Exhibit 6b, #30

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A new genus and species of mealybug with a consideration of morphological convergence in three arboreal species (Homoptera: Pseudococcidae)

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ABSTRACT. Descriptions and illustrations are given of male and female instars of the mealybug *Plotococcus eugeniae,* gen.n. and sp.n. This pseudococcid inhabits the dense hammock vegetation of southern Florida and is found primarily on *Eugenia.* It has the unusual habit of infesting many microhabitats on leaf undersurfaces rather than limiting its distribution to primary and secondary veins as do most leaf-inhabiting mealybugs. *Plotococcus eugeniae* has unusually long legs, tarsal claws, antennae, and lateral wax filaments. *Leptococcus metroxyli* Reyne from New Guinea and *Macrocepicoccus loranthi* Morrison from Guyana also have these features. These species are redescribed and illustrated, and morphological comparisons are given that document the similarity of gross body structure among all three taxa. Evidence is presented suggesting that the unique morphology of these species has evolved independently through selection for dispersal as adult females.

Introduction

An unusual, and previously undescribed mealybug commonly inhabits the leaf undersurfaces of stoppers (*Eugenia*) in the hammock vegetation of southern Florida. This insect is unique to the mealybug fauna of the United States because it possesses unusually long antennae, legs, tarsi, and lateral wax filaments.

A survey of the literature on the Pseudococcidae has revealed two other mealybugs (*Leptococcus metroxyli* Reyne and *Macrocepicoccus loranthi* Morrison) that share the unique constellation of biological and morphological features mentioned above (Morrison, 1919; Reyne, 1961). The intent of this study is to provide a name for the Floridian species, to describe all male and female instars of each species, to investigate the possibility of morphological convergence, and to interpret ecologically the atypical structure of these mealybugs.

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Methods

Measurements in the taxonomic descriptions are averages for ten specimens, taken from a variety of locations, at magnifications of 256× or 640× using a Zeiss, phase contrast microscope. Measurements of leg segments, antennae, and body length were made with an ocular micrometer. Values are reported as the range and mean respectively (e.g., 2–5(3)). Roman numerals label abdominal segments (e.g., V = abdominal segment 5).

Depositories

Depositories are abbreviated as follows: British Museum (Natural History), London (BMNH); California State Department of Agriculture, Sacramento (CDA); Florida State Collection of Arthropods, Gainesville (FSCA); Museo de Historia Natural de Ciudad de Mexico, Mexico City (MHN); Museum National d'Histoire Natural, Paris (MNHN); South African National Collection of Insects, Pretoria (SA); University of California, Davis (UCD); University of Hawaii at Manoa, Honolulu (UH); United States National Museum of Natural History, Washington, D.C. (USNM); Virginia Polytechnic Institute and State University, Blacksburg (VPI); Zoological Institute, Academy of Sciences of USSR, Leningrad (ZI); Instituut voor Taxonomische Zoologie (Zoologisch Museum), Amsterdam, Netherlands (ZM).

Comparison of instars

Fourth instar females (adults) are unique in having a vulva, and also in having translucent pores on the hind tibia. This instar is about 1.4 mm long by 0.7 mm wide and has multilocular pores, hind tibia/tarsus ratio about 2.7, nine-segmented antennae that are over 700 μm long, and 10–16 pairs of cerarii.

Third instar females are about 1.0 mm long by 0.4 mm wide and have multilocular pores, hind tibia/tarsus ratio about 1.5, seven- or eight-segmented antennae that are 370–800 μm long, and 9–16 pairs of cerarii.

Second instar females are about 0.8 mm long by 0.4 mm wide and have multilocular pores, hind tibia/tarsus ratio about 1.0, six-segmented antennae that are 240–500 μm long, and 2–10 pairs of cerarii.

First instars are unique in lacking tubular ducts and multilocular pores. This instar is about 0.6 mm long by 0.3 mm wide and has hind tibia/tarsus ratio about 0.8, six-segmented antennae which are 190–350 μm long, and two pairs of cerarii.

Fifth instar males (adults) are unique in having fully-developed wings, a penial sheath, ten-segmented antennae, and an aedeagus. The hind tibia/tarsus ratio is 1.9–2.6.

Fourth instar males (prepupae) are unique in having wing buds which are over 340 μm long. This instar has no trilocular pores, and the hind tibia/tarsus ratio is 1.4 or 1.5 when the tibia and tarsus are not fused.

Third instar males (prepupae) are unique in having wing buds that are less than 200 μm long. This instar has no trilocular pores, and the hind tibia/tarsus ratio is 1.2 or 1.3 when the tibia and tarsus are not fused.

Second instar males may be distinguished from all but second instar females by being about 0.8 mm long by 0.3 mm wide, and by having multilocular pores, hind tibia/tarsus ratio about 1.0, six-segmented antennae that are 260–450 μm long, and 2–9 pairs of antennae. The second instar males of *Leptococcus metroxyli* and *Plotococcus eugeniae* have tubular ducts which are absent on the second instar females of the species. The second instar male of *Macrocepicoccus loranthi* has fewer tubular ducts and multilocular pores than the second instar female.

Leptococcus Reyne

Leptococcus Reyne, 1961: 145; Morrison and Morrison, 1966: 108. Type-species: *Leptococcus metroxyli* Reyne, 1961, by original designation and monotypy.

Etymology. The generic name is masculine and is derived from the Greek words *leptos* meaning 'fine, or delicate' and *coccus* meaning 'seed' or 'scale insect'.

Diagnosis of adult female. Less than 17 pairs of cerarii. Cerarii with loosely associated trilocular pores. Multilocular pores of one size, on both body surfaces. Trilocular pores restricted to dorsum. Oral-collar tubular ducts on both body surfaces, each with small dermal rim. Legs and antennae in relation to body length unusually long for pseudococcid. Antennae normally nine-segmented. Claws without denticles. Anterior ostioles present. Circulus absent.

Leptococcus metroxyli Reyne

Leptococcus metroxyli Reyne, 1961: 147; Morrison & Morrison, 1965: 35; Morrison & Morrison, 1966: 113.

Type-material. Through the courtesy of W. N. Ellis, Instituut voor Taxonomische Zoologie (Zoologisch Museum) it has been possible to borrow the type-series of this species. Unfortunately this material is in poor condition, and it was necessary to remount

most of the slide-mounted specimens. Additional preparations were made from specimens preserved in alcohol. Only four of the original forty slides had labels with adequate data; the remainder lacked all data or had writing in ink on the glass indicating only the instar present on the slide. Because the ink washed off in the remounting process, it was necessary to copy this information, when possible, and put it on a new label. Because Reyne did not designate a holotype, we have chosen and marked as lectotype an adult female that is the middle specimen of three on a slide. The slide is labelled as follows: The left label is in Reyne's handwriting, '*Leptococcus metroxyli* A R Fred Hendrik isl [Frederick Hendrik Island] (New Guinea) IV. 1957 by E. W. v Heurn.' The right label maps the position of the lectotype and states: 'Lectotype desig. by Miller & Denno paralectotypes. Remounted from original Reyne sl. 1975 3 ad ♀.' Slide material borrowed from ZM, including the lectotype, has been returned. Material from the type series that we mounted from alcohol has been returned or is deposited in the following: BMNH, MNHN, SA, UCD, UH, USNM, VPI, ZI.

Material examined. Specimens other than the lectotype and paralectotypes are from eight other New Guinea locations. All collections are from *Metroxylon* except for a collection from *Cocos nucifera* and one from 'pineapple'.

Field features. According to Reyne (1961), 'Body flat; height only ⅓–½ of width. The body is slightly dusted with wax . . . A fringe of about 15 long wax filaments is seen on both sides of the body; their length is usually about equal to the width of the insect . . . These wax filaments have peculiar structure. In their axis one, or usually two glass threads are observed which are covered by a thin layer of small waxy curls . . . crowded colonies, . . . sometimes cover ¾ of the lower surface of the separate pinnae of the palm leaf . . . Body, legs and antennae yellowish . . . they are frequented by ants.'

Fourth instar females (adult) (Fig. 1)

Recognition characters. Mounted, 1.3–2.1 (1.7) mm long, 0.5–1.2 (0.9) mm wide.

Dorsum with 14–16 pairs of cerarii, specimens with 14 or 15 pairs also frequently with one or two cerarian areas with 1 conical seta but without basal trilocular pores. Cerarii of normal pseudococcid type. Anal-lobe cerarii each with 2 conical setae, 2–4(3) auxiliary setae, basal cluster of 19–24(21) trilocular pores, 0–2(1) discoidal pores, basal area of sclerotization. Next 6 pairs of cerarii counting anteriorly each with about 21, 11, 11, 11, 16, 15 trilocular pores respectively, also with 2 conical setae decreasing in size anteriorly, with 1–5(2) auxiliary setae, 0–2(1) discoidal pores, conspicuous basal sclerotization. Next 5 cerarii each with 1, or normally 2, conical setae, about 5 basal trilocular pores, 1 or 2 auxiliary setae, few discoidal pores, basal sclerotization. Next cerarius with 2 conical setae, about 15 basal trilocular pores, 2–4(2) auxiliary setae, 0–2(1) discoidal pores, basal sclerotized area. Three anterior cerarii each with 2–5(3) conical setae, about 17 trilocular pores, 0–4(2) auxiliary setae, 0–2(1) discoidal pores, basal sclerotized area. Multilocular pores along body margin, normally in transverse row on segment VIII, occasionally in rows on segments VII–V or IV, on mediolateral areas of anterior abdominal segments, and on thorax and head forming pair of longitudinal lines. Trilocular and discoidal pores scattered over surface. Oral-collar tubular ducts along body margin, on mediolateral areas of anterior abdominal segments, on thorax, and head forming pair of longitudinal lines. Dorsal body setae bristle shaped, those on segment IX not unusually elongate; segment V with 11–18(13) such setae excluding those in cerarii. Both pairs of ostioles present.

Anal ring normally bent around apex of abdomen, with two rows of pores, each of its 6 setae slightly longer than greatest diameter of ring.

Venter with multilocular pores of one size, along body margin and on medial areas of posterior abdominal segments. Trilocular pores absent. Discoidal pores in small number over surface. Oral-collar tubular ducts of two sizes, larger size in marginal areas, smaller size with or without dermal rim, ducts located medially and/or mediolaterally on segment VIII and rarely VII, each specimen with

0–5(1) such ducts. Anal lobes sclerotized, longest anal-lobe seta 83–105(95) μm long.

Circulus absent. Legs with hind tibiae dorsally with 32–68(47) translucent pores, ventrally without pores; hind tibia/tarsus ratio 2.4–2.9(2.6); hind tibia + tarsus length 378–500(432) μm; apices of tarsal and claw digitules enlarged, those of claw noticeably larger than those of tarsus; hind claws 40–45(42) μm long. Antennae nine-segmented; length 573–878(673) μm.

This description is based on eighty-three specimens from eight localities.

Third instar females (Fig. 4)

Recognition characters. Same as for adult female except as follows: mounted, 0.7–1.3(1.0) mm long, 0.3–0.6(0.4) mm wide.

Dorsum with 9–12 pairs of cerarii, with 0–2 additional cerarian areas represented by single conical seta. Anal-lobe cerarii each with two conical setae both about same size, 1–2(2) auxiliary setae, basal cluster of 11–17(14) trilocular pores, 1–2(1) discoidal pores, area of basal sclerotization. Penultimate cerarii each with two conical setae about same size as those on anal lobe, with 1–2(1) auxiliary setae, basal cluster of 9–13(11) trilocular pores, 0–3(1) discoidal pores, area of basal sclerotization. Next 5 pairs of cerarii counting anteriorly each with 2 conical setae noticeably smaller than those on posterior cerarii, 0–1 auxiliary setae, each with about 2, 2, 2, 5, 5 trilocular pores respectively, normally without discoidal pores, with small area of basal sclerotization. Cerarian area 8, 10, 11, 12, sometimes 14 counting forward from anal lobes normally without conical setae. Cerarii 9 and 13 each normally with 2 conical setae, no auxiliary setae, 3 and 6 trilocular pores respectively, no discoidal pores, small area of basal sclerotization. Cerarii 14 and 15 each normally with 3 conical setae, no auxiliary setae, 6 trilocular pores, no discoidal pores, area of basal sclerotization. Multilocular pores and oral-collar tubular ducts less numerous than on adult female. Trilocular pores scattered over surface. Discoidal pores restricted to marginal areas. Segment V with 9–12(10) setae.

Venter with multiloculars less numerous than on adult female. Oral-collar tubular ducts of one size, restricted to marginal areas. Longest anal-lobe seta 60–75(68) μm.

Legs with hind tibia/tarsus ratio 1.4–1.8(1.5); hind tibia + tarsus length 258–330(294) μm; hind claws 38–40(38) μm long. Antennae seven- or eight-segmented, normally seven; length 378–555(443) μm.

This description is based on eighty-six specimens from seven localities.

Second instar females (Fig. 7)

Recognition characters. Same as for adult female except as follows: mounted, 0.7–1.0(0.8) mm long, 0.3–0.4(0.4) mm wide.

Dorsum with 4–10(7) pairs of cerarii, 1–5 additional areas represented only by single conical seta or by pair of associated bristle-shaped setae. Anal-lobe cerarii each with 2 conical setae, lateral seta smallest, 1 auxiliary seta, basal cluster of 5–9(7) trilocular pores, 0–2(1) discoidal pores, basal area of sclerotization. Penultimate cerarii each with 2 conical setae about same sizes as those on anal lobe, 0–2(0) auxiliary setae, basal cluster of 4–6(6) trilocular pores, 0–1(1) discoidal pores, area of basal sclerotization. Counting anteriorly, following cerarii normally well developed: 6, 7, 13, 15, each with 2 conical setae noticeably smaller than those on posterior cerarii, with 0–1 auxiliary setae, 1 or 2 trilocular pores, without discoidal pores, with small area of basal sclerotization. Cerarius 16 well developed, with 2 or 3 conical setae, 0–1(1) auxiliary setae, 1–5(3) trilocular pores, 0–1(1) discoidal pores, small area of basal sclerotization. Cerarius 9 normally composed of one conical seta or two closely associated bristle-shaped setae and one basal trilocular pore; other cerarii frequently absent, cerarii numbers 8, 9, 10, 11, 12 and 14 absent, numbers 3, 4 and 5 normally absent. Multilocular pores generally of same distribution as on adult female but less abundant. Trilocular pores scattered over surface. Discoidal pores generally restricted to marginal areas. Oral-collar tubular ducts normally restricted to marginal areas, rarely with one or two in longitudinal line with multilocular pores. Segment V with 4–6(5) bristle-shaped setae excluding those in cerarian areas.

Venter with multilocular pores less

abundant than on adult female. Oral-collar tubular ducts of one size, restricted to marginal areas. Discoidal pores along body margin and near legs. Longest anal-lobe seta 45–63(56) μm.

Legs with hind tibia/tarsus ratio 1.0–1.1(1.1); hind tibia + tarsus length 178–230(207) μm; hind claw 30–33(32) μm long. Antennae six-segmented; 244–360(311) μm long.

This description is based on fifty-eight specimens from three localities.

First instars (Fig. 10)

Recognition characters. Same as for adult female except as follows: mounted, 0.5–0.7(0.6) mm long, 0.2–0.3(0.3) mm wide.

Dorsum with posterior two pairs of cerarii definite, remaining cerarii absent or composed of 2 bristle-shaped setae with 0–1 associated trilocular pores. Anal-lobe cerarii each with 2 conical setae about equal in size, no auxiliary setae, 1 trilocular pore, no discoidal pores, small area of basal sclerotization. Penultimate cerarii similar to anal-lobe pair. Trilocular pores forming two or three pairs of longitudinal lines, medial line frequently indefinite, mediolateral and lateral lines obvious. Discoidal pores absent. Segment V with 4 bristle-shaped setae excluding those in cerarii. Anterior ostioles absent.

Venter with discoidal pores forming longitudinal line near body margin. Longest anal-lobe seta 40–58(48) μm long.

Legs with hind tibia/tarsus ratio 0.7–0.9(0.8); hind tibia + tarsus length 148–168(159) μm; hind claws 28–30(30) μm long. Antennae six-segmented; 200–270(238) μm long.

This description is based on twenty-seven specimens from three localities.

Fifth instar males (adult) (Fig. 13)

Recognition characters. Mounted, 0.9–1.2(1.0) mm long, 0.2–0.3(0.3) mm wide.

Dorsum with one pair of tail-forming pore clusters, each with 2 long setae and 1 short seta, longest seta 188–233(205) μm long, shortest seta 28–43(37) μm long, each cluster with 25–33(29) pores, predominantly of quinquelocular type, occasionally with three, four, or six loculi, with 1–3(2) discoidal pores. Multilocular derm pores with 3–5(4) loculi, near margin on some of segments VIII–II, each side of abdomen with 3–9(6) pores, occasionally near pronotal ridge. Clear centre pores scattered over abdomen, most abundant near body margin, often associated with multilocular derm pores. Head pores normally near base of antennae. Body setae of two kinds, slender setae scattered over surface, fleshy setae abundant in medial areas of abdomen, also on thorax and head. Posterior ostioles present. Abdominal sclerotization normally restricted to medial portion of segment IX, sometimes sclerotization on mediolateral areas of segments VIII–II. Metapostnotal ridge well developed. Scutum sclerotized throughout. Prescutum with posterior margin lightly sclerotized, subrectangular. Postoccipital ridge normally absent; dorsal arm of midcranial ridge well developed, extending forward to near posterior edge of lateral arms of midcranial ridge. Dorsomedial sclerite normally weakly sclerotized. Preocular and postocular ridges separate on dorsal aspect of head, normally without connecting ridges, sometimes with darkly sclerotized area around ocellus. Dorsal eye 30–40(34) μm in diameter. Ocellus 18–23(21) μm in diameter.

Penial sheath 100–115(110) μm long, width/length ratio 0.7–0.9(0.8). Penial sheath undivided, without medial lobes. Aedeagus 93–103(99) μm long; basal apodeme present. Setae pattern on sheath consistent.

Venter with multilocular derm pores absent or with total of 1–3 pores on mediolateral areas of segments VI–IV, present or absent near anterior pair of legs. Clear centre pores in mediolateral areas of abdomen. Body setae of same two kinds as on dorsum, bristle-shaped setae most abundant, fleshy setae numerous on anterior portion of head. Precoxal ridge of metathorax absent. Pleural ridge of metathorax well developed. Lateropleurite of mesothorax well developed. Prosternum weakly sclerotized. Preocular + interocular ridge well developed, joining postocular ridge just below ocellus. Ventral arm of midcranial ridge normally not evident. Ventral cavity conspicuous. Ventral eye 33–43(38) μm in diameter.

Prothoracic legs slightly shorter than mesothoracic legs, metathoracic legs longest. Hind

tibia/tarsus ratio 2.2–3.0(2.6); hind tibia + tarsus length 311–390(354) μm; hind claw 45–55(51) μm long; legs with bristle-shaped and fleshy setae; tarsal digitules equal in size, not exceeding length of claw, apically capitate; claw digitules less than one-half length of claw, apically acute; tarsi two-segmented. Body length/antennal length 1.2–1.8(1.6); antennae normally ten-segmented, of nineteen antennae examined, two were eight-segmented, two were nine-segmented, and fifteen were ten-segmented; two specimens had nine-segmented antennae on one side and ten on the other; third antennal segment 1.4–2.0(1.7) times longer than apical segment. Antennal setae as follows when ten-segmented: without subapical sensory setae; with fleshy setae on segments 10–2; hairlike setae on all segments; antennal bristles on distal three segments. Front wings each 0.9–1.1(1.0) times longer than length of body, with 1–3(2) circular sensoria and 2–5(3) alar setae. Hamulohalterae absent.

This description is based on twenty-two specimens from two localities.

Fourth instar males (pupae) (Fig. 16)

Recognition characters. Same as for adult female except as follows: mounted, 1.0–1.2(1.1) mm long, 0.3–0.4(0.4) mm wide. Body shape normal for pseudococcid.

Dorsum with cerarian areas similar to those on prepupae. Multilocular pores present in mediolateral areas of segments VIII, VII, or VI–prothorax absent from mesothorax. Trilocular pores absent. Discoidal pores associated with multilocular pores and tubular ducts. Oral-collar tubular ducts along body margin. Segment V with 5–7(6) bristle-shaped setae excluding those in cerarian areas. Anterior ostioles absent.

Anal ring dorsal, without pores and setae.

Venter with multilocular pores normally in two pairs of longitudinal lines on mediolateral and lateral areas of abdomen, sometimes without lateral line, also in small numbers on thorax. Discoidal pores associated with multilocular pores. Oral-collar tubular ducts absent. Anal lobes unsclerotized, longest anal-lobe seta 63–85(72) μm.

Eyes not protuberant. Legs with hind tibia/tarsus ratio 1.2–1.8(1.5); hind tibia + tarsus length 208–318(265) μm; hind claws 35–43(40) μm long. Antennae ten-segmented, apical segment sometimes partially fused with ninth segment; antennae 348–494(406) μm long. With one pair of wing buds, 342–402(376) μm long.

