pattern as triloculars, less abundant. Multilocular pores forming longitudinal band along body margin; with 1–12(6) pores on segment VII near intersegmental line between VII and VIII. Oral-collar tubular ducts of 1 variable size, absent or rare on segment VIII except in anal tube, abundant over remainder of surface.

Ventral surface with setae similar to those on dorsum. Multilocular disc pores present in band along body margin, with 0–7(2) pores on abdominal segment IV within area delimited by lateral margin of disc-like pore clusters on each side of segment; with multilocular pores on segment VIII restricted to posterior half or quarter of distance between vulva and posterior apex of body, occasionally with 1 to 3 such pores just posterior to vulva; dermal surface surrounding opening of anal tube with cluster of multilocular pores and oral-collar tubular ducts. Disc-like pores present in mediolateral areas from metathorax to segments VII or VIII. Trilocular pores of 2 or 3 sizes, smaller size in plate outside of spiracular atrium; larger size scattered around mouth-

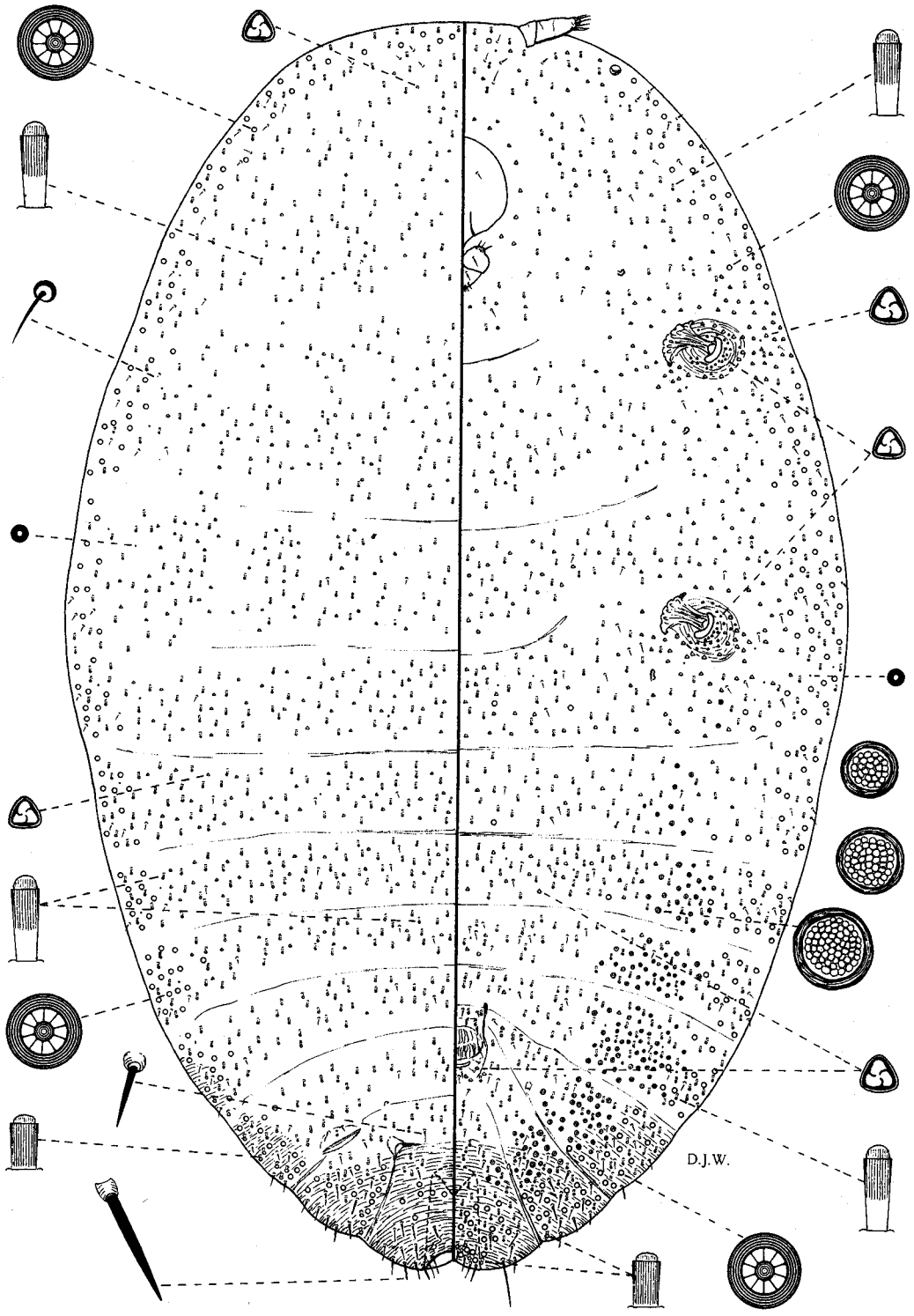

Fig. 4. *Antonina socialis*. Specimen from U.S., Louisiana, New Orleans, on bamboo.

