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Redescription of the adult male and description of second-instar male, prepupa and pupa of *Ceroplastes japonicus* Green (Hemiptera: Coccoidea: Coccidae)

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Abstract

The adult male of *Ceroplastes japonicus* Green is redescribed and illustrated and compared with other known males of *Ceroplastes*. In addition, the 2nd-instar male, male test, prepupa and pupa of *C. japonicus* are also described and illustrated for the first time.

Key words: male morphology, adult males identification key *Ceroplastes cirripediformis, C. ceriferus, C. berliniae (=Waxiella berliniae), Ceroplastes* sp. *(=Waxiella* sp.*)*

Introduction

The genus *Ceroplastes* comprises many widespread and economically important wax scale species, mainly pests of tropical and subtropical fruit trees, citrus, fig, ornamentals (e.g. *C. sinensis* Del Guercio, *C. rusci* (Linnaeus), *C. rubens* Maskell, *C. destructor* Newstead, *C. floridensis* Comstock). This genus includes both bisexual species, where males are known (i.e. *C. sinensis, C. rusci*), even if only rarely recorded (i.e. *C. ceriferus* (Fabricius) (Gimpel *et al*., 1974), and species that can reproduce parthenogenetically. Parthenogenetic reproduction may be either facultative, where males only occur rarely, or obligatory, where males do not occur, as with *C. floridensis* and *C. destructor* (Qin & Gullan, 1994). Differences in the presence or absence of males in populations of a given species living in different geographic areas have also been reported. For instance, according to Kuwana (1923), males of *C. rubens* are present in Japan, but they have not been recorded in the USA (Gimpel *et al*., 1974), nor in Australia (Qin & Gullan, 1994).

With regard to *Ceroplastes japonicus* Green, males are known in the supposed native area of the species (China, Korea, Japan) (Kuwana, 1923; Jiang & Gu, 1988; Park *et al.*, 1992; Xie *et al*., 2006), and also in Georgia and Russia (Abkhazia), where it is an introduced species (Borchsenius, 1957; Japoshvili, 2001, *pers. com*.). In Europe, *C. japonicus* was first recorded outdoors in Italy (Kozár *et al*., 1984), and later in France, Slovenia and Croatia (Pellizzari & Camporese, 1994; Jančar *et al*., 1999; Masten Milek *et al*., 2007) In the above recorded countries it is a pest of ornamentals (e.g. *Hedera helix, Ilex aquifolium, Laurus nobilis* and Citrus) in urban environments. Males of *C. japonicus* were not noticed in Italy for a long time, even though its biology was studied in different areas by several authors (Longo, 1985; Camporese, 1991; Camporese & Pellizzari, 1998; Raspi & Antonelli, 1998). Although populations of this species have been regularly monitored in Padua (Italy) since 1990, males were not observed until 2003, when male tests were noticed for the first time on *Citrus reticulata*. At this time (the end of September), several male tests were empty or had dead specimens inside. Subsequently, many adult males, 2nd-instar male nymphs, prepupae and pupae were observed on 14th October 2007 on *Laurus nobilis*, in the province of Venice.

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The morphology of the adult male of *C. japonicus* was at first studied by Borchsenius (1957). He gave a detailed description and illustration of the head, the third and last antennal segments, scutum and penial sheath. Probably because the description is in Russian and some illustrations are in the first part of his book (p. 22: male; p. 26: head; p. 30: penial sheath; p. 32: male test) and not in the pages dealing with *C. japonicus* (p. 461–468), they were overlooked for a long time. Another description and illustration of *C. japonicus* male was published by Xie *et al*. (2006), but the small size of the illustration and the short description (in Chinese) does not allow a clear understanding of some morphological characters. No descriptions are available of the 2nd-instar male nymph, the prepupa and pupa. With the recent collections, the opportunity is here taken to illustrate and describe the 2nd-instar male, prepupa and pupa, and to give a detailed redescription of the adult male of this species.