This description is based on twenty-three specimens from two localities.

Third instar males (prepupae) (Fig. 19)

Recognition characters. Same as for adult female except as follows: mounted, 1.0–1.2(1.1) mm long, 0.4–0.5(0.4) mm wide.

Dorsum without cerarii, cerarian areas on segments IX–II each with 2 closely associated bristle-shaped setae. Multilocular pores scattered over mediolateral and lateral areas of abdomen, also distributed over thorax and head. Discoidal pores uncommon. Trilocular pores absent. Oral-collar tubular ducts of one size, marginal. Segment V with 4–6(5) bristle-shaped setae excluding those in cerarian areas. Anterior ostioles absent.

Anal ring dorsal, without pores or setae.

Venter with multilocular pores of one size on mediolateral and lateral areas. Discoidal pores few, marginal. Oral-collar tubular ducts of one size, along body margin. Anal lobes unsclerotized; longest anal-lobe seta 38–70(60) μm.

Eyes not protuberant. Legs with hind tibia/tarsus ratio 1.1–1.5(1.3); hind tibia + tarsus 195–273(227) μm long; tibia and tarsus partially fused; hind claws 30–35(33) μm long. Antennae normally nine-segmented, one specimen with seven-segmented antennae; antennal length 293–388(340) μm. One pair of wing buds 85–104(97) μm long.

This description is based on eight specimens from three localities.

Second instar males (Fig. 22)

Recognition characters. Same as for second instar female except as follows: mounted, 0.8–1.1(0.9) mm long, 0.3–0.5(0.4) mm wide.

Dorsum with 3–7(4) pairs of cerarii, with one or two additional areas composed of single conical seta or pair of associated bristle-shaped setae. Anal-lobe cerarii each with 2–3(2) conical setae one auxiliary seta, basal cluster of 7–10(8) trilocular pores, 1–2(1) discoidal pores, basal area of sclerotization. Penultimate cerarii each with 2

conical setae about same size as those on anal lobe, 0–1(1) auxiliary setae, basal cluster of 5–8(6) trilocular pores, 0–1(1) discoidal pores, area of basal sclerotization. Counting anteriorly, following cerarii normally well developed: 6, 7, 13, 16; number 15 rarely developed; numbers 3, 4, 5, 8, 9, 10, 11, 12, 14 not developed; cerarius 16 normally with 3 conical setae. Oral-collar tubular ducts scattered over surface, of two sizes: Larger size predominant on abdomen; smaller size predominant elsewhere. Segment V with 5–6(5) bristle-shaped setae excluding those in cerarian areas. Anterior ostioles absent.

Venter with multilocular pores less abundant than on adult female. Oral-collar tubular ducts of two sizes: Larger size restricted to marginal areas; smaller size present in mediolateral line on abdomen, numerous over thorax, especially abundant near legs, frequently absent on head. Discoidal pores present in mediolateral and lateral areas. Longest anal-lobe seta 50–68(59) μm.

Legs with hind tibia/tarsus ratio 1.1–1.3(1.1); hind tibia + tarsus 185–238(212) μm long; hind claw 30–35(32) μm long. Antennae 244–329(290) μm long.

This description is based on twenty specimens from four localities.

Macrocepicoccus Morrison

Macrocepicoccus Morrison, 1919: 198; Ferris, 1921: 60; MacGillivray, 1921: 130; Borchsenius, 1949: 44; Morrison and Morrison, 1966: 113.

Type-species. Macrocepicoccus loranthi Morrison, 1919, by original designation and monotypy.

Etymology. The generic name is masculine and is derived from the Greek words *Macro* meaning 'long', *cepium* meaning 'garden', and *coccus* meaning 'scale insect'. The name apparently refers to this mealybug's unusually long appendages and to the type-locality, the Botanic Gardens at Georgetown, Guyana.

Diagnosis of adult female. Less than 17 pairs of cerarii. Cerarii with trilocular pores closely appressed to cerarian setae forming basal plate. Multilocular pores of one size. Trilocular pores restricted to dorsum. Oral-collar tubular ducts on both body surfaces, each with small dermal rim. Legs and antennae in relation to body length unusually long for pseudococcid. Antennae normally nine-segmented. Claws without denticles. Anterior ostioles absent. Circulus present.

Macrocepicoccus loranthi Morrison

Macrocepicoccus loranthi Morrison, 1919: 198; MacGillivray, 1921: 142; Cockerell & Bueker, 1930: 4; Lindinger, 1937: 188: Morrison & Renk, 1957: 161; Bennett, 1957: 571: Reyne, 1961: 159; Morrison & Morrison, 1966: 113.

Type-material. From the syntypes we have chosen and marked as lectotype one of three adult females on a slide. The lectotype is on the upper right side of the cover slip with left label '*Macrocepicoccus loranthi* Morrison on *Loranthus* Georgetown, B. G. [Guyana] H. Morrison Sept. 24, 1918. A-655.' The right label maps the location of the lectotype and states 'lectotype, paralectotypes, desig. D. R. Miller & R. F. Denno 3 ad ♀♀' (USNM).

Material examined. Specimens other than the type locality are as follows: Canal Zone, Ancon on 'a parasitic plant on *Citrus*' and on 'leaves of mistletoe on Moringa'. *Macrocepicoccus loranthi* is also reported from Trinidad (Bennett, 1957).

Field features. According to Morrison (1919), 'Occurring normally on the under sides of the leaves of the host, usually in numbers; maximum length of living specimens about 2 mm, width less than 1 mm, elongate, rather slender, . . . very pale yellowish with a faint greenish tinge; body dorsally with faint traces of white mealy secretion, this most pronounced just inside the body margin and again in a submedian band on each side forming two very vague and indistinct longitudinal stripes; also dorsally with scattered very delicate glassy threads, these most conspicuous along the margins where they frequently project as far beyond the body as do the femora or even farther, and where they are grouped into a series of clusters, each surrounding . . . long, slender cylindrical white wax threads, which project forward, laterally and caudally from the margin,

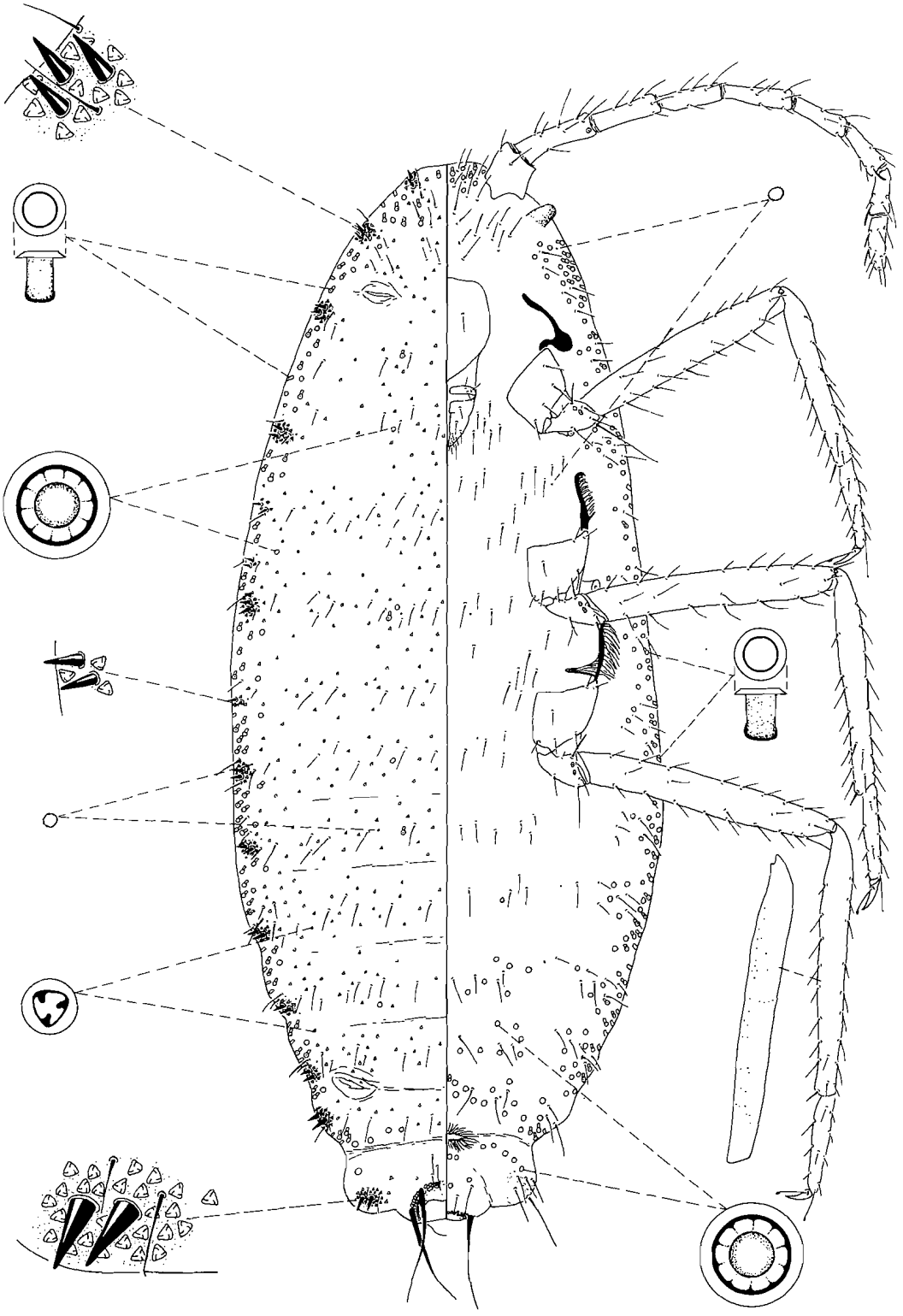

FIG. 1. Fourth instar female (adult) of *Leptococcus metroxyli* Reyne.

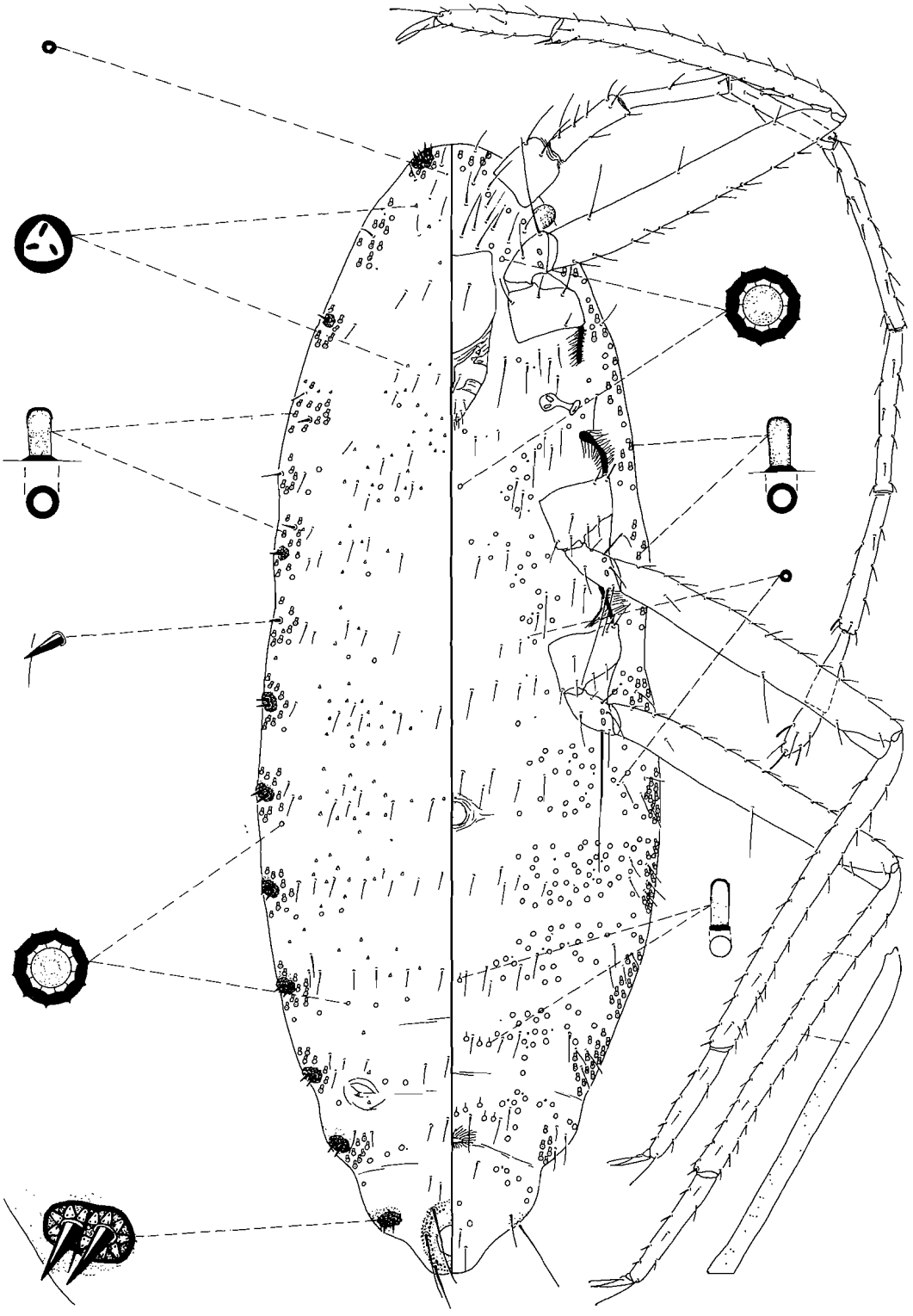

FIG. 2. Fourth instar female (adult) of *Macrocepicoccus loranthi* Morrison.

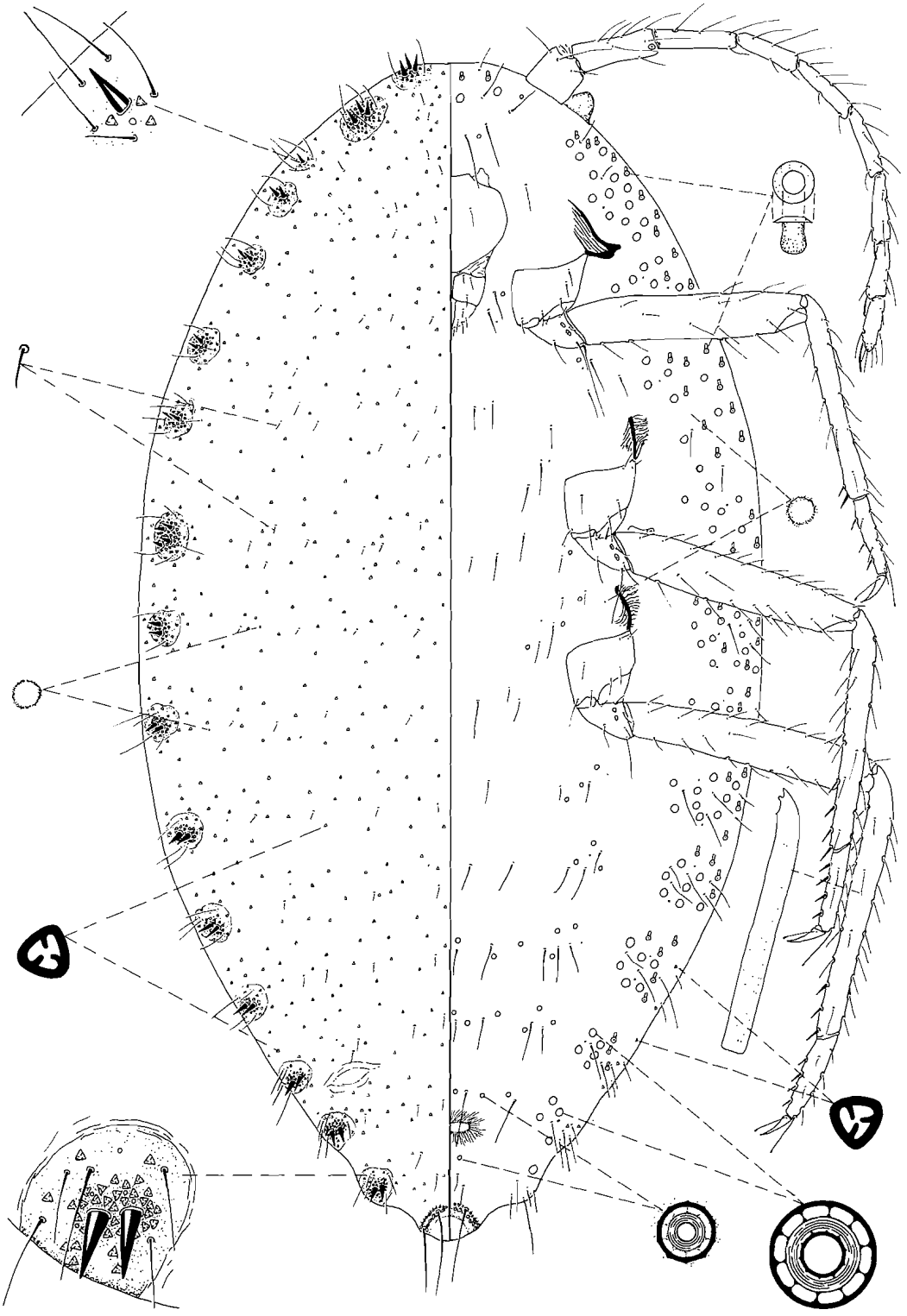

FIG. 3. Fourth instar female (adult) of *Plotococcus eugeniae* sp.n.

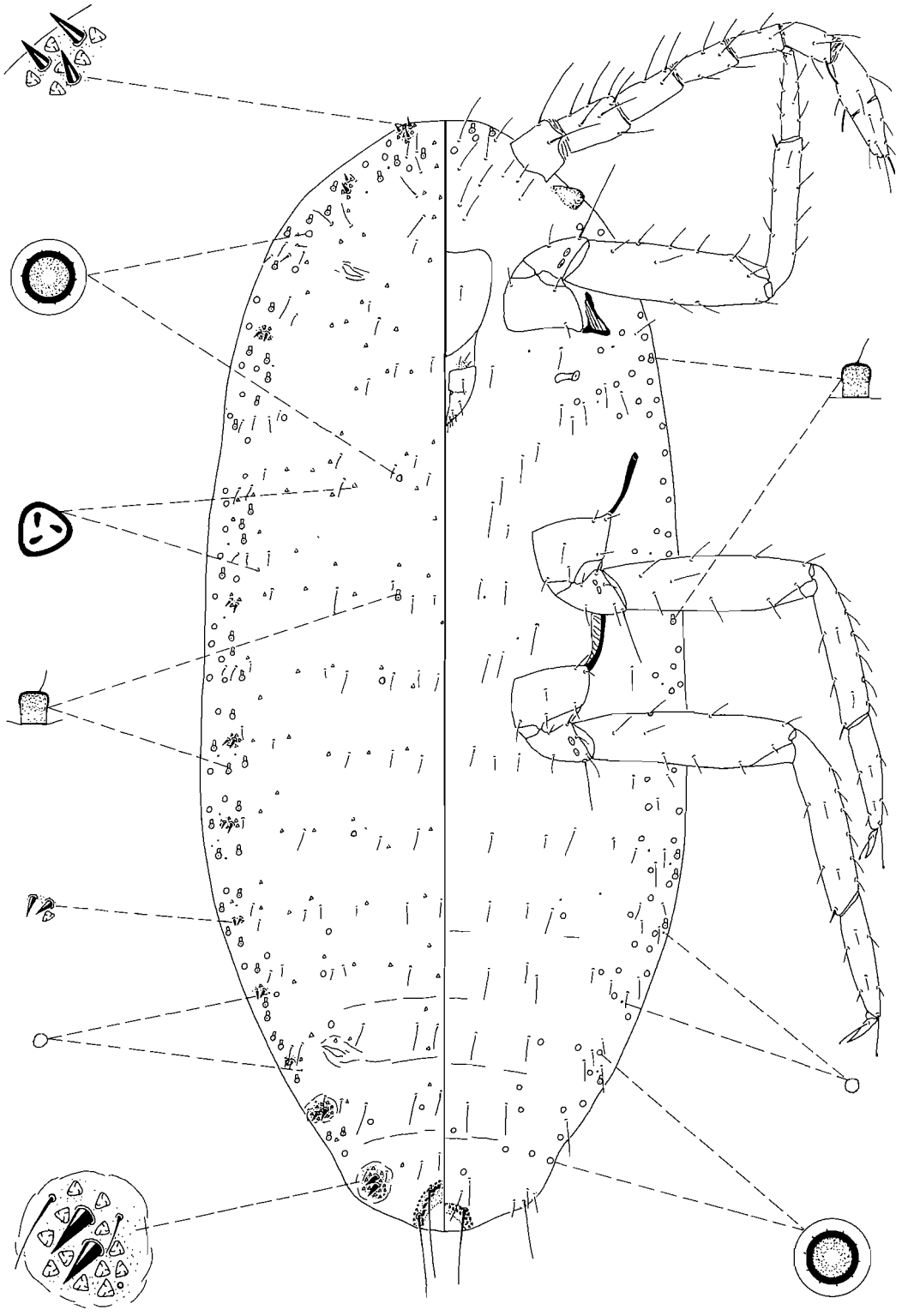

FIG. 4. Third instar female of *Leptococcus metroxyli* Reyne.