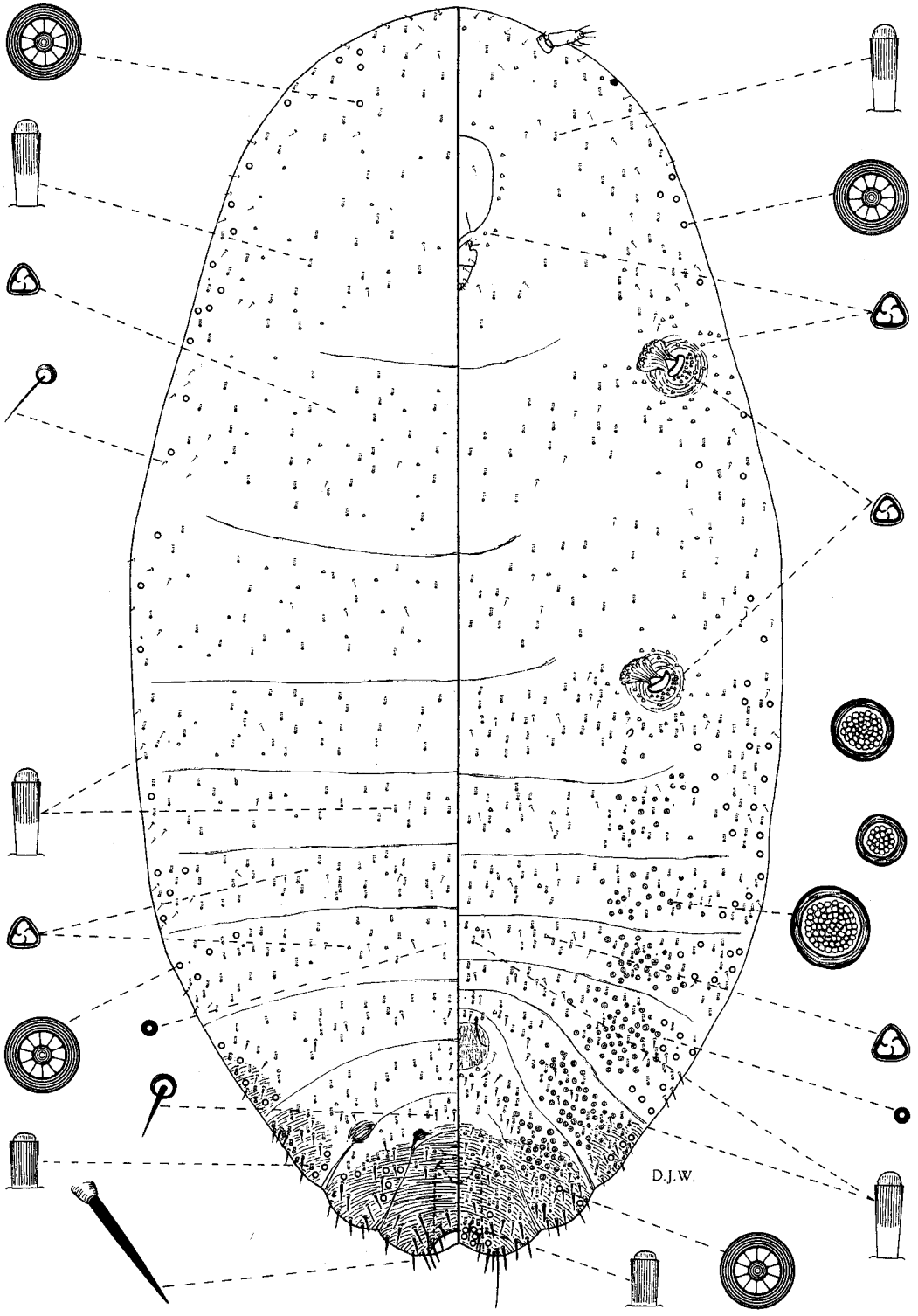

Fig. 5. *Antonina socialis*. Specimen from Bermuda, on bamboo.

parts, medium size scattered over remainder of surface except absent or rare on posterior 3 or 4 segments, most abundant near body margin. Oral-collar tubular ducts present over surface. Vulvar area with 1 pair of lateral apophyses and 1 pair of weakly indicated posterior apophyses.