Material and methods

All specimens were slide mounted according to the procedures of Ben-Dov and Hodgson (1997). Measurements and numbers are given as ranges, followed by the mean in parentheses. Terminology follows that of Giliomee (1967). With regard to the male test, terminology follows that of Miller and Williams (1990). Specimen depositories: mounted and unmounted specimens are deposited in the entomological collection in the Department of Environmental Agronomy and Crop Production–Entomology (DEAE), University of Padua, Italy.

Ceroplastes japonicus Green

Ceroplastes floridensis japonicus Green, 1921: 258.
Ceroplastes japonicus Green; Borchsenius 1949: 181.

Material examined. **ITALY**: Padua, on *Citrus reticulata*, ix.2003, G. Pellizzari: 11 adult males, 10 2nd-instar males, 10 prepupae, 11 pupae, 6 male tests; and Noale (Venice), on *Laurus nobilis*, 14.x.2007, A. Rainato: 17 adult males, 10 2nd-instar males, 10 prepupae, 10 pupae + 10 male tests.

MALE TEST (Plate 1: a–d)

Described from 10 male tests; total length and total width measured from 5 specimens in fairly good condition, with undamaged waxy projections; details checked on remaining specimens.

General appearance of male test: white, opaque, with a dry wax structure, oblong, star-shaped; median plate strongly elevated, slightly broadened and more elevated anteriorly; with 13 distinct marginal waxy projections plus 2 small anal plate projections; parastigmal processes not seen on examined specimens. Total length, including waxy projections, 1758–2012 (1874) μm; width 1043–1639 (1416) μm. Test base well-defined, ellipsoidal, with peripheral waxy fringe along margin; length of test base: 835–1363 (1027) μm; width: 461–725 (585) μm.

Distribution on host plant: male tests are usually located on the lower surface of leaves.

Comments. Borchsenius (1957) provided a short description (p. 465) and a drawing (p. 32) of the test of *C. japonicus*. Our description and measurements agree with his (about 2.1 mm in length and 1.6 mm in width).

ADULT MALE (Fig. 1, Plate 1: e, f)

Described from 8 males in fairly good condition; details checked on remaining specimens.

Mounted material: 983–1267 (1132) μm long; 326–359 (338) μm wide across triangular plates; body broad and stocky, but this possibly due to specimen becoming squashed when mounted. Body and appendages covered with numerous setae, mostly fleshy setae (*fs*); hair-like setae (*hs*) fewer. Dermal pores entirely absent. Abdominal glandular pouches and associated setae absent. Caudal extensions present on abdominal segments VII and VIII.