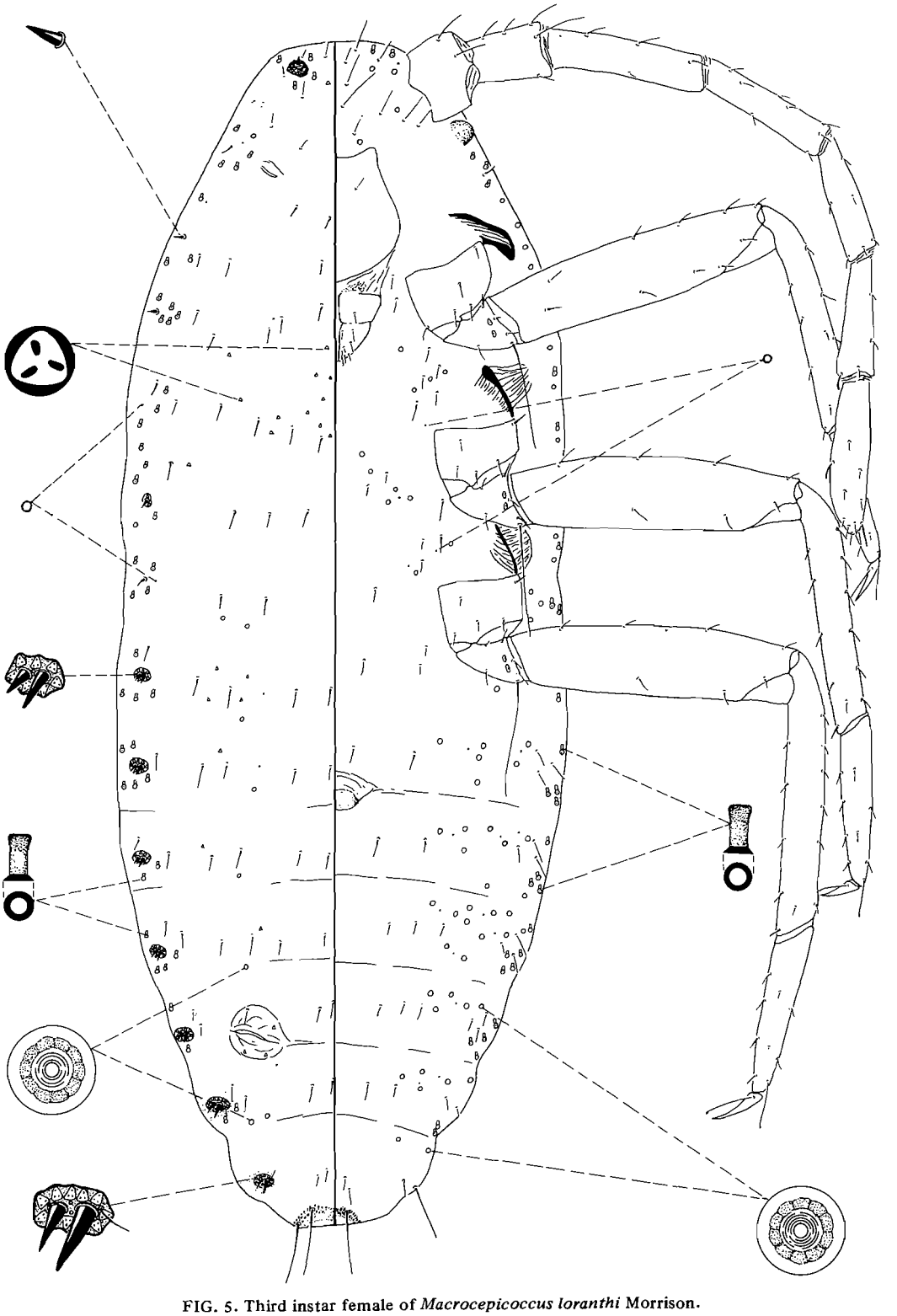

FIG. 5. Third instar female of *Macrocepicoccus loranthi* Morrison.

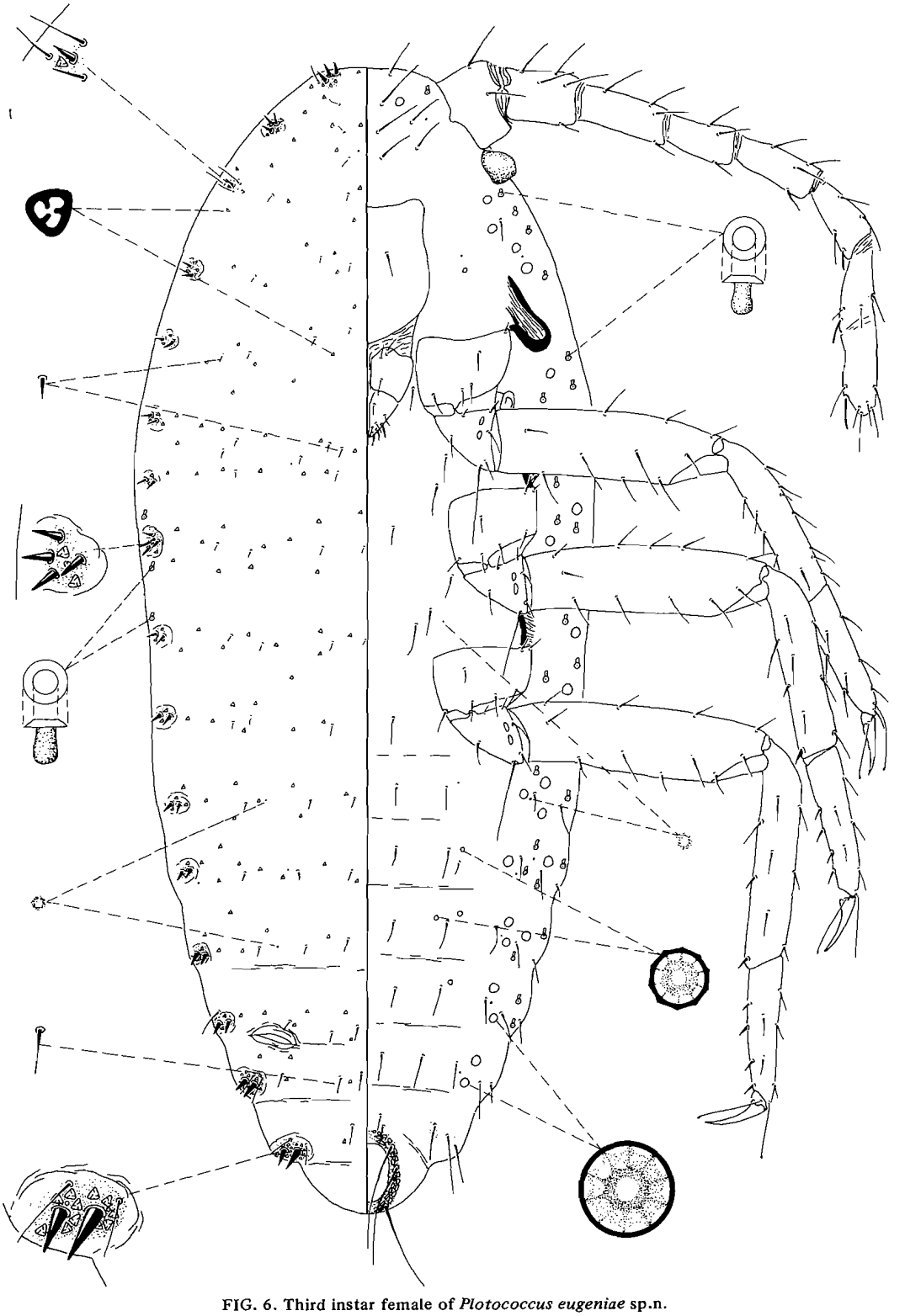

FIG. 6. Third instar female of *Plotococcus eugeniae* sp.n.

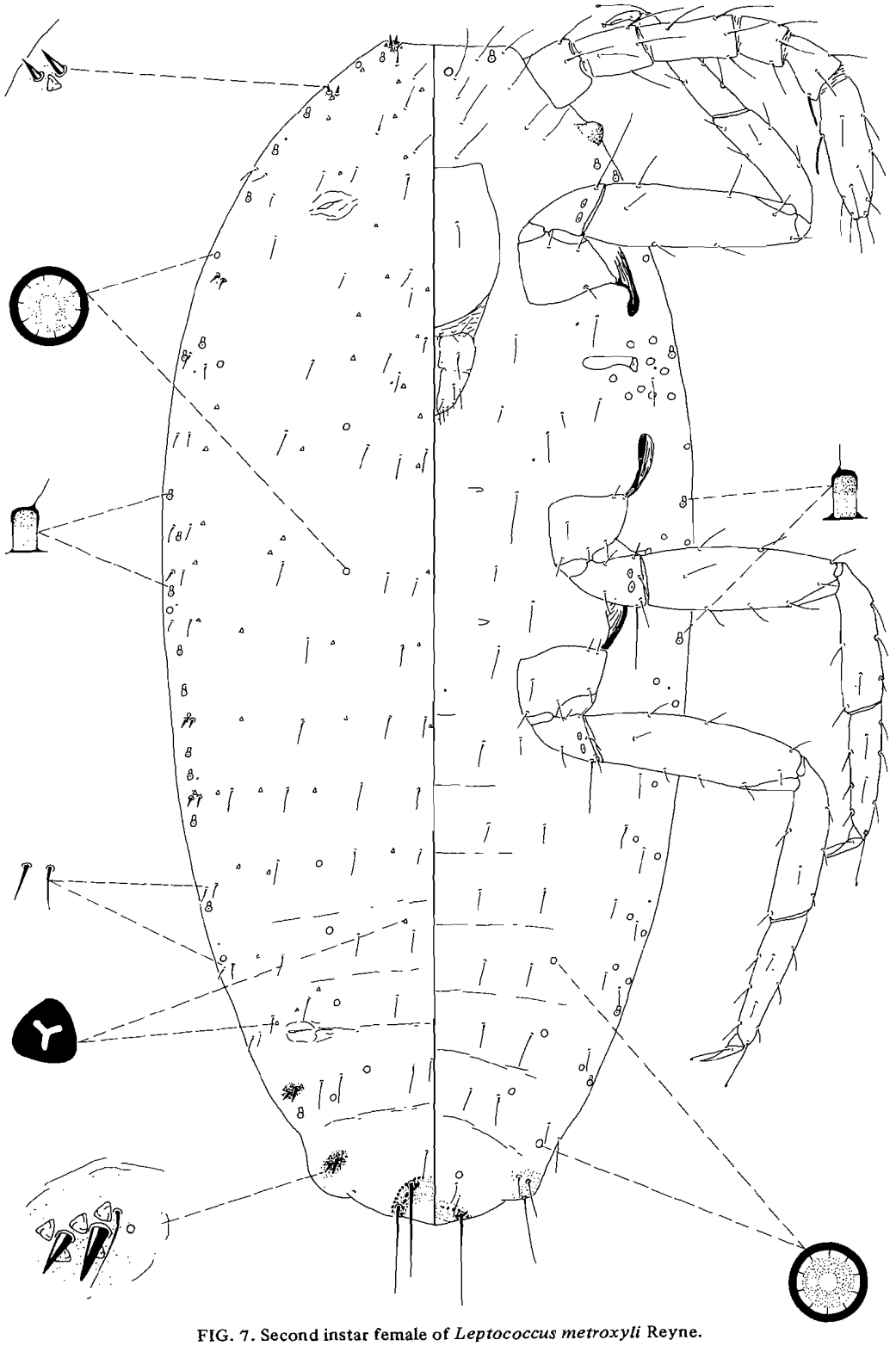

FIG. 7. Second instar female of *Leptococcus metroxyli* Reyne.

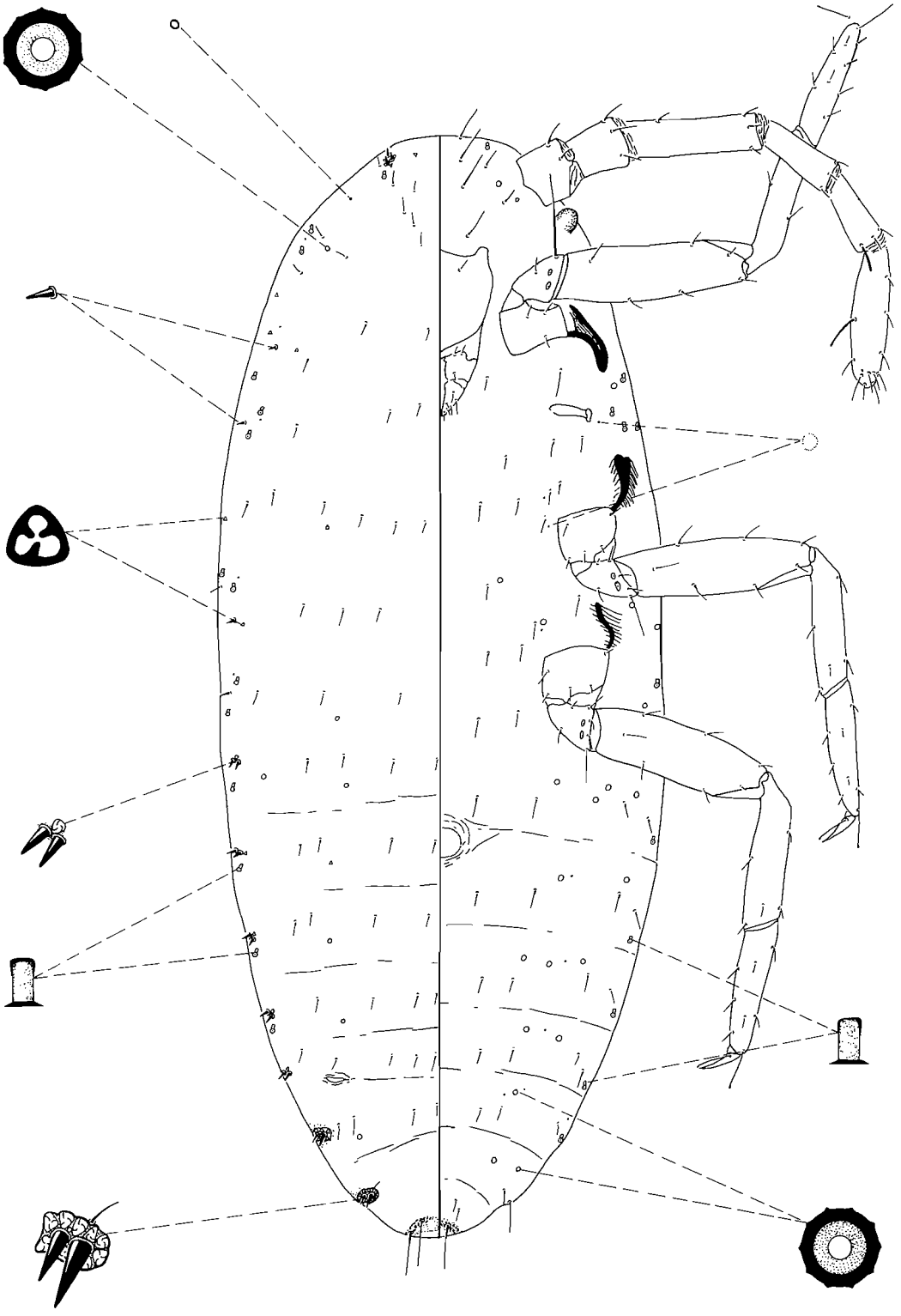

FIG. 8. Second instar female of *Macrocepicoccus loranthi* Morrison.

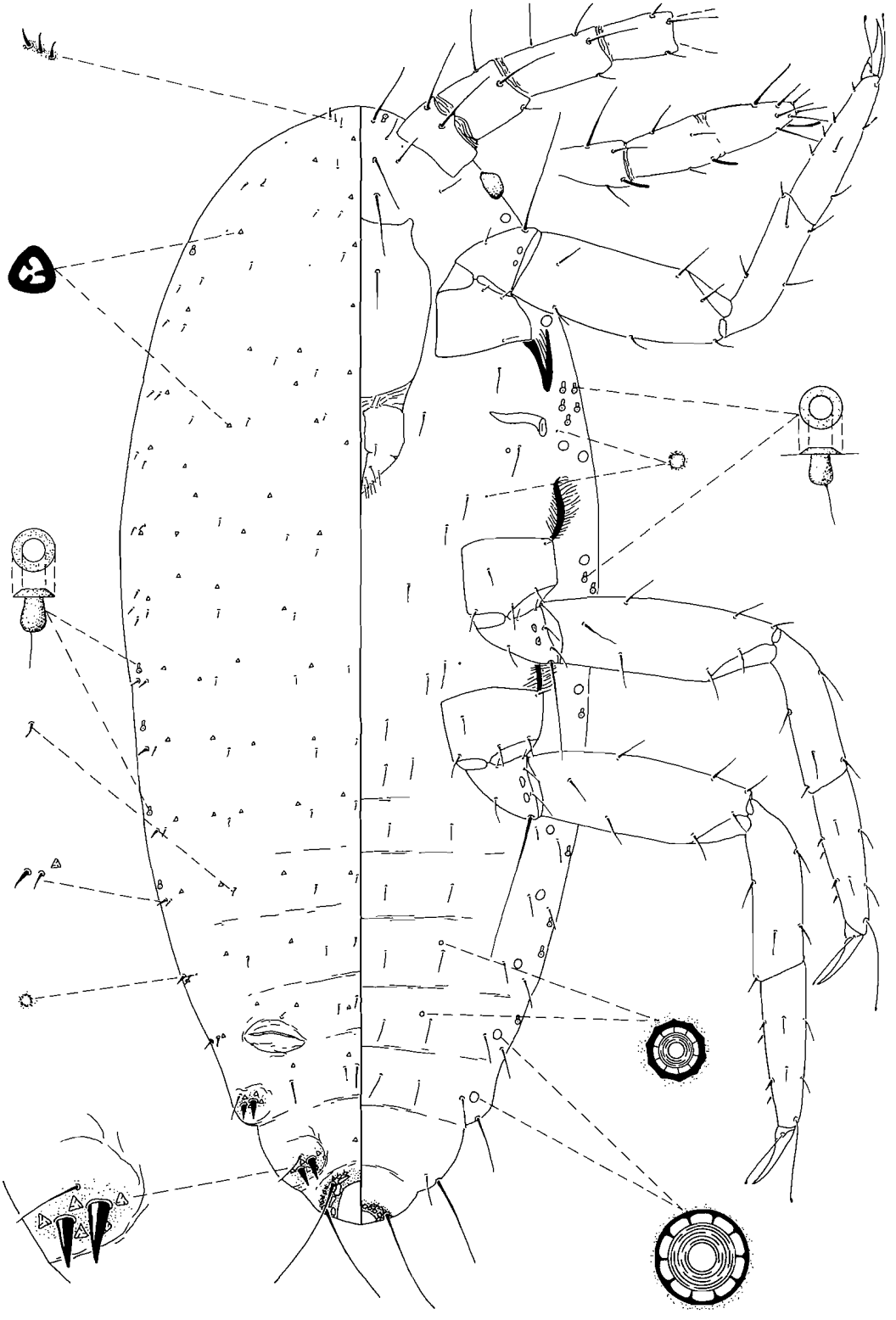

FIG. 9. Second instar female of *Plotococcus eugeniae* sp.n.