Notes.—For a comparison of this species with *A. crawi* and *A. nakaharai* see the "Notes" section of the former species.

Original material of this species is not satisfactory for illustrating. Fig. 4 is reasonably similar in appearance to the type series. Fig. 5 shows a variant that has fewer multilocular pores.

Specimens examined.—BERMUDA: locality ?, on bamboo, date and collector ? (6 ad ♀ on 4 sl.) (BMNH); locality ?, on *Arundinaria* sp., V-7-1955, F. J. Simmonds (4 ad. ♀ on 1 sl.) (USNM). CHINA: Hong Kong, on *Bambusa* sp., X-21-1921, A. S. Hitchcock (1 ad. ♀, 1 imm. on 1 sl.) (USNM); locality ?, on *Indocalamus nanicus,* I-30-1941, Gouldman (2 ad. ♀, 4 first instars on 2 sl.) (USNM); Lingnan University, Canton, on small bamboo, XI-7-1948, G. F. Ferris (1 ad. ♀ on 1 sl.) (UCD). JAPAN: Kagoshima, on bamboo, V-12-1901, C. L. Marlatt (2 ad. ♀ on 1 sl.) (USNM); Yokohama, on *Arundinaria hindsii,* VII-12-1921, A. S. Hitchcock (1 ad ♀, 5 first instar on 1 sl.) (USNM); Yokohama, on bamboo, date ?, Kuwana (1 ad. ♀) (UCD); Locality ?, on bamboo, date and collector? (CDFA); locality ?, on *A. hindsii,* VIII-2-1921, A. S. Hitchcock (2 ad. ♀ on 2 sl.) (USNM). TAIWAN: Taihoku, on bamboo, XI-20-1914, M. Mumi (4 ad. ♀ 2 imm. on 2 sl.) (UCD); locality ?, on *A. kansan,* I-30-1941, Gouldman (3 ad. ♀ on 1 sl.) (USNM). UNITED KINGDOM: ENGLAND: Hertfordshire, Broxbourne, on *A. japonica,* I-26-1899, editor of Gardener's Chronicle (3 ad. ♀ on 1 sl) (BMNH); Hertfordshire, Broxbourne, on *A. japonica,* date and collector ? (1 ad. ♀) (BMNH). SCOTLAND: East Lothian, Prestonkirk, on freshly imported bamboo from Japan, VII-?-1905, A. Hepburn (4 ad. ♀ on 1 sl.) (BMNH). UNITED STATES: CALIFORNIA: Sacramento, on ?, II-24-1913, E. O. Essig (3 ad ♀, 1 first instar on 4 sl.) (USNM); Ventura, on bamboo, XI-1-1910, collector ? (5 ad ♀ on 3 sl.) (USNM); Ventura, on bamboo, I-10-1911, E. O. Essig (1 ad ♀) (USNM); Ventura, on bamboo, I-12-1913, S. H. Essig (5 ad ♀, 6 imm., 1 first instar on 5 sl.) (UCD, USNM). HAWAII: Honolulu, host and date ?, E. M. Ehrhorn (7 ad. ♀ on 3 sl.) (UCD, BMNH); Moanalua Gardens, Honolulu, on bamboo, X-3-1908, Kotinsky (2 ad. ♀ on 2 sl.) (USNM); Moanalua Gardens, Honolulu, on bamboo, III-10-1910, E. M. Ehrhorn (7 ad. ♀ on 1 sl.) (USNM); Moanalua Gardens, Honolulu, on bamboo, IV-22-1914, collector ? (2 ad. ♀ on 1 sl.) (USNM). LOUISIANA: Metaire Ridge Nurseries, New Orleans, on bamboo, IV-5-1921, F. Foster (1 ad. ♀); New Orleans, IV-2-1921, on bamboo, W. Bradley (2 ad. ♀ on 1 sl.) (UCD); New Orleans, on *Pseudosasa japonica, Sasa japonica,* and *Arundinaria japonica,* II-11-1943, R. A. Young (3 ad. ♀, 1 imm. on 2 sl.) (USNM); New Orleans, on bamboo, II-17-1945, G. Rau (4 ad. fem on 2 sl.) (USNM).