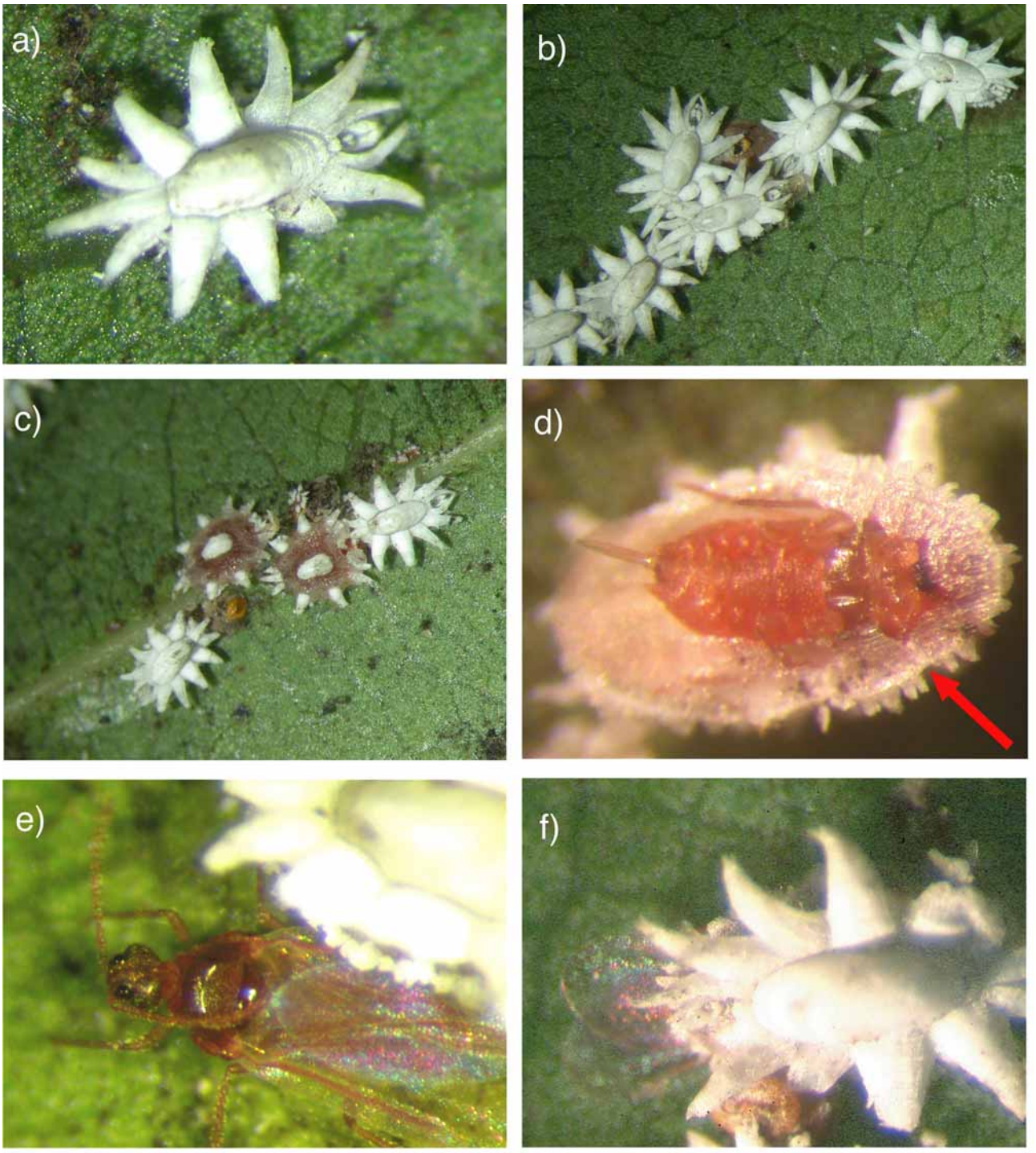
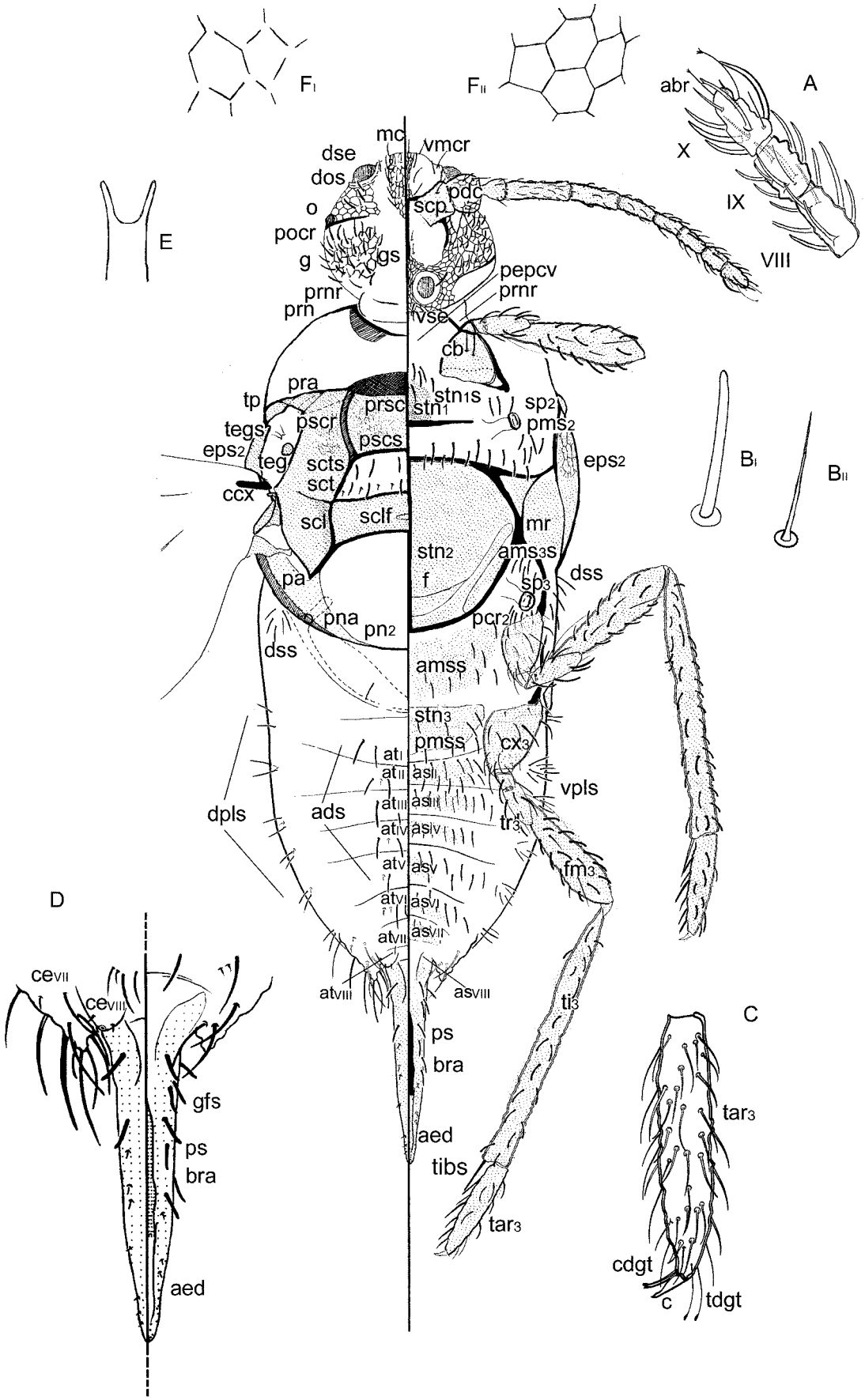