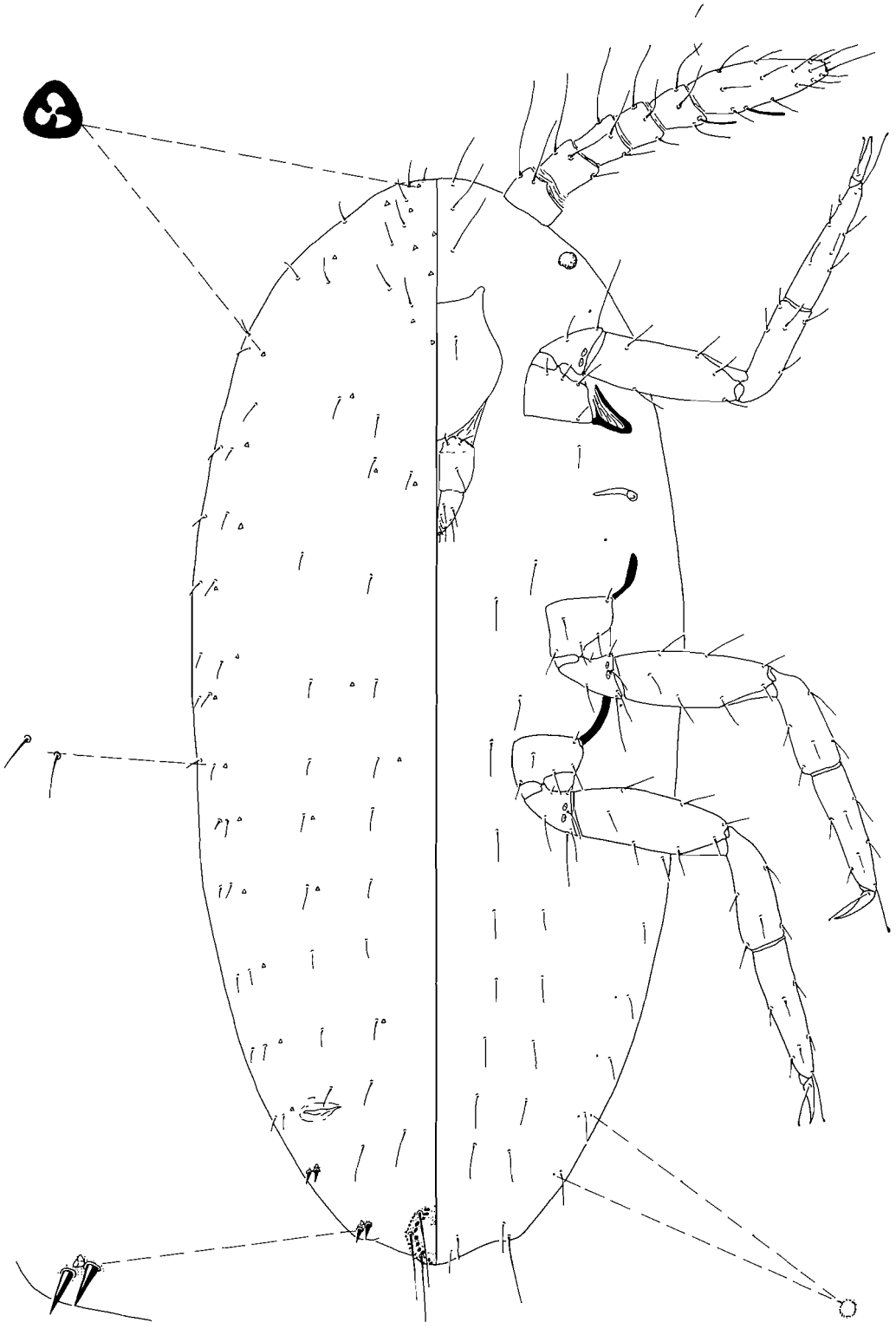

FIG. 10. First instar of *Leptococcus metroxyli* Reyne.

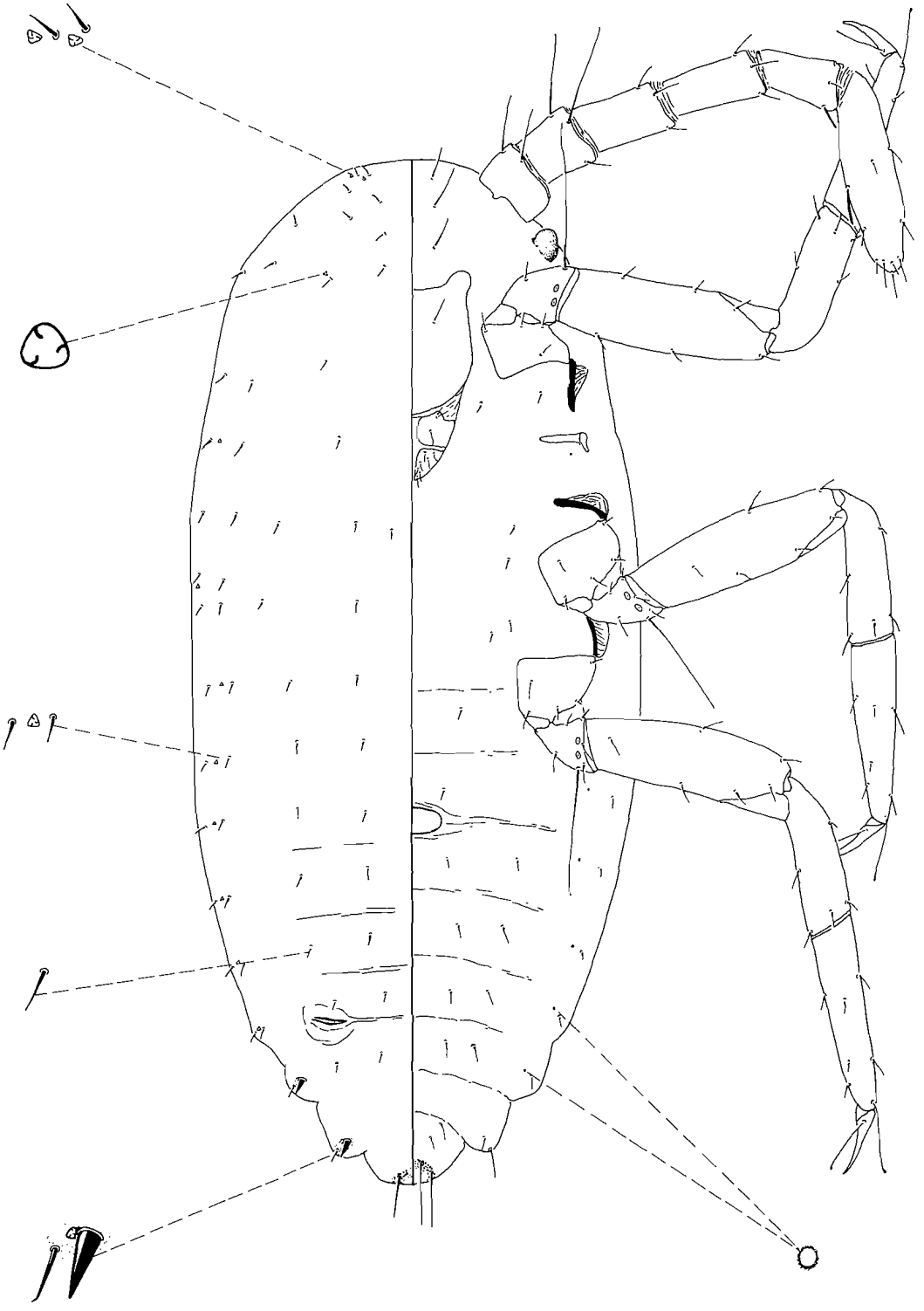

FIG. 11. First instar of *Macrocepicoccus loranthi* Morrison.

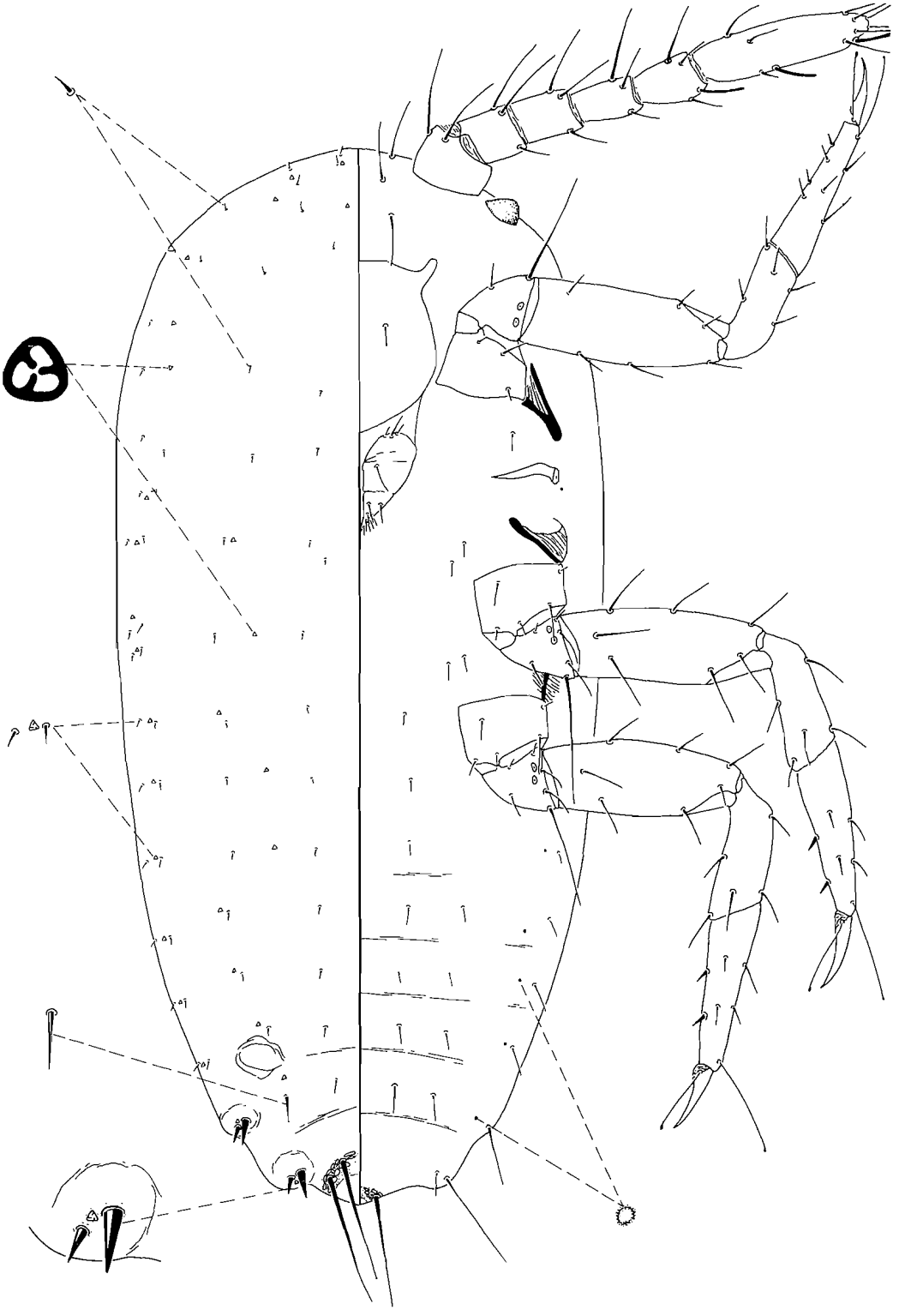

FIG. 12. First instar of *Plotococcus eugeniae* sp.n.

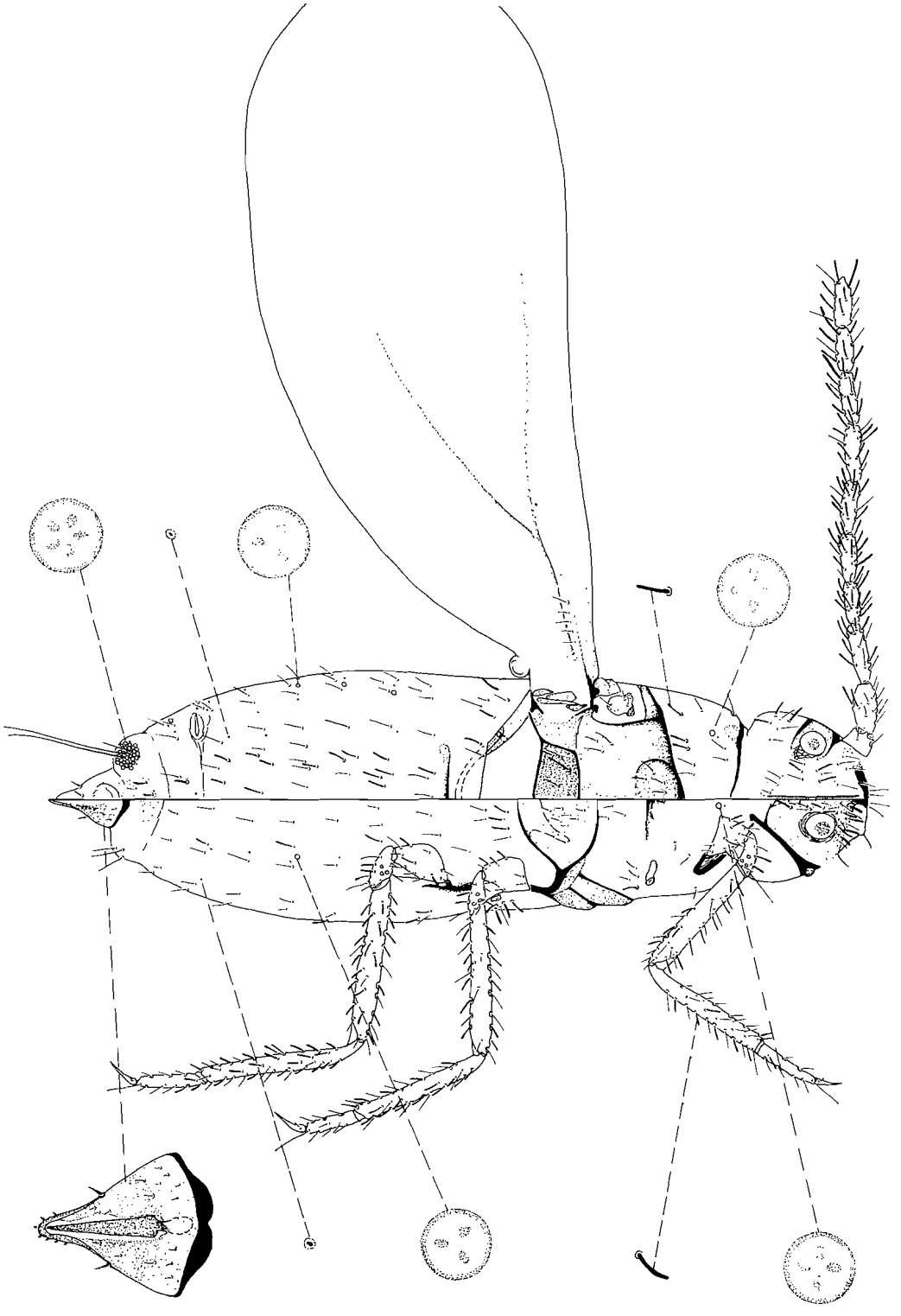

FIG. 13. Fifth instar male (adult) of *Leptococcus metroxyli* Reyne.

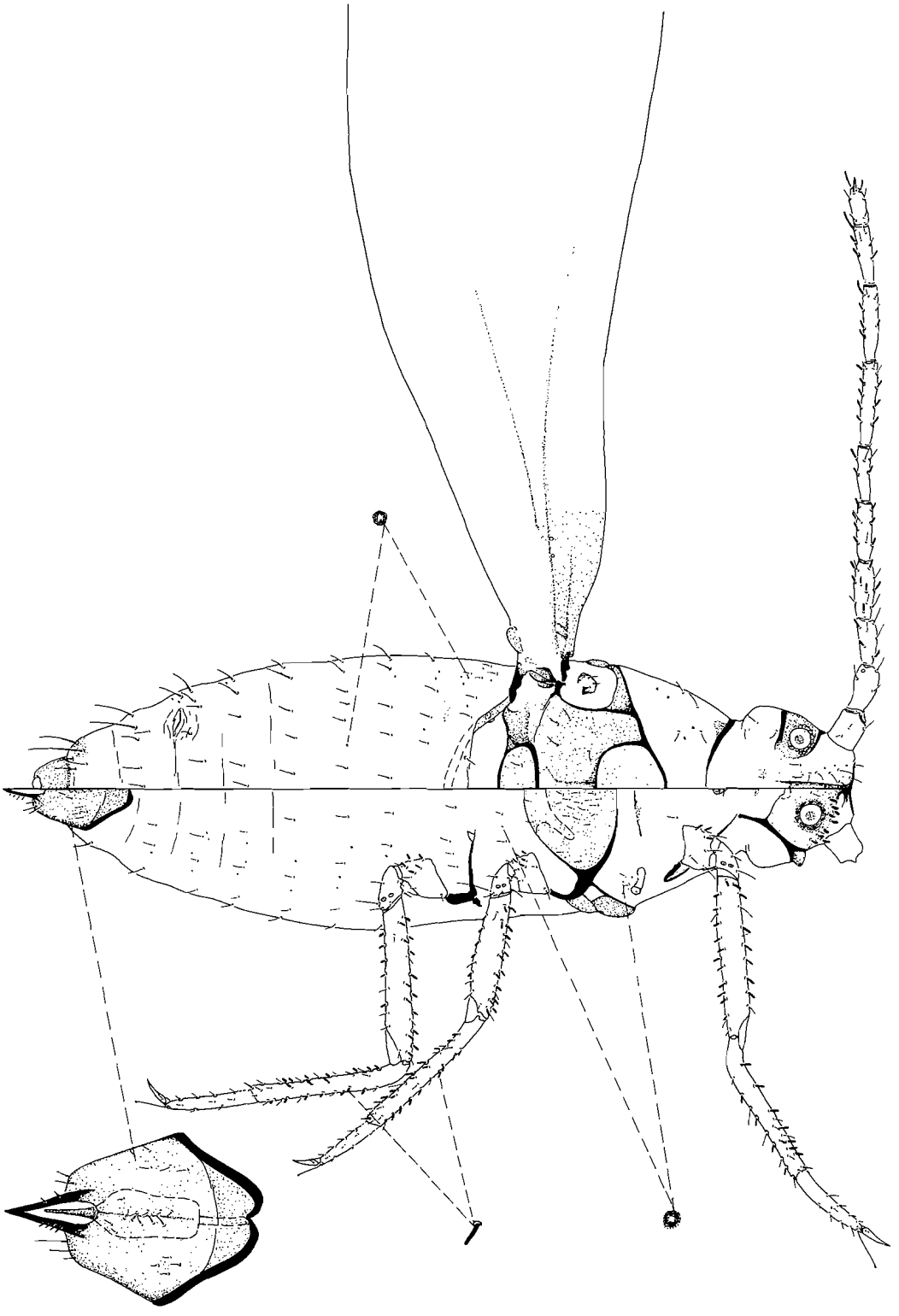

FIG. 14. Fifth instar male (adult) of *Macrocepicoccus loranthi* Morrison.

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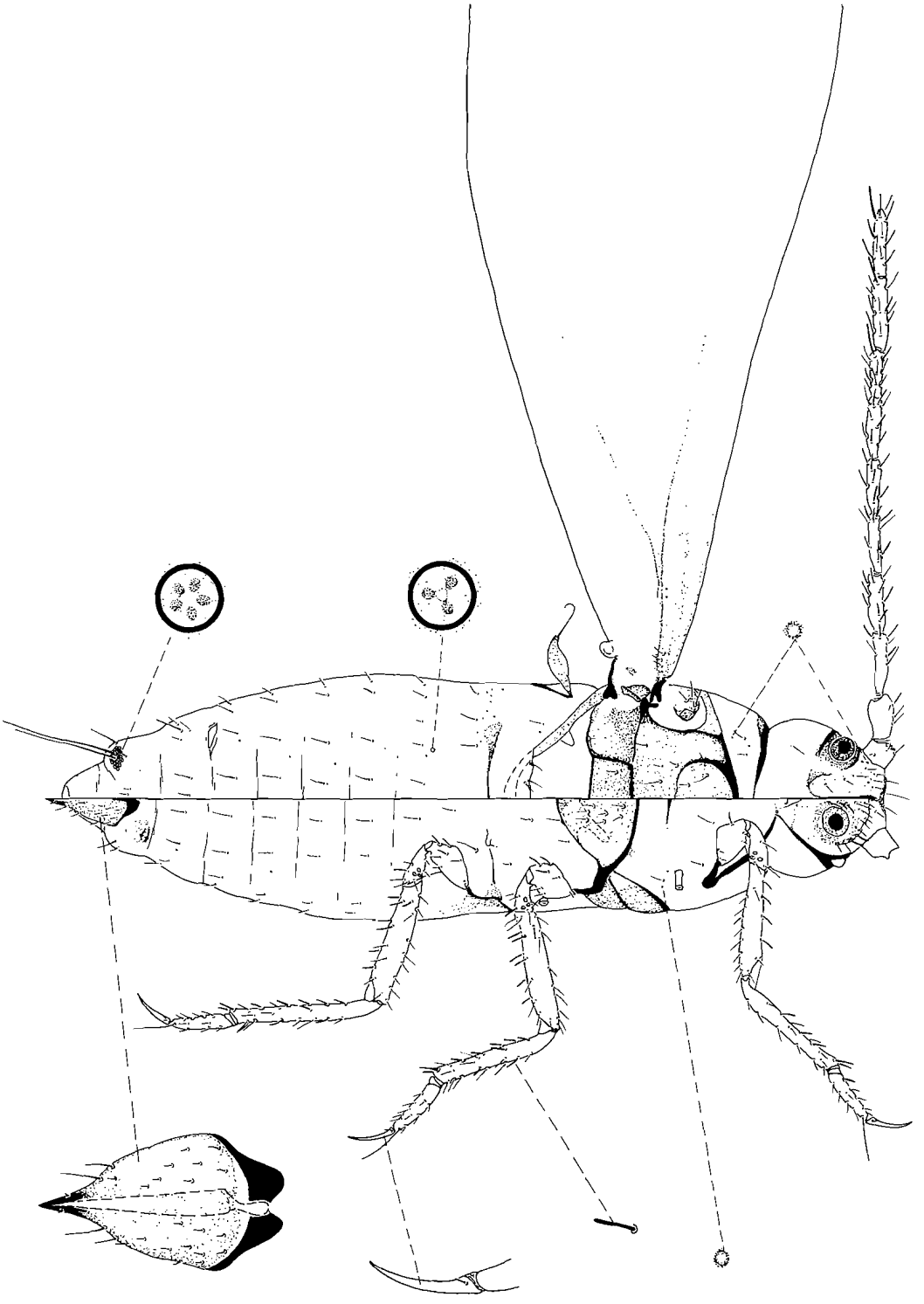

FIG. 15. Fifth instar male (adult) of *Plotococcus eugeniae* sp.n.