Key to Adult Females of *Antonina* Species Occurring on Bamboo

1. Anal ring not on dermal surface but present in internal tube; without a circulus 2
– Anal ring on dermal surface, not in internal tube; apparently with a circulus .... *bambusae* Khalid and Shafee

2(1). Disc-like pores not confined to segments V or VI to VIII 3
– Disc-like pores confined to segments V or VI to VIII .... *meghalayaensis* Khalid and Shafee

3(2). Abdominal segments plate-like and sclerotized from body margin to medial or sublateral areas of segments III or IV to VIII 4
– Abdominal segments not plate-like and sclerotized from body margin to medial or sublateral areas, or with plate-like areas restricted to segments VI to VIII 5

4(3). Disc-like pores in definite submedial groups, forming a band from abdominal segment II posteriorly around abdomen; multilocular pores absent except near opening of anal tube ..... *pretiosa* Ferris
– Disc-like pores confined to single subme-

dial group behind each posterior spiracle on abdominal segment II; multilocular pores present along body margin of venter and near opening of anal tube (Fig. 2) . . . . . *maai* Williams and Miller, n. sp.

5(3). Disc-like pores present in large group from metathorax posteriorly to at least segment III 6

– Disc-like pores restricted to small group posterior to each second spiracle between metathorax and abdominal segment II . . . . . *zonata* Green

6(5). Multilocular pores absent from crescentic band adjacent to atrium of each spiracle (Fig. 4); crescentic band containing trilocular pores only 7

– Multilocular pores present in crescentic band adjacent to atrium of each spiracle; crescentric band containing multiloculars and triloculars . . . . . *purpurea* Signoret

7(6). Multilocular pores present on dorsum . . . 8

– Multilocular pores absent from dorsum . . . . . *graminis* (Maskell)

8(7). Multilocular pores not encircling crescentic band of trilocular pores adjacent to anterior spiracles 9

– Multilocular pores encircling crescentic band of trilocular pores adjacent to anterior spiracles . . . . . *thaiensis* Takahashi

9(8). Disc-like pores restricted to segments II to IV, V, or VI (rarely with 1 or 2 on VII) 10

– Disc-like pores present on segments II to VII or VIII (Figs. 4–5) . . . *socialis* Newstead

10(9). Ventral abdominal multilocular pores abundant, with 6 or more pores on segment IV in area defined by lateral margins of disc-like pore clusters (Fig. 1) . . . . . *crawi* Cockerell

– Ventral abdominal multilocular pores uncommon, with 5 or fewer pores on segment IV in area defined by lateral margins of disc-like pore clusters (Fig. 3) . . . . . *nakaharai* Williams and Miller

Discussion

We have examined the first instars of representatives of each species of the Crawi complex and find no consistent morphological differences among them. The illustration and description of the first instar by Yang and Kosztarab (1967) is reasonably accurate, except there is an extra longitudinal line of trilocular pores near the body margin. The species that they treated as *A. crawi* is actually *A. nakaharai.*

Because of confusion about the correct identities of *A. socialis, A. crawi,* and *A. nakaharai,* it is difficult to determine which was the focus of the treatments of most authors. Ferris (1953) presented an illustration of what was labeled as *A. crawi,* but it actually is fairly typical of *A. socialis.* The specimens that he illustrated were either collected in Ventura, California by E. O. Essig or New Orleans, Louisiana by W. Bradley. Ferris' illustration also was used by McKenzie (1967) (he treated specimens of *A. socialis* and *A. crawi*), Williams and Granara de Willink (1992) (they treated only *A. socialis*), and Zimmerman (1948) (probably treated only *A. nakaharai*). We have attempted to associate as many literature citations as possible of *A. crawi* with the correct species from the Crawi complex. This information is as follows: Affifi and Kosztarab (1967) (probably *A. nakaharai*); Beardsley (1965) (probably *A. nakaharai*); Ben-Dov (1994) (all three species); Cockerell (1900) (*A. crawi*); Danzig (1980) (probably *A. nakaharai*); Hendricks and Kosztarab (1999) (all three species); Hodgson and Hilburn (1991 and 1991b) (probably *A. socialis*); Hu et al. (1992) (probably *A. socialis*); McKenzie (1967) (*A. crawi* and *A. socialis*); Newstead (1901) (*A. socialis*); Nur et al. (1987) (probably *A. nakaharai*); Paik (1978) (probably *A. socialis*); Tang (1977) (probably *A. socialis*); Tang (1992) (not part of Crawi complex; similar to *A. tesquorum*); Tereznikova (1975) (possibly *A. nakaharai*); Williams and Granara de Willink (1992) (probably *A. socialis*); Yang and Kosztarab (1967) (first instar probably *A. nakaharai;* second instar ?); Zimmerman (1948) (probably *A. nakaharai*).

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