PLATE 1. (a) Star-shaped male test of *C. japonicus* (Green); the test exhibits 13 noticeable lateral waxy projections; (b) Male tests on lower surface of a leaf; (c) Comparison between young females (pinkish, in the middle) and male tests (white); (d) Adult male inside the test, the arrow indicates the peripheral fringe around the test base; (e & f) Adult male emerging backwards from waxy test .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Head: Bluntly triangular in dorsal view; length from apex to pronotal ridge (*prnr*) 137–204 (170) μm, width across genae 179–241 (209) μm. Median crest (*mc*) showing polygonal reticulations; dorsal head setae with 12–14 (13) *fs* and 4–8 (7) *hs*. Dorsal mid-cranial ridge absent; ventral midcranial ridge (*vmcr*) strong, extending from short lateral arms posteriorly to margin of ocular sclerite; with 4 ventral midcranial ridge *hs*. Genae (*g*) sclerotised, with polygonal reticulations and with 22–27 (24) *fs* and 2–5 *hs* genal setae (*gs*) on each side. Simple eyes round, subequal in size; dorsal eyes (*dse*) situated near head apex, each 24–33 (29) μm wide; ventral eyes (*vse*) on posterior ventral area of head, each 22–37 (27) μm wide. Ocelli (*o*) situated laterally, each 14.8–18.5 (15.4) μm wide, lying just anterior to postocular ridge (*pocr*); interocular ridge absent. Ocular sclerite fairly well sclerotised, with polygonal reticulations throughout. Preocular ridge quite distinct but short; postocular ridge (*pocr*) strongly developed. Dorsal ocular setae (*dos*) 3 *fs* and 1 *hs*. Ventral head setae 12–16 (14) *fs*, mainly situated antero-laterally to ventral simple eyes. Preoral ridge in some specimens fairly well developed, about 15 μm in length. Cranial apophysis poorly defined, with bifurcate apex.