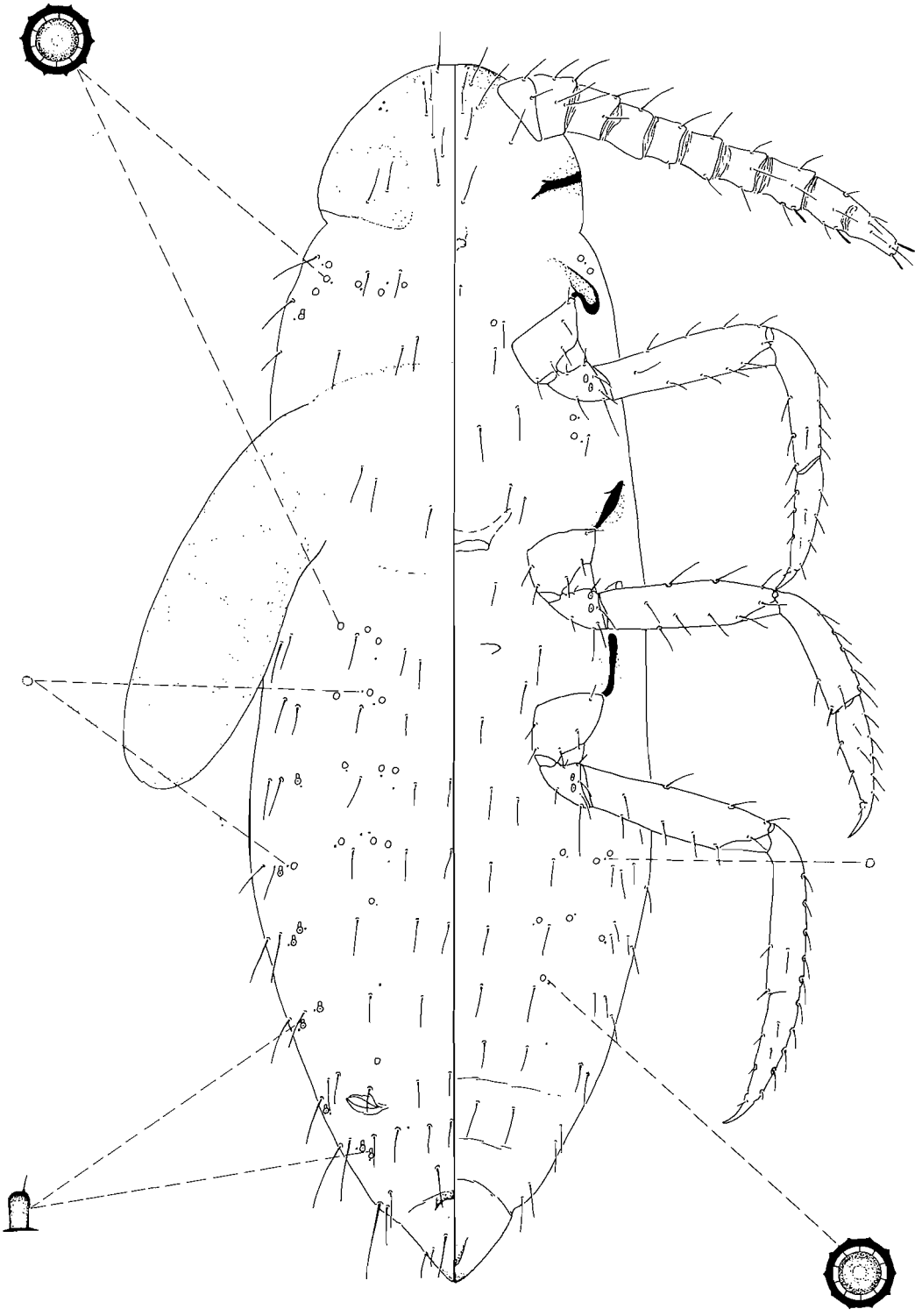

FIG. 16. Fourth instar male (pupa) of *Leptococcus metroxyli* Reyne.

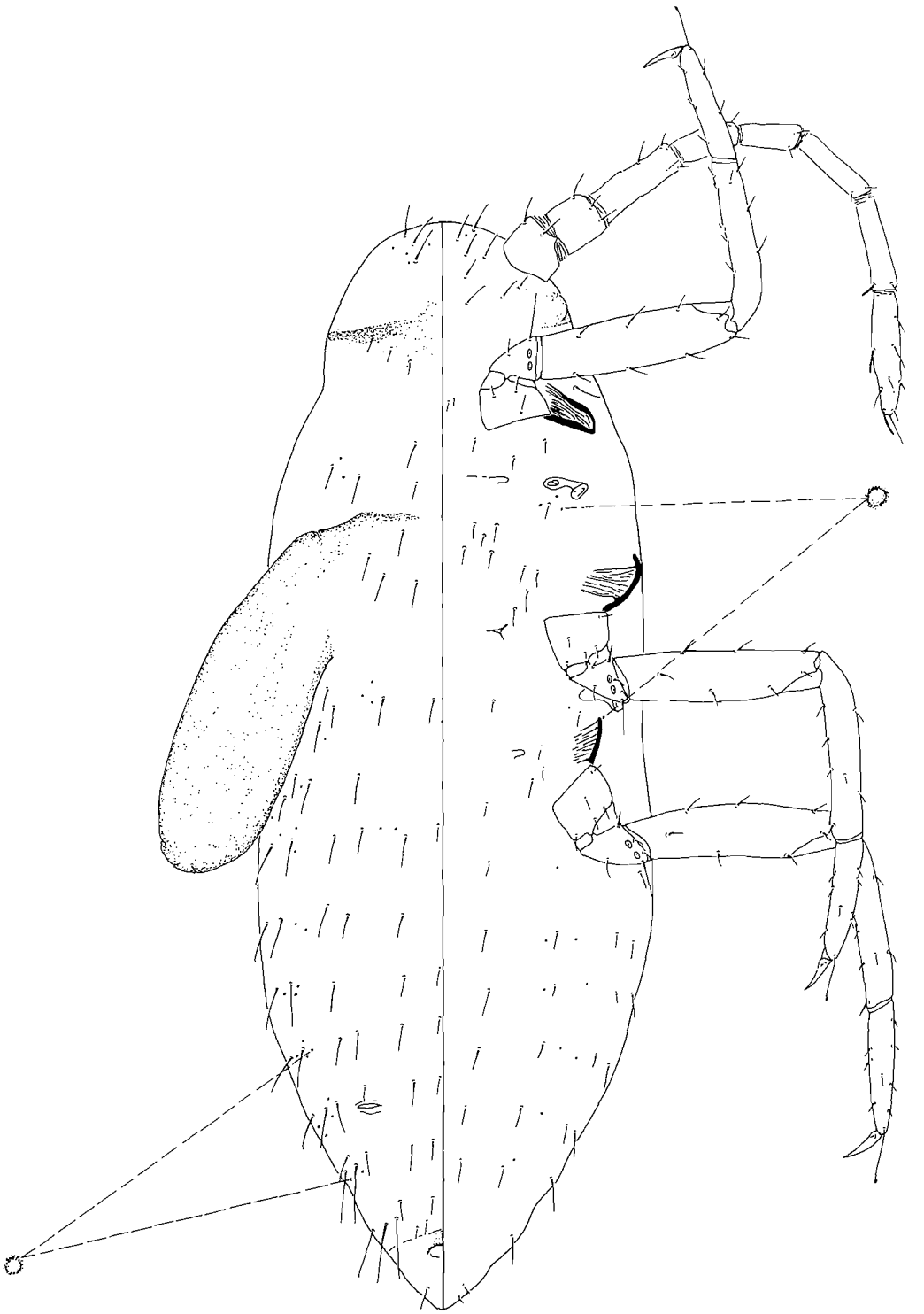

FIG. 17. Fourth instar male (pupa) of *Macrocepicoccus loranthi* Morrison.

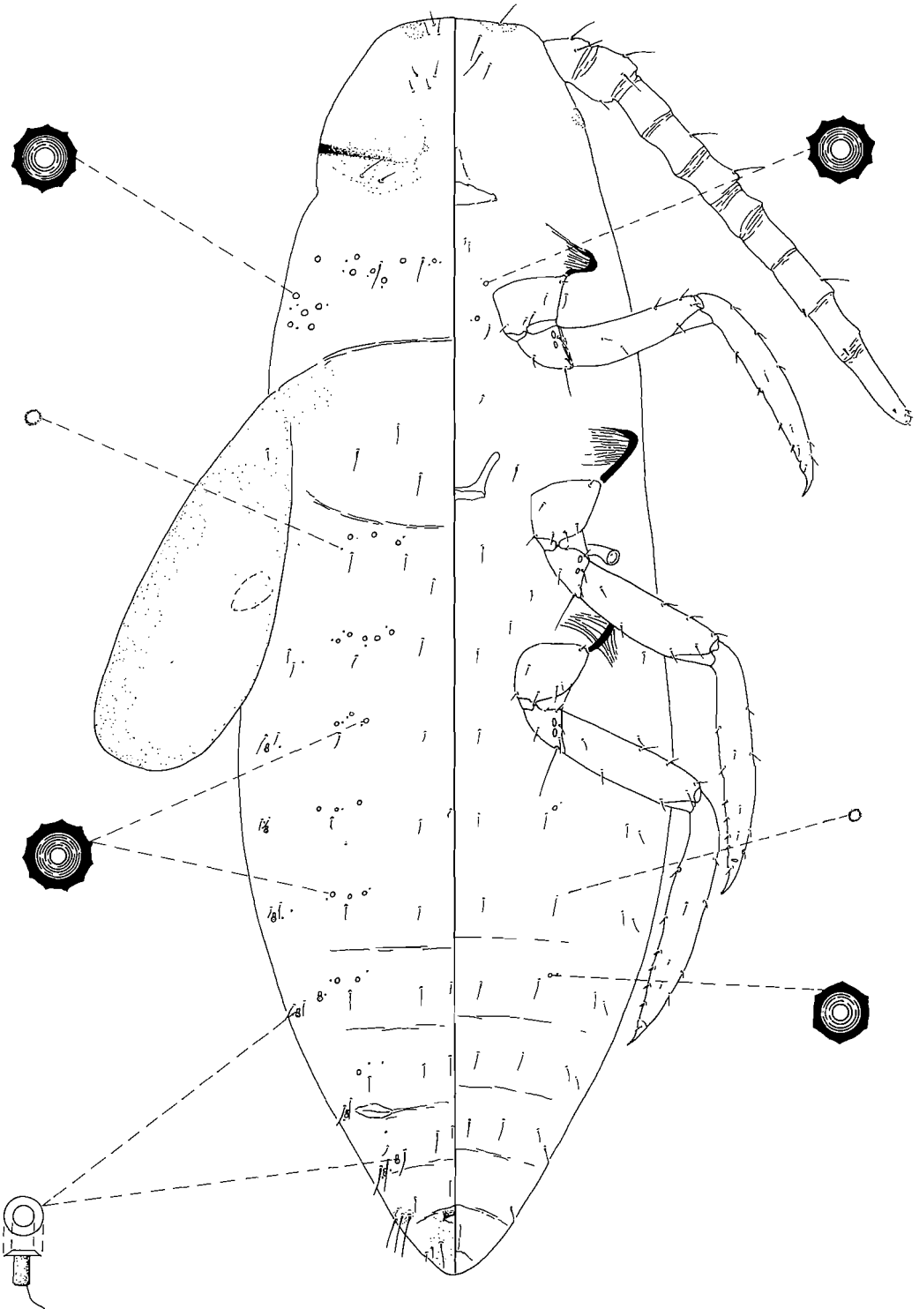

FIG. 18. Fourth instar male (pupa) of *Plotococcus eugeniae* sp.n.

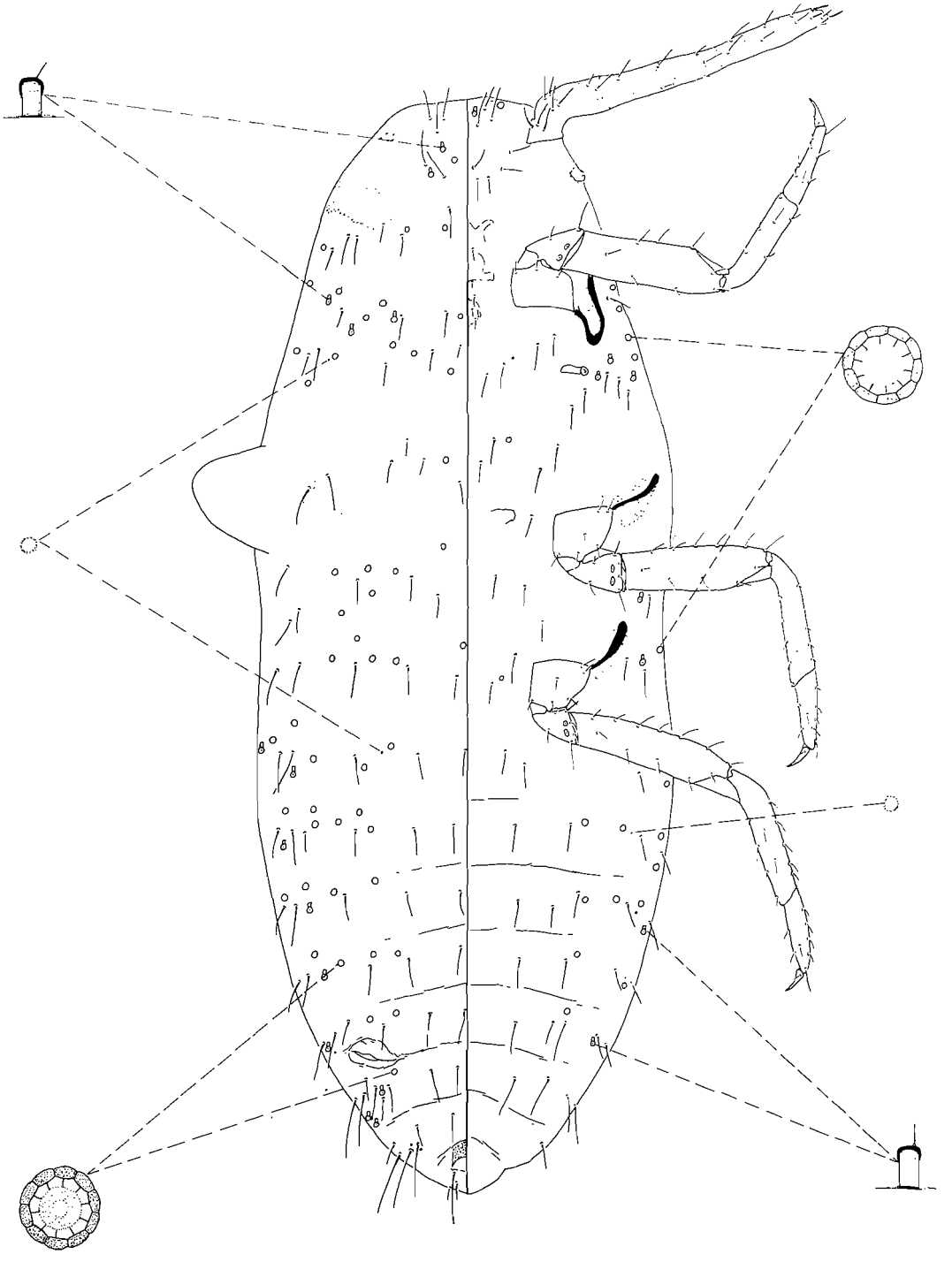

FIG. 19. Third instar male (prepupa) of *Leptococcus metroxyli* Reyne.

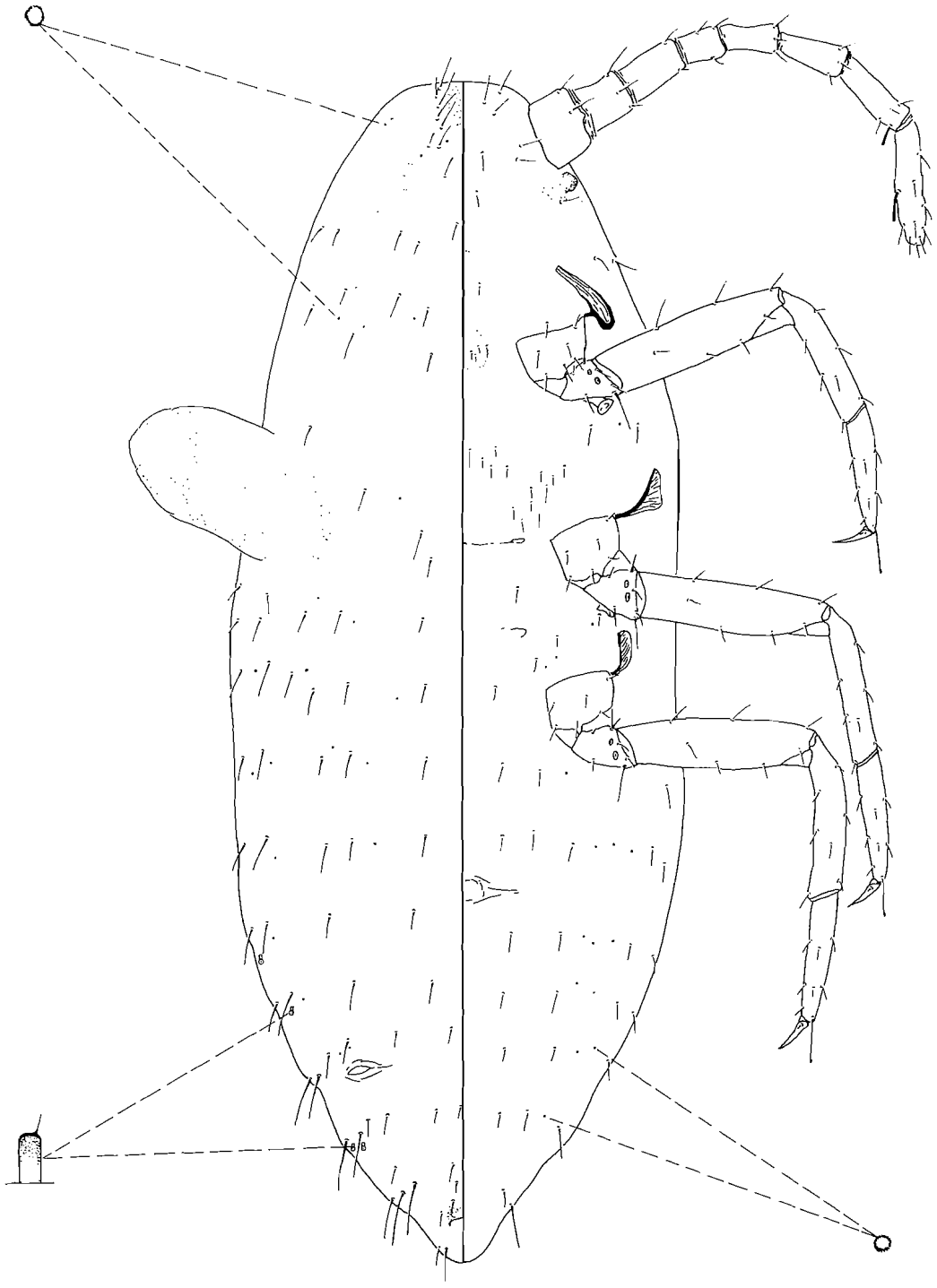

FIG. 20. Third instar male (prepupa) of *Macrocepicoccus loranthi* Morrison.

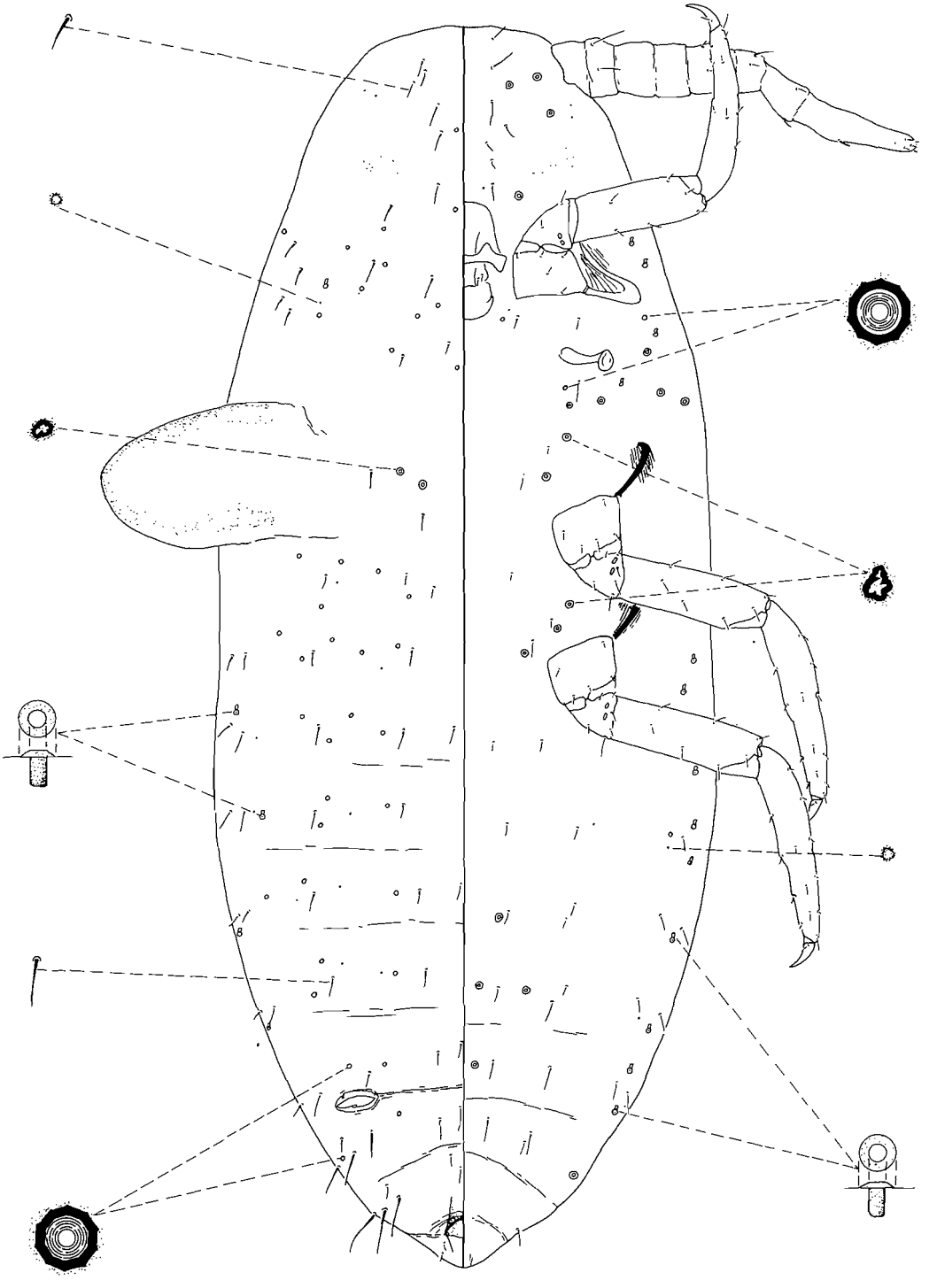

FIG. 21. Third instar male (prepupa) of *Plotococcus eugeniae* sp.n.

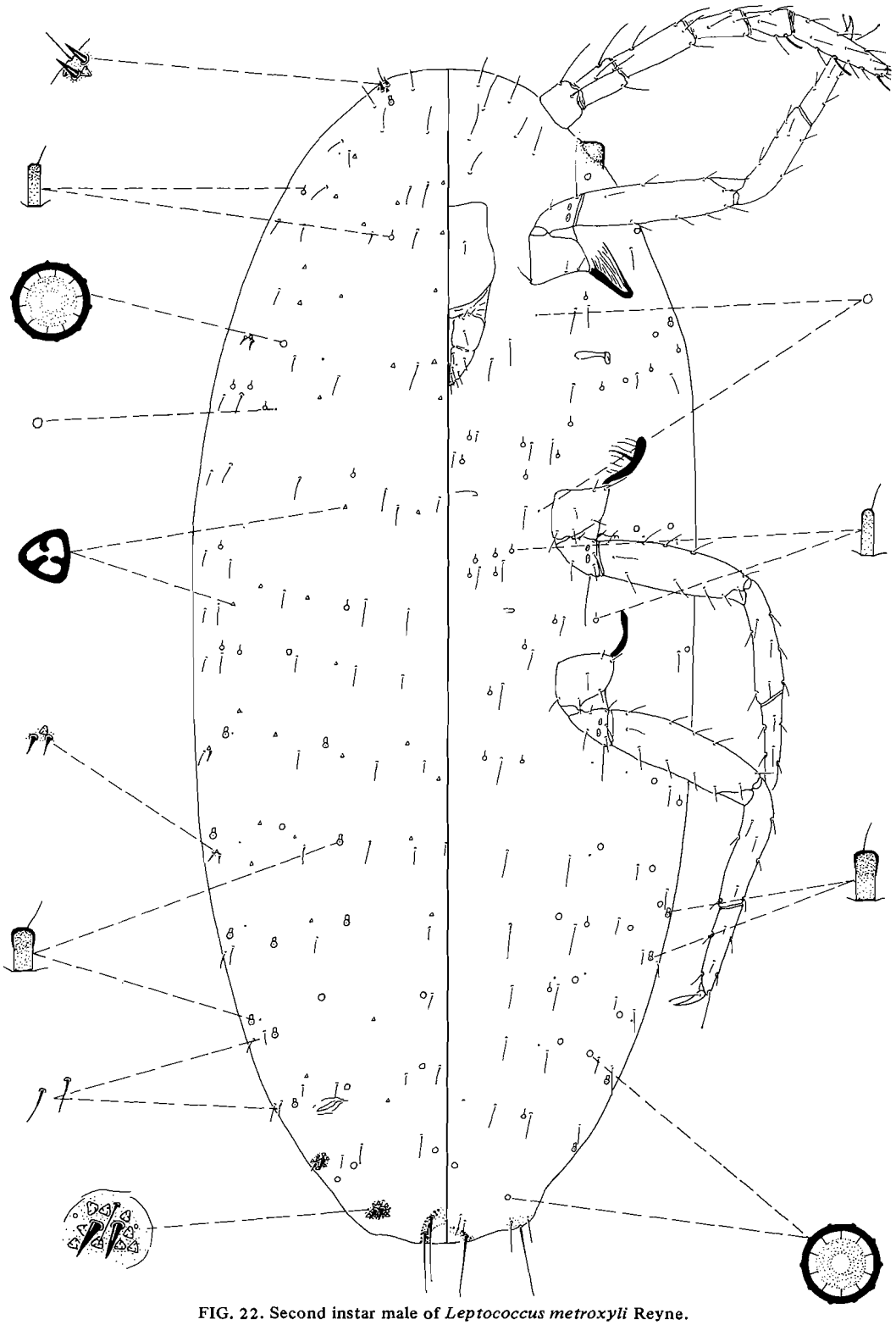

FIG. 22. Second instar male of *Leptococcus metroxyli* Reyne.

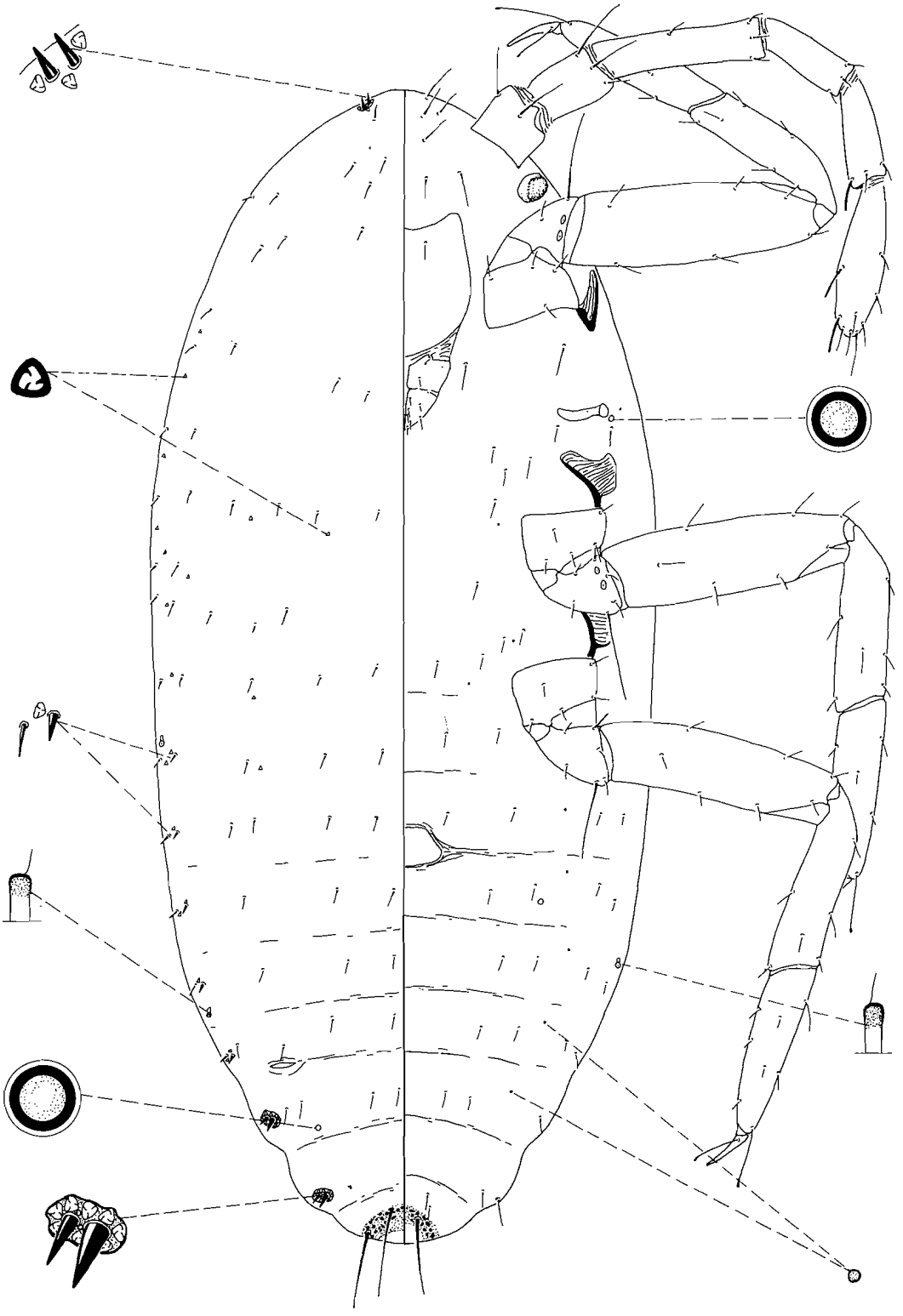

FIG. 23. Second instar male of *Macrocepicoccus loranthi* Morrison.

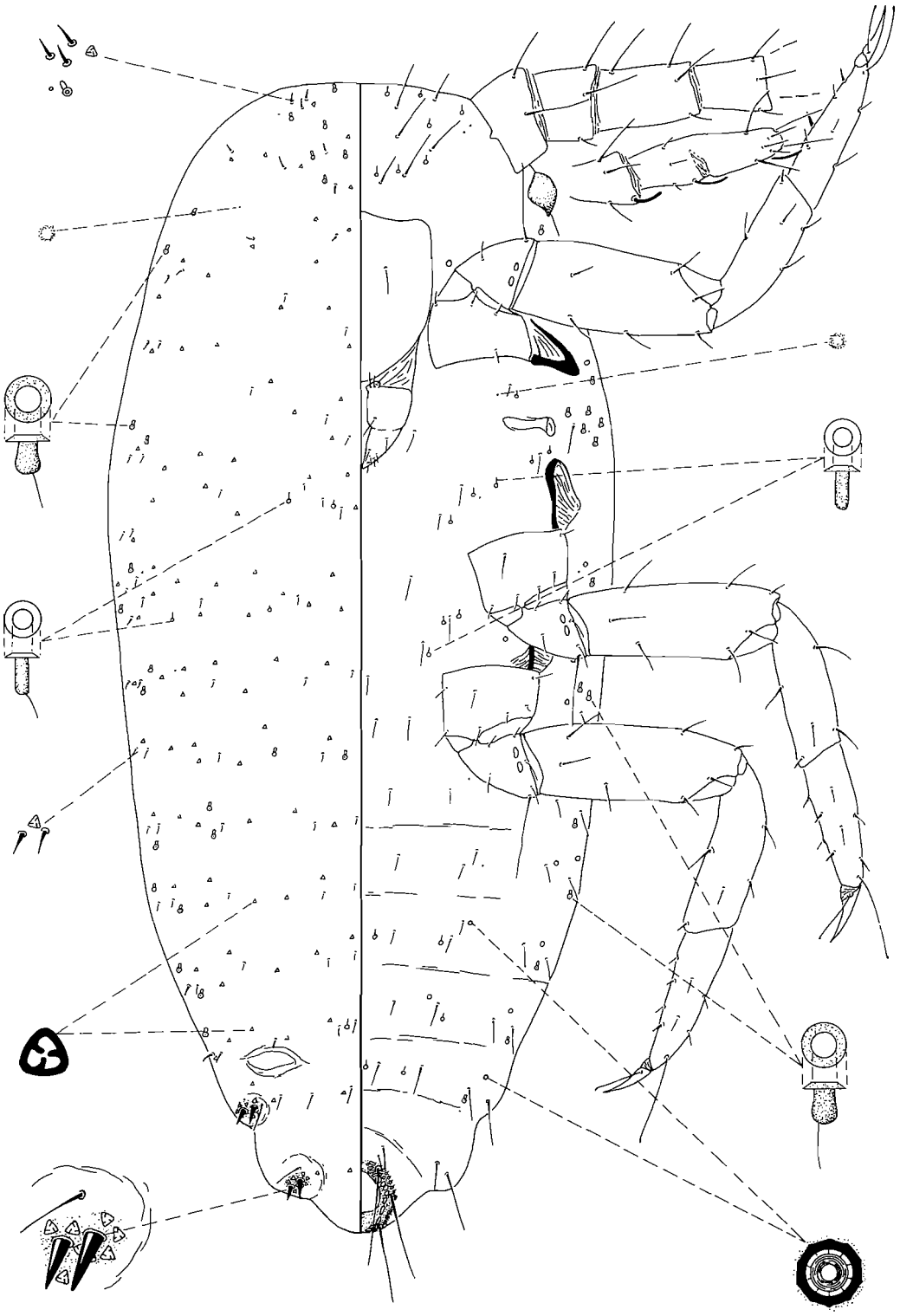

FIG. 24. Second instar male of *Plotococcus eugeniae* sp.n.

normally . . . (with) ten on each side of the body . . . which . . . may reach a length of one and a half or more times that of the body . . . although usually irregularly broken off.'

Fourth instar females (adult) (Fig. 2)

Recognition characters. Mounted, 0.8–1.8(1.4) mm long, 0.3–1.0(0.6) mm wide.

Dorsum with 10 pairs of cerarii, four additional areas near body margin with clusters of oral-collar tubular ducts similar to normal cerarian areas, sometimes with 1 conical seta, but without cluster of trilocular pores. Cerarii unusual for pseudococcid because single row of trilocular pores surrounds base of conical setae forming plate. Anal-lobe cerarii each with two conical setae, one or two slender auxiliary setae, basal cluster of 13–18(16) trilocular pores, 2–5(3) discoidal pores, conspicuous area of sclerotization. Next six pairs of cerarii, counting anteriorly, each with about 15, 12, 12, 13, 13, 14 trilocular pores respectively, also with 2 conical setae about same size as those on anal lobe, with several discoidal pores, basal sclerotization, normally without auxiliary setae except on antepenultimate pair which occasionally has one. Cerarii 8, 10, 11 and 13 composed of cluster of oral-collar tubular ducts and sometimes 1 conical seta. Cerarii 9 and 12 each with 1 conical seta and basal cluster of about 6 and 4 trilocular pores respectively. Cerarii 14 each normally with 3 conical setae, rarely 2, 1–4(2) slender auxiliary setae, about 16 trilocular pores, several discoidal pores, large area of basal sclerotization. Multilocular pores scattered over surface, often with one or two associated with each cerarius, normally absent on segment IX. Trilocular pores restricted to medial and mediolateral areas except in cerarii. Small-sized discoidal pores uncommon. Oral-collar tubular ducts in clusters in cerarian areas. Dorsal body setae bristle-shaped, those on segment IX not unusually elongate; segment V with 10–14(13) such setae excluding those in cerarii. Posterior ostioles present, anterior pair absent.

Anal ring normally bent around apex of abdomen, sometimes dorsal, with two or three rows of pores, each of its 6 setae about 1.5 times longer than greatest diameter of ring.

Venter with multilocular pores of one size, in large clusters in mediolateral areas, scattered in lateral areas, normally absent medially. Trilocular pores absent. Discoidal pores scattered. Oral-collar tubular ducts of two sizes, larger size in clusters near body margin, smaller size present in medial areas of segments VIII, VII, and sometimes VI. Anal lobes sclerotized, longest anal-lobe seta 60–78(70) μm long.

Circulus undivided, circular. Legs with hind tibiae dorsally with 31–44(35) translucent pores, ventrally without pores; hind tibia/tarsus ratio 2.6–3.0(2.7); hind tibia + tarsus length 524–628(579) μm; apices of tarsal and claw digitules enlarged, those of claw slightly larger than those of tarsus; hind claws 50–55(53) μm long. Antennae nine-segmented, occasionally distal segments partially fused; antennal length 1104–1360(1224) μm.

This description is based on seventy specimens from four localities.

Third instar females (Fig. 5)

Recognition characters. Same as for adult females except as follows: mounted, 0.8–1.5(1.1) mm long, 0.3–0.8(0.5) mm wide.

Dorsum with 9 or 10 pairs of cerarii, with four or five additional areas similar to normal cerarian areas but without clusters of trilocular pores. Anal-lobe cerarii each with 2 conical setae, lateral seta smallest, 0–1(1) auxiliary seta, basal cluster of 8–12(10) trilocular pores, 1–4(2) discoidal pores, area of basal sclerotization. Penultimate cerarii each with two conical setae about same sizes as those on anal lobe, with 0–1(0) auxiliary setae, basal cluster of 8–12(10) trilocular pores, about two discoidal pores, area of basal sclerotization. Next five pairs of cerarii counting anteriorly each with two conical setae noticeably smaller than those on posterior cerarii, without auxiliary setae, with about 6 trilocular pores, 0–3 discoidal pores, basal area of sclerotization. Remaining cerarii similar to adult female but with fewer trilocular pores and conical setae; cerarii 9 and 12 sometimes without associated trilocular pores. Multiloculars less abundant

than on adult female. Trilocular pores absent from posterior abdominal segments, less abundant than on adult female. Segment V with 8–11(10) bristle-shaped setae. Posterior and anterior ostioles present, anterior pair inconspicuous.

Venter with multiloculars less abundant than on adult female. Oral-collar tubular ducts of one size, restricted to lateral areas. Longest anal-lobe seta 43–50(48) μm.

Legs with hind tibia/tarsus ratio 1.4–1.5(1.5); hind tibia + tarsus length 348–384(368) μm; hind claws 43–48(44) μm long. Antennae seven-segmented, distal segment frequently partially divided; length 665–793(723) μm.

This description is based on thirty specimens from three localities.

Second instar females (Fig. 8)

Recognition characters. Same as for adult female except as follows: mounted, 0.7–1.0(0.8) mm long, 0.3–0.4(0.4) mm wide.

Dorsum with 7 or 8 pairs of cerarii, with two or three additional areas composed of single conical seta. Anal-lobe cerarii each with 2 conical setae, lateral seta smallest, 0–3(1) auxiliary setae, basal cluster of 7–9(8) trilocular pores, 0–3(1) discoidal pores, small area of basal sclerotization. Penultimate cerarii each with 2 conical setae about same sizes as those on anal lobe, without auxiliary setae, with basal cluster of 5–9(7) trilocular pores, 0–1(1) discoidal pore, area of basal sclerotization. Next 5 pairs of cerarii counting anteriorly each with 2 conical setae noticeably smaller than those on posterior cerarii, without auxiliary setae, with 1 or 2 trilocular pores, 0–1 discoidal pores, no basal sclerotization. Thoracic cerarii absent or composed of small conical seta, normally 2 or 3 such cerarii on each side of thorax. Head with frontal cerarii only, each with 2–4(3) conical setae, without auxiliary setae, with 1–3(2) trilocular pores, 0–1(0) discoidal pores. Multilocular and trilocular pores forming longitudinal line on mediolateral areas, a few such pores scattered along body margin. Discoidal pores restricted to margin. Oral-collar tubular ducts in reduced numbers along body margin. Segment V with 6–9(7) bristle-shaped setae. Posterior ostioles evident, anterior ostioles absent or represented by small wrinkles in derm.

Venter with multiloculars less abundant than on adult female. Oral-collar tubular ducts of one size, restricted to marginal areas, not in clusters except near anterior spiracle. Discoidal pore as illustrated. Anal lobes apparently unsclerotized; longest anal-lobe seta 25–38(32) μm.

Legs with hind tibia/tarsus ratio 1.0–1.1(1.0); hind tibia + tarsus length 248–280(257) μm; hind claws 35–40(38) μm long. Antennae six-segmented; 450–506(476) μm long.

This description is based on forty specimens from three localities.

First instars (Fig. 11)

Recognition characters. Same as for adult female except as follows: mounted, 0.5–0.7(0.6) mm long, 0.2–0.3(0.3) mm wide.

Dorsum with posterior two pairs of definite cerarii, remaining cerarii absent or composed of pair of associated bristle-shaped setae and 0–1 associated trilocular pores. Anal-lobe cerarii each with 1 conical seta, 1 robust bristle-shaped seta, no auxiliary setae, 1 trilocular pore closely appressed to base of conical seta, no discoidal pores, small area of basal sclerotization. Penultimate cerarii similar to anal-lobe cerarii except with conical seta slightly smaller. Trilocular pores in cerarii only, except single pore on mediolateral area of head. Discoidal pores absent. Segment V with 4 bristle-shaped setae excluding those in cerarii. Anterior ostioles absent or inconspicuous.

Venter with discoidal pores near body margin of each abdominal segment, absent on thorax near spiracles, absent on head. Longest anal-lobe seta 18–28(24) μm.

Legs with hind tibia/tarsus ratio 0.7–0.8(0.7); hind tibia + tarsus length 175–190(181) μm; hind claws 33–38(35) μm long. Antennae six-segmented; 305–348(325) μm long.

This description is based on seventy specimens from three localities.

Fifth instar males (adults) (Fig. 14)

Recognition characters. Mounted, 1.0–1.1(1.1) mm long, 0.3–0.4(0.3) mm wide.

Dorsum without tail-forming pore clusters; areas where clusters would normally be each with 2 setae, longest seta 60–88(73) μm long, shortest seta 40–70(56) μm long, normally with 1 discoidal pore near base of longest seta, area of basal sclerotization, 1 short seta near cluster area not on sclerotized area. Without multilocular derm pores. Clear centre pores present in marginal areas of abdomen, also present in cluster near metapostnotal ridge and in membranous area anterior of scutum. Head pores present near midcranial ridge. Body setae slender, 2 setae on lateral margin of each abdominal segment, noticeably more elongate than other body setae; body setae in small numbers on thorax and head. Posterior ostioles present. Abdominal sclerotization apparently absent. Metapostnotal ridge normally composed of lateral sclerotization only. Scutum with medial area lightly sclerotized. Prescutum heavily sclerotized, rectangular. Postoccipital ridge normally absent, occasionally weakly sclerotized; dorsal arm of midcranial ridge well developed, extending forward to near posterior edge of lateral arms of midcranial ridge. Dorsomedial sclerite weakly or not sclerotized. Preocular and postocular ridges separate on dorsal aspect of head, frequently with small ridge connecting pre- and postocular ridges on dorsal side of ocellus. Dorsal eye 25–33(28) μm in diameter. Ocellus strongly protuberant, 23–25(23) μm in diameter.

Penial sheath 130–150(140) μm long, width/length ratio 0.7–0.8(0.7). Penial sheath undivided, without medial lobes. Aedeagus 95–120(112) μm long; basal apodeme absent. Setal pattern as illustrated.

Venter without multilocular pores. Clear centre pores forming longitudinal line on abdomen, also near anterior spiracle. Body setae bristle-shaped, slightly shorter than those on dorsum, unusually abundant on basisternum of mesothorax; setae on anterior margin of ocular sclerite short, fleshy, same type as on antennae and legs. Precoxal ridge on metathorax well developed; anterior portion of metapleural ridge absent. Pleural ridge of metathorax absent or rudimentary. Lateropleurite of mesothorax absent. Prosternum weakly sclerotized. Preocular + interocular ridge well developed, joining postocular ridge just below ocellus. Ventral arm of midcranial ridge absent. Ventral cavity conspicuous. Ventral eye 28–35(32) μm in diameter.

Pro- and mesothoracic legs about equal in length, metathoracic legs longest. Hind tibia/tarsus ratio 1.8–2.0(1.9); hind tibia + tarsus length 293–323(311) μm; hind claw 40–50(45) μm long; leg setae of two kinds, bristle-shaped and short and fleshy; tarsal digitules nearly equal in size, apically capitate, exceeding length of claw; claw digitules short, normally not visible; tarsi one-segmented. Body length/antennal length ratio 1.5–1.6(1.6); antennae normally ten-segmented, apical segment occasionally only partially divided; third antennal segment 1.0–1.3(1.2) times longer than apical segment. Antennal setae as follows: without subapical sensory setae; short fleshy setae on segments 9–3; hairlike setae on all segments; antennal bristles on apical three segments. Front wings each 0.9–1.1(1.0) times longer than length of body, wings with 1–2(2) circular sensoria and 1–3(2) alar setae. Hamulohalterae absent.

This description is based on twenty-six specimens from two localities.

Fourth instar males (pupae) (Fig. 17)

Recognition characters. Same as for adult female except as follows: mounted, 1.0–1.1(1.1) mm long, 0.3–0.4(0.4) mm wide. Body shape normal for pseudococcid.

Dorsum with cerarian areas similar to those on prepupae. Multilocular pores, trilocular pores, and oral-collar tubular ducts absent. Discoidal pores scattered over surface, but absent on medial areas of abdomen. Segment V with 5–7(6) bristle-shaped setae excluding those in cerarian areas. Anterior ostioles absent.

Anal ring dorsal, without pores and setae.

Venter without multilocular pores and oral-collar tubular ducts. Discoidal pores on mediolateral areas. Anal lobes unsclerotized, longest anal-lobe seta 75–95(87) μm.

Circulus absent. Eyes not protuberant. Legs with hind tibia/tarsus ratio 1.4–1.5(1.4); hind tibia + tarsus length 300–325(315) μm; hind claws 43–45(44) μm long. Antennae eight-segmented, normally with distal segment partially divided; antennae 573–622(606)

μm long. With one pair of wing buds, 366–427(392) μm long.

This description is based on ten specimens from one locality.

Third instar males (prepupae) (Fig. 20)

Recognition characters. Same as for adult female except as follows: mounted 1.0 and 1.1 mm long, 0.4 mm wide.

Dorsum without cerarii; cerarian areas on segments IX–II each with two closely associated elongate bristle-shaped setae. Multilocular and trilocular pores absent. Discoidal pores scattered over surface, except absent medially on abdomen. Oral-collar tubular ducts marginal. Segment V with 4 or 5 bristle-shaped setae excluding those in cerarian areas. Anterior ostioles absent.

Anal ring dorsal, represented by simple, slightly sclerotized ring, without pores and setae.

Venter without multilocular pores. Discoidal pores present on mediolateral areas. Oral-collar tubular ducts marginal, treated in description of dorsum. Anal lobes unsclerotized; longest anal-lobe seta 75 and 90 μm.

Circulus composed of a few wrinkles in derm. Eyes not protuberant. Legs with hind tibia/tarsus ratio 1.1 and 1.2; hind tibia + tarsus length 295 and 303 μm; hind claws about 45 μm long. Antennae eight-segmented 506 and 530 μm long. With one pair of wing buds 83 and 88 μm long.

This description is based on two specimens from one locality; each specimen was in the process of molting to the fourth instar.

Second instar males (Fig. 23)

Recognition characters. Same as for second instar female except as follows: mounted, 0.7–1.0(0.7) mm long, 0.3–0.5(0.3) mm wide.

Dorsum with 8 or 9 pairs of cerarii, with three or four additional areas composed of slightly enlarged setae or paired bristle-shaped setae. Anal-lobe cerarii each with 2 conical setae, lateral seta smallest, 0–2(1) auxiliary setae, basal cluster of 6–9(8) trilocular pores, 0–3(1) discoidal pores, small area of basal sclerotization. Penultimate cerarii similar to anal-lobe cerarii, without auxiliary setae, with 5–7(6) basal, trilocular pores, normally without discoidal pores. Next 5 or 6 pairs of cerarii counting anteriorly each with 2 small conical setae which become progressively smaller and further apart anteriorly, each with 1–2(1) trilocular pores, without auxiliary setae, discoidal pores, and basal sclerotization. Thoracic 'cerarii' composed of slightly enlarged setae in areas where cerarii would normally be, normally with 3 or 4 such cerarii on each side of thorax. Head with frontal cerarii only, each with 2–3(2) conical setae, without auxiliary setae, with 2–5(3) trilocular pores, 0–1(0) discoidal pores. Multilocular pores as follows: of ten specimens examined, five have multiloculars on one side of segment VIII and four have these pores on both sides of segment VIII, three have multiloculars on one side of segment VI, one has them on one side of segment V, two have them on one side of segment III, three have them on one side of segment II; multiloculars absent from segments IX, VII, IV, on thorax, and head; of ten specimens examined the number of multilocular pores on each specimen is 1–5(2). Oral-collar tubular ducts marginal, difficult to decide if dorsal or ventral; of ten specimens examined, one specimen has these ducts on both sides of segment VIII, one specimen has them on both sides of segment VII, four have them on one side of segment VI, three have them on one side of segment V, three have them on one side of segment IV, three have them on one side of segment III, two have them on one side of segment II, one has them on one side of thorax near posterior spiracle, two have them on one side of thorax near anterior spiracles, and one specimen has one oral-collar tubular duct on posterior margin of head; of ten specimens examined, the number of tubular ducts on each specimen is 0–6(2). Segment V with 6 bristle-shaped setae. Posterior ostioles evident, anterior ostioles absent.

Venter with multilocular pores as follows: of ten specimens examined, three have multiloculars on one side of segment VIII, one has multiloculars on both sides and two have these pores on one side of segment VII, one has them on both sides and two have them on one side of segment VI, four have them on one side of segment V, one has them near both

Fifth instar males (adults) (Fig. 15)

Recognition characters. Allotype mounted, 1.1 mm long (paratypes 1.0–1.2(1.1) mm), 0.3 mm wide (paratypes 0.3–0.4(0.3) mm).

Dorsum with one pair of tail-forming pore clusters, each with 2 long setae and 1 short seta, longest seta 183 μm long (paratypes 138–213(179) μm), shortest seta 25 μm long (paratypes 13–33(23) μm), each cluster also with 20 pores predominantly of quinquelocular type, occasionally with 3, 4, or 6 loculi (paratypes with 15–24(19) pores in each cluster), without discoidal pores. One multilocular derm pore with 3 loculi present in mediolateral area of abdominal segment III on one side only, absent elsewhere. Clear centre pores forming one pair of longitudinal lines on mediolateral area of abdomen, also present in cluster near metapostnotal ridge and in membranous area anterior of scutum. Head pores in small numbers near base of antennae. Body setae slender, clusters composed of 2 or 3 setae near margins of each abdominal segment, in small numbers on each thoracic segment and on head. Posterior ostioles present. Abdominal sclerotization restricted to small area on medial portion of segment IX. Metapostnotal ridge well defined laterally, occasionally not sclerotized medially. Scutum sclerotized throughout. Prescutum heavily sclerotized, somewhat rectangular. Postoccipital ridge evident; dorsal arm of midcranial ridge well developed, extending from postoccipital ridge forward to near posterior edge of lateral arms of midcranial ridge. Dorsomedial sclerite weakly or not sclerotized. Preocular and postocular ridges separate on dorsal aspect of head, without connecting ridges. Dorsal eye 33 μm in diameter (paratypes 28–35(32) μm). Ocellus 18 μm in diameter (paratypes 18–25(20) μm).

Penial sheath 130 μm long (paratypes 125–143(132) μm), width/length ratio 0.6 (paratypes 0.5–0.6(0.6)). Penial sheath undivided, without medial lobes. Aedeagus 98 μm long (paratypes 90–118(104) μm); basal apodeme present. Setal pattern on sheath relatively consistent.

Venter without multilocular derm pores. Clear centre pores restricted to area near anterior spiracle. Body setae bristle-shaped, about same length as those on dorsum, especially abundant on basisternum of mesothorax and on anterior portion of head; several setae on anterior part of head of fleshy type. Precoxal ridge on metathorax evident. Lateral ridge of metathorax well developed. Lateropleurite of mesothorax poorly developed, restricted to small sclerotized area. Prosternum with little sclerotization anterior of prosternal ridge. Preocular + interocular ridge well developed, joining prosternal ridge. Preocular + interocular ridge well developed, joining postocular ridge just below ocellus. Ventral arm of midcranial ridge absent. Ventral cavity conspicuous. Ventral eye 40 μm in diameter (paratypes 35–43(39) μm).

Pro- and mesothoracic legs about equal in length, metathoracic legs longest. Hind tibia/tarsus ratio 2.3 (paratypes 2.1–2.4 (2.2)); hind tibia + tarsus length 293 μm (paratypes 253–293(285) μm); claw unusually elongate for pseudococcid, 58 μm long (paratypes 58–63(59) μm); legs with bristle-shaped and fleshy setae; tarsal digitules of two lengths, longest digitule apically capitate, not exceeding length of claw, shortest digitule slightly longer than one-half of length of longest digitule, apically acute; claw digitules less than half length of claw, apically acute; tarsi two-segmented. Body length/antennal length ratio 1.4 (paratypes 1.3–1.6(1.4)); antennae ten-segmented, third segment 1.1 times longer than apical segment (paratypes 1.0–1.3(1.1)). Antennal setae as follows: with one or two subapical sensory setae on apical segment; with fleshy setae on segments 10–2, most numerous on apical segments; with hairlike setae on all segments, most numerous on basal segments; antennal bristles restricted to one on each of apical three segments. Front wings each 1.1 times longer than length of body (paratypes 1.0–1.1(1.1)), wings with two circular sensoria and three or four alar setae. Hamulohalterae present.

Variation. Paratypes may rarely have one or two discoidal pores in tail-forming pore clusters; dorsal multilocular derm pores variable, with 3–5(4) loculi, one specimen entirely without these pores, normally with one pore on mediolateral area of prothorax and one on mediolateral areas of abdominal

segments II and/or III or rarely IV, 0–4(2) such pores on each specimen. Ventral arm of midcranial ridge occasionally weakly developed. Short tarsal digitule occasionally capitate.

This description is based on thirty-five specimens from seven localities.

Fourth instar males (pupae) (Fig. 18)

Recognition characters. Same as for adult female except as follows: mounted, 1.0–1.1(1.1) mm long, 0.4 mm wide. Body shape normal for pseudococcid.

Dorsum with cerarian areas similar to those on prepupae, anal-lobe area frequently sclerotized. Longest seta on anal lobe 38–45(42) μm long. Multilocular pores in mediolateral areas of abdominal segments VIII or VII, posterior part of thorax, also abundant on prothorax. Trilocular pores absent. Discoidal pores associated with multiloculars, also near tubular ducts. Oral-collar tubular ducts restricted to abdomen, normally associated with paired setae in cerarian areas. Segment V with 5 bristle-shaped setae excluding those in cerarian areas. Anterior pair absent.

Anal ring dorsal, without pores and setae.

Venter with multilocular pores present on mediolateral areas of anterior one or two abdominal segments and 1 or 2 such pores near base of prothoracic legs. Discoidal pores associated with multiloculars. Trilocular pores and tubular ducts absent. Anal lobes unsclerotized; longest seta displaced to dorsal surface.

Eyes not protuberant. Legs with hind tibia and tarsus fused; hind tibia + tarsus length 205–228(215) μm; hind claws 33–35(34) μm long. Antennae ten-segmented, 458–519(484) μm long. With two pairs of wing buds, hind pair 31–43(37) μm long, front pair 378–458(411) μm long.

This description is based on twelve specimens from two localities.

Third instar males (prepupae) (Fig. 21)

Recognition characters. Same as for adult female except as follows: mounted, 1.0–1.1(1.0) mm long, 0.4–0.5(0.4) mm wide.

Dorsum without cerarii; cerarian areas on segments IX–II each with 2 closely associated, elongate bristle-shaped setae. Normally with 3 associated setae in each anal-lobe region; these setae noticeably more elongate and robust than those on remainder of dorsum; paired lateral setae becoming progressively shorter anteriorly. Multilocular pores normally scattered over surface, few or absent on posterior part of abdomen and on head. Irregular pores, of type abundant on venter, rare or absent on dorsum. Discoidal pores scattered over surface. Oral-collar tubular ducts normally lateral, occasionally mediolateral. Segment V with 5 bristle-shaped setae excluding those in cerarian areas. Anterior ostioles absent.

Anal ring dorsal, without pores and setae.

Venter with multilocular pores rare or absent, replaced by irregular pores which are probably poorly formed multilocular pores; irregular pores scattered over surface. Discoidal pores few. Trilocular pores absent. Oral-collar tubular ducts near body margin. Anal lobes unsclerotized; longest anal-lobe seta 85–98(90) μm.

Eyes not protuberant. Legs with tibia and tarsus partially or completely fused; hind tibia + tarsus length 163–188(176) μm; hind claws 28–33(30) μm long. Antennae eight-segmented, apical segment partially divided; antennae 299–335(320) μm long. With one pair of wing buds, 118–175(151) μm long.

This description is based on nine specimens from three localities.

Second instar males (Fig. 24)

Recognition characters. Same as for second instar female except as follows: mounted, 0.6–0.9(0.7) mm long, 0.3–0.5 (0.3) mm wide.

Dorsum with anal-lobe cerarii with 5–8(6) trilocular pores. Trilocular pores more abundant than on second instar female. Oral-collar tubular ducts of two sizes: Larger size normally along body margin scattered over remainder of surface; smaller size present in medial areas. Segment V with 4 or 5 setae excluding those in cerarian area.

Venter with multiloculars of one size, arranged similarly to those on second instar female, normally with one pore near lateral margin of each abdominal segment, sometimes two or rarely three pores on each of segments

VI–II, rarely one pore near lateral margin of segment IX or without pore on segment VII; normally one pore in mediolateral areas of segments VIII–VI, rarely on only one or two of these segments, also near each spiracle and on posterior margin of head, occasionally without thoracic and cephalic mediolateral pores; without medial multilocular pores. Tubular ducts of same two sizes as on dorsum, larger size generally restricted to marginal areas, smaller size present elsewhere. Anal lobes with longest seta 38–53(46) μm.

Legs with hind tibia/tarsus ratio 0.9–1.1(1.0); hind tibia + tarsus length 178–185(181) μm; hind claws 35–40(36) μm long. Antennae six- or seven-segmented; 268–299(282) μm long.

This description is based on twenty-three specimens from six localities.

Comparison of species

For a detailed comparison of the adult females and adult males see Tables 1 and 2 respectively.

Species differences among the third instar

TABLE 1. Micromorphological comparisons of adult females of *L.metroxyli, M.loranthi* and *P.eugeniae*. +, – = structure present and absent respectively.

Character	*L.metroxyli*	*M.loranthi*	*P.eugeniae*
$\bar{X}$ total no. cerarii	16	10	16
Cerarian trilocular pores (tp) forming plate	–	+	–
$\bar{X}$ no. anal-lobe cerarian tp	21	16	24
Dorsal multilocular pores (mp) coalesced into longitudinal dorsal band	–	+	–
Oral-collar tubular duct (old)	+	+	–
Two sizes ventral old	+	+	–
Two sizes ventral mp	–	–	+
Ventral tp	–	–	+
Anterior ostioles	+	–	–
Circulus	–	+	–
Setae long on segment IX	–	–	+
$\bar{X}$ no. setae on segment V	13	13	7
$\bar{X}$ length longest anal-lobe seta (μm)	95	70	81

TABLE 2. Morphological comparisons of adult males of *L.metroxyli, M.loranthi* and *P.eugeniae*. +, – = structure present and absent respectively.

Character	*L.metroxyli*	*M.loranthi*	*P.eugeniae*
Tarsi two-segmented	+	–	+
Hamulohalterae	–	–	+
$\bar{X}$ length third antennal seg./apical ant. seg.	1.7	1.2	1.1
Antenna with subapical sensory setae	–	–	+
Fleshy setae on ant. seg. 2	+	–	+
Postoccipital ridge	–	–	+
Ridge connecting pre- and postocular ridges	–	+	–
Metathoracic pleural ridge well developed	+	–	+
Lateral pleurite of mesothorax well developed	+	–	–
Abdominal sclerotization	+	–	+
Tail-forming pore cluster	+	–	+
Dorsal multilocular pores	+	–	±
Dorsal fleshy setae	+	–	–
Ventral fleshy setae short	–	+	–
Penial sheath width/length	0.8	0.7	0.6
Basal apodeme of penial sheath	+	–	+

female, the second instar female, and the second instar male are relatively consistent. *Leptococcus metroxyli* has dorsal multilocular pores, relatively short antennae and legs, scattered cerarian trilocular pores, and no circulus. *Macrocepicoccus loranthi* has dorsal multilocular pores, relatively long antennae and legs, the cerarian trilocular pores closely appressed forming a plate, and a circulus. *Plotococcus eugeniae* has no dorsal multilocular pores, relatively short antennae and legs, scattered cerarian trilocular pores, and no circulus.

Species differences among the first instars are: *Leptococcus metroxyli* has two or three pairs of longitudinal lines of trilocular pores, a relatively long anal-lobe seta, relatively short legs and antennae, no circulus, and no enlarged seta mesad of the penultimate cerarii. *Macrocepicoccus loranthi* has one pair of longitudinal lines of trilocular pores, a relatively short anal-lobe seta, relatively long legs and antennae, a circulus, and no enlarged seta mesad of the penultimate cerarii. *Plotococcus eugeniae* has two or three pairs of longitudinal lines of trilocular pores, a relatively long anal-lobe seta, relatively short legs, no circulus, and an enlarged seta mesad of the penultimate cerarii.

Species differences among the fourth and third instar males are: *Leptococcus metroxyli* has multilocular pores, relatively short legs and antennae, and a relatively short anal-lobe seta. *Macrocepicoccus loranthi* has no multilocular pores, relatively long legs and antennae, and a relatively long anal-lobe seta. *Plotococcus eugeniae* has multilocular pores, relatively short legs and antennae, and a relatively long anal-lobe seta.

Results of morphometric comparisons

Leg, antenna, and body-length were measured for eleven species of mealybugs [*Plotococcus eugeniae, Leptococcus metroxyli, Macrocepicoccus loranthi, Puto arctostaphyli* Ferris, *P.albicans* McKenzie, *Pseudococcus longispinus* (Targioni-Tozzetti), *P.calceolariae* (Maskell), *Planococcus citri* (Risso), *Ferrisia virgata* (Cockerell), *Spilococcus larreae* Ferris, and *Nipaecoccus nipae* (Maskell)] which occupy a variety of above-ground plant microsites. Analyses of variance performed on leg to body-length, antenna to body-length ratios, and absolute body length of the eleven species revealed a significant difference in each parameter ($F_{10,40} = 45.639$, $P < 0.001$; $F_{10,40} = 113.912$, $P < 0.001$; and $F_{10,40} = 41.739$ $P < 0.001$ respectively). To determine which means (species) were significantly different from others, least significant intervals (LSI) were calculated at the 0.1% probability level. Nonoverlapping LSIs indicate a significant difference between means.

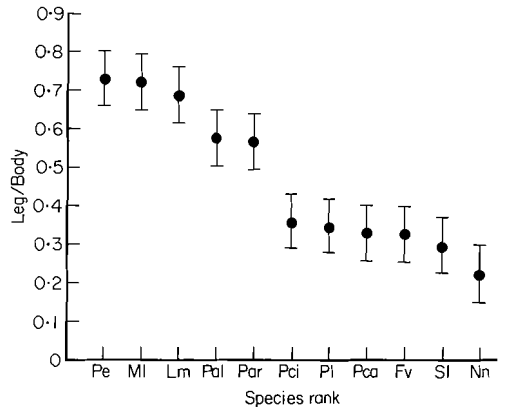

FIG. 25. Mean leg/body length ratios ranked by species for *P.eugeniae* (Pe), *M.loranthi* (Ml), *L. metroxyli* (Lm), *P.albicans* (Pal), *P.arctostaphyli* (Par), *P.citri* (Pci), *P.longispinus* (Pl), *P.calceolariae* (Pca), *F.virgata* (Fv), *S.larreae* (Sl), and *N.nipae* (Nn). Means based on $r = 5$. Non-overlapping least significant intervals (LSI), calculated at the 0.1% probability level, demonstrate significant difference between means.

Leg to body-length ratios, ranked by species, are shown in Fig. 25. *Plotococcus eugeniae* and *M.loranthi* have significantly higher leg to body-length ratios than all other species except *L.metroxyli* which is not significantly different from either *P.albicans* or *P.arctostaphyli.* All other mealybugs have significantly lower leg to body-length ratios than the species of *Puto* but do not differ significantly from one another.

Antenna to body-length ratios were calculated for the same mealybugs (Fig. 26). *Macrocepicoccus loranthi* possesses an antenna to body-length ratio significantly higher than all other insects examined, followed by *P.eugeniae* and *L.metroxyli.* The two *Puto* species have significantly smaller antenna to body-length ratios than

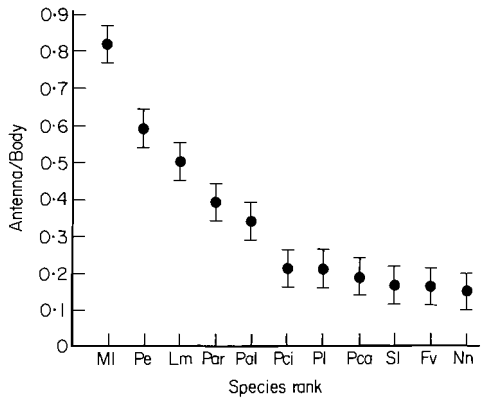

FIG. 26. Mean antenna/body length ratios ranked by species. Species legend and LSIs as in Fig. 25.

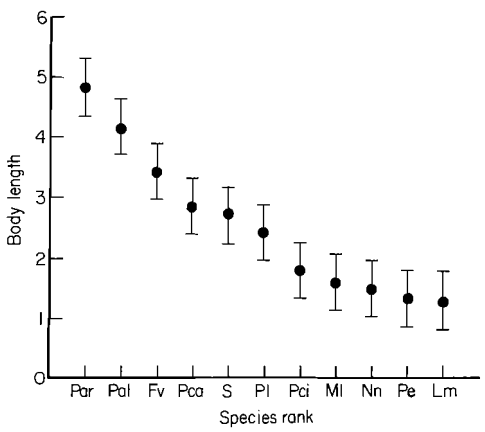

FIG. 27. Mean body lengths ranked by species. Species legend and LSIs as in Fig. 25.

M.loranthi, P.eugeniae, and *L.metroxyli.* The other species of mealybugs have antenna to body-length ratios significantly lower than those just discussed.

Absolute body-lengths are compared in Fig. 27. The species of *Puto* have significantly longer bodies than all others except *F.virgata. Macrocepicoccus loranthi, P.eugeniae, L. metroxyli,* and *N.nipae* have the smallest bodies of the species we measured.

Females of *P.eugeniae, L.metroxyli* and *M.loranthi* have long legs (femur + tibia + tarsus > 800 μm, leg length/body length ratio ~ 0.7), long antennae (scape + pedicel + flagellum > 610 μm, antenna length/body length ratio > 0.45), long tarsal claws (~ 50 μm), numerous, exceptionally long, lateral wax filaments, and a small body size (body-length ~ 2.5 mm, body-width ~ 1.0 mm).

Even though the gross body morphology of the females of the three species is quite similar, there are many micromorphological differences among them (Table 1). Comparisons of adult male morphology (Table 2) reveal numerous seemingly major differences between *P.eugeniae, L.metroxyli* and *M.loranthi.*

Discussion

The adult females of *L.metroxyli, M.loranthi* and *P.eugeniae* share a number of similar biological and gross morphological characters, many of which are unusual or unique for members of the Pseudococcidae. Females are arboreal, infest the entire leaf undersurfaces, have extraordinarily long legs, antennae, tarsal claws, and lateral wax filaments, and have a relatively small body. However, the fact that the adult females of these species possess many micromorphological differences is inconsistent with the observed trend in gross body morphology and suggests that these taxa may be products of convergent evolution.

Typically, adult female coccoids have evolved in close association with their host plants, where active host- and mate-searching activities have been 'sacrificed' for increased feeding efficiency and reproductive effort. Crawlers, whose primary function appears to be the location of host plants or specific feeding sites (Johnson, 1969), are also products of evolutionary specialization, and body form and function are influenced primarily by selective forces associated with dispersal. However, crawlers feed and are subject also to the particular selective regime on the host to some degree. Adult males, on the other hand, whose main function is to locate and inseminate females, have not undergone adaptation to the host plant as intensively as the females. For these reasons, males may retain ancestral or generalized characters and better reflect the phylogeny of coccoid taxa. Borchsenius (1965) also alludes to the importance of males in unravelling coccoid systematics.

In a review of the adult females of the grass-sheath inhabiting genera *Brevennia* and *Heterococcus,* Miller & McKenzie (1970)

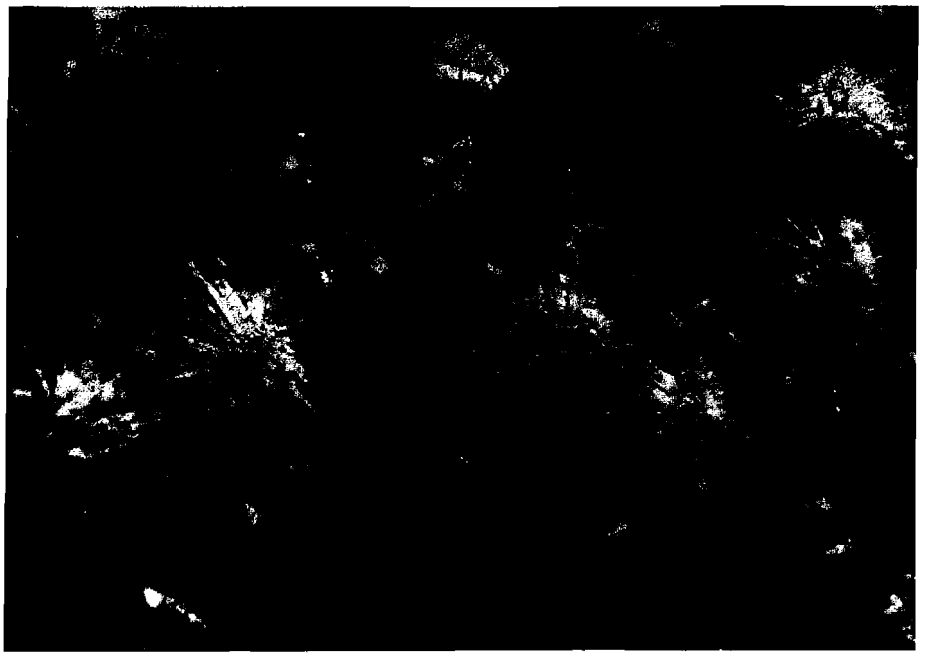

FIG. 28. Habitus photograph of *Plotococcus eugeniae* sp.n.

FIG. 29. Habitat of *Plotococcus eugeniae* sp.n. Hardwood hammock with understory of white stopper (*Eugenia axillaris*), on Noname Key, Florida.

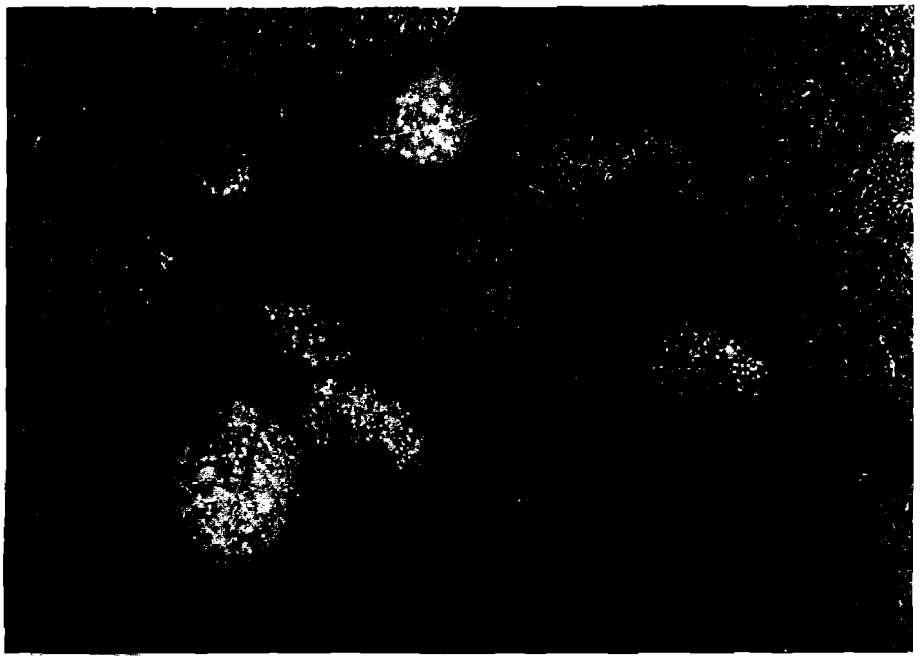

FIG. 30. Heavy *Plotococcus eugeniae* infestation on leaf undersurfaces of *Eugenia axillaris.*

treated *Brevennia* as a junior synonym of *Heterococcus.* In a later revision, Miller (1975) examined all available instars, and, primarily as a result of differences found among adult males, concluded that these genera are so distinct that they actually belong to different tribes. Apparently there is an 'optimum phenotype' for existence in grass-sheath habitats toward which female and immature instars morphologically converge. However, adult males of these groups show considerable differences and more truly reflect ancestral relationships.

A similar situation exists in *Leptococcus, Macrocepicoccus* and *Plotococcus.* Except for the usual structure of the cerarii in *Macrocepicoccus,* female morphology would suggest a magnitude of difference that separates species, but not genera. In fact, when Reyne consulted Morrison about the generic placement of *L.metroxyli,* Morrison suggested that it be described as a second species of *Macrocepicoccus* (Reyne, 1961). Adult male morphology, however, suggests that these three taxa are very different. Adult males of *Macrocepicoccus* have one-segmented tarsi and lack tail-forming pore clusters and multilocular derm pores. These features immediately separate it from all adult, macropterous, male pseudococcids. One-segmented tarsi are atypical of all macropterous mealybugs. *Nairobia bifrons* DeLotto is the only pseudococcid which lacks multilocular derm pores, and the absence of tail-forming pore clusters occurs only on *Rhizoecus falcifer* Künckel d'Herculais. Adult males of *L.metroxyli* and *P.eugeniae* are more similar to one another than to *M.loranthi* (Table 2). *Plotococcus* has hamulohalterae, antennae with subapical sensory setae, and a postoccipital ridge. *Leptococcus* lacks these structures, but has dorsal fleshy setae and a well-developed lateral mesothoracic pleurite, features that are absent on *Plotococcus.* Based on the adult male classification of Afifi & Kosztarab (1967), *Leptococcus* should be placed in the 'Pseudococcus group', *Plotococcus* in the 'Planococcus group', and *Macrocepicoccus* in a 'group of genera' not described.

It is fairly evident that *M.loranthi* is derived from a very different ancestral line than either *L.metroxyli* or *P.eugeniae.* Differences in the former are most apparent in the adult male, pupa, prepupa, first instar,

and second instar male. We believe that the remarkable similarity of the gross female morphology in these genera is attributable to convergent evolution, as in *Brevennia* and *Heterococcus*.

With the objective of finding possible reasons for the apparent convergent body morphology of *P.eugeniae, L.metroxyli* and *M.loranthi,* we examined some of the biological characteristics of these taxa. Each species was found scattered over many microsites on leaf undersurfaces unlike most leaf-infesting pseudococcids that are concentrated near the primary veins. *Plotococcus eugeniae* was found on *Eugenia* spp. in dense hammocks. Populations were small and patchy at most collection sites, but on some trees they were so dense that leaf surfaces were completely obscured. Reyne (1961) reported that 'crowded colonies' of *L.metroxyli* occasionally covered three-quarters of the undersurfaces of the pinnae of sago palms. Although Morrison (1919) did not discuss the distribution of *M.loranthi* on leaves, it is obvious from our examination of dry material that this species was scattered over leaf undersurfaces similarly to *P. eugeniae.*

The exploitation of leaf areas other than primary veins might require increased capabilities for clinging to the host. Long legs and tarsal claws could be modifications to facilitate holding onto the host in exposed habitats. Long lateral filaments might buffer the dislodging potential of winds by directing air over the body of the mealybug.

The morphological convergence might also be explained by a common response to predation pressure. Perhaps long lateral wax filaments that fringe these mealybugs disuade predators or parasitoids. However, Reyne (1961) found coccinellid larvae (*Cryptolaemus montrouzier*) associated with *L.metroxyli,* and we observed brown lacewing larvae among infestations of *P.eugeniae.* These limited data suggest that the general regime of predators on *L.metroxyli* and *P.eugeniae* is not unusual compared with that on other mealybugs, many of which lack long lateral filaments. Also, the predation argument does not offer a convincing explanation for the unusually long antennae, legs, and tarsal claws.

Berland (1935) and Glick (1939) characterized 'aerial plankton' (insects carried aloft by ascending air currents) as being small, light weight, weak flying insects with a large surface area. Females of *P.eugeniae, L.metroxyli* and *M.loranthi* have a small body size compared with other arboreal species, also they have long legs and antennae and a dense fringe of lateral wax filaments, structures that increase the surface area of the insect. When infested *Eugenia* trees were abruptly jarred, we observed some individuals of *P.eugeniae* dislodged from their holds and float through the air like snowflakes. These data suggest that the unusual collection of characters found in these three genera of mealybugs may be dictated by selection pressures for an optimum body morphology for adult dispersal.

If dispersal is indeed occurring in the adult female, it is unusual, for the great majority of mealybugs disperse as first-instar crawlers (Johnson, 1969; Willard, 1974). Dispersal during the crawler stage is undoubtedly an adaptation that allows colonization of particularly diffuse or patchy resources. Because long-range dispersal is passive (wind) and the probability of locating a host is small, the optimum strategy for most mealybugs would seem to be to allocate a fixed amount of energy to the production of many very small propagules rather than to a few large ones. Only where host resources are very abundant and located in mild environments (usually free of strong winds) would it seem profitable to disperse as an adult female. The habitat of *P.eugeniae* in the hammock vegetation of Florida meets these criteria.

For these reasons, it is unlikely that adult dispersal in mealybugs is an adaptation to allow colonization of distant resources, although it is certainly possible because adults, with their relative large body size, are probably less subject to desiccation than crawlers. If females are mated or parthenogenetic, the advantage of their dispersal lies with their ability to reproduce immediately and colonize new host plants. The immediate exploitation of host plants is further enhanced by ovoviviparity (present in *L.metroxyli,* Reyne, 1961) whereby crawlers are deposited rather than eggs. In *P.eugeniae* we found many first instar crawlers but never

found eggs, possibly suggesting that this species also is ovoviviparous.

Long legs and tarsal claws, in addition to increasing the surface area of the insect, probably aid the mealybugs in holding onto exposed leaves. Their long legs allow adult females to be quite mobile (personal observation of *P.eugeniae*) which could be important in locating host plants. Although there are certainly other possibilities, we feel that dispersal is the best explanation for the convergence of gross body structure in *P.eugeniae, L.metroxyli* and *M.loranthi.*

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Book notices

INSECT DEVELOPMENT. Edited by P. A. Lawrence. Vol. 8, Symposia of the Royal Entomological Society of London. Pp. 230. Blackwell Scientific Publications, Oxford, 1976. £10.50.

The study of insect metamorphosis and its hormonal control has long been a rewarding field for the developmental biologist. Until recently, however, an intractable obstacle, the egg shell, has discouraged a more concerted examination of the important early events in embryogenesis when the body axis is laid down and the organ primordia are determined and positioned. These difficulties are now being overcome. New surgical techniques, such as the microinjection of nuclei and ooplasm, have been perfected. The awesome edifice of *Drosophila* genetics has provided both the spur and the means of developing the ingenious method of clonal analysis. Nevertheless, the refinements of this technique could not have been devised were it not that *Drosophila* larvae possessess large masses of embryonic cells in the form of imaginal discs which can be labelled, cut in two, joined together, allowed to grow and finally made to metamorphose. The rapid exploitation of this material has resulted in a flood of specialist papers which illuminate many of the fundamental problems of developmental biology. The present volume which reviews progress in this field, is an important landmark.

The dozen papers in *Insect Development* are grouped in three sections devoted respectively to embryogenesis, to the *Drosophila* imaginal disc, and to the development of anatomical pattern in later development. In the introductory section H. A. Schneiderman discusses recent techniques and concepts, then K. Sander examines the problems associated with morphogenetic movements, and K. Kaltoff and K. Illmensee independently review the evidence for the specification of the antero-posterior body pattern in the blastoderm, as revealed by different experimental techniques. The papers in the second group are also closely linked. The progressive determination of the disc, either demonstrated by surgery (W. Gehring) or by the clonal analysis of defined cell groups (R. Nöthiger; P. A. Lawrence and G. Morata) is the central theme, the last authors providing an admirably succinct resumé of the recently formulated compartment hypothesis. Little is known of the early biochemical effects of genes that control patterns but some pointers are available in the case of wing disc mutants (J. R. S. Whittle). The third group is more diverse. The subjects reviewed include the principles of leg regeneration in the cockroach, illustrated by the elegant surgery of H. Bohn; the establishment of the neural connections in the retina and optic lamina of *Drosophila* (P. M. J. Shelton); and the determination of cuticular patterns in *Rhodnius* (V. B. Wigglesworth). The only contribution in which the emphasis is placed upon hormonal mechanisms rather than on the orderly development of structure is by M. Ashburner and G. Richards who survey the role of ecdysone in stimulating puffing patterns and gene activity in the polytene chromosomes of *Drosophila*.

Like all good symposia this well-produced volume conveys a feeling of intense, even competitive, research activity. The convenor and editor is to be congratulated on harvesting the products in so timely a manner.

A. D. LEES

THE NATURE TRAIL BOOK OF INSECT WATCHING. By Ruth Thomson. Pp. 32. Usborne Publishing Limited, London, 1976. Hardback £1.40, Paperback 75p.