Antennae: ten-segmented and filiform, with short, stout fleshy setae (*fs*); each antenna 372–522 (434) μm long; shorter than half body length (ratio of total body length to antennal length 1: 0.38–0.41, average 0.38), shorter than posterior leg (ratio of posterior leg length to antennal length 1:0.30) and longer than penial sheath (ratio of penial sheath to antennal length 1:1.52–1.68, average 1.63). Scape (*scp*) approximately square, 26–37 (31) μm long, 22–56 (37) μm wide; with 2 or 3 *hs*, plus sometimes 1 *fs*. Pedicel (*pdc*), 26–37 (31 μm) long, 33–41 (37) μm wide; with 1–5 (3.5) *fs* and 0–4 (2) *hs*, and with polygonal reticulations on distal 1/3. Segment III club-shaped, 1.77–2.25 (1.79) times longer than wide; 33–59 (39) μm long, 15–33 (22) μm maximum width, with 3–10 (6) *fs* and 0–2 *hs*. Segments IV–IX cylindrical, each about 15–28 (21μm) wide; lengths (μm): III 15–33 (22); IV 85–111 (97); V 59–85 (71); VI 36–57 (51); VII 15–33 (26); VIII 35–48 (41); IX 33–43 (38); setal distribution: III 3–10 (6), IV 18–28 (23), V 12–18 (15), VI 10–21 (15), VII 5–9 (7), VIII 8–17 (11), IX 6–11 (9) all *fs* except for 1 or 2 *hs* on each of segments III, VIII and IX. One antennal bristle (*abr*) present on segments VIII & IX, each 37–48 (44) μm long and distinctly larger than *fs*. Segment X 37–52 (44) μm long, 15–22 (20) μm wide, with apex constricted; with 2–6 (4) *fs*, 0–4 *hs*, 3 *abr* and 3 or 4 subapical capitatae setae;.

FIGURE 1. *Ceroplastes japonicus* Green, adult male. Where A = last antennal segments; B = body setae: fleshy seta (B_I), hair seta (B_{II}); C = metatarsus and claw; D = dorsal and ventral view of the genital segment; E = cranial apophysis; F = dorsal (F_I) and ventral (F_{II}) view of polygonal reticulations on head capsule. And where abr = antennal bristles; ads = dorsal abdominal setae; aed = aedeagus; ams_3s = antemetaspiracular setae; amss = anterior metasternal setae; as_{II-} as_{VIII}= abdominal sternites II–VIII; at_I – at_{VIII}= abdominal tergite I–VIII; bra = basal rod of aedeagus; c = claw; cb = coxal bristles; ccx = costal complex of wing veins; cdgt = claw digitules; ce_{VII} = caudal extension of segment VII; ce_{VIII} = caudal extension of segment VIII; cx_3 = coxa of methathoracic leg; dos = dorsal ocular setae; dpls = dorsopleural setae; dse = dorsal simple eye; dss = dorsal spiracular setae; eps_2 = mesepisternum; f = furca; fm_3 = femur of metathoracic leg; g = genae; gfs = genital fleshy setae; gs = genal setae; mc = median crest; mr = marginal ridge; o = ocellus; pa = postalare; pdc = pedicel; pepcv = proepisternum + cervical sclerite; pms_2 = postmesospiracular setae; pmss = posterior metasternal setae; pn_2 = mesopostnotum; pna = postnatal apophysis; pocr = preocular ridge; pra = prealare; prn = lateral pronotal sclerite; prnr = pronotal ridge; prsc = prescutum; ps = penial sheath; pscr = prescutal ridge; pscs = prescutal suture; scl = scutellum; sclf = scutellar foramen; scp = scape; sct =scutum; scts = scutal setae; sp_2 = mesothoracic spiracle; sp_3 = metathoracic spiracle; stn_1 = prosternum; stn_1s = prosternal setae; stn_2 = basisternum or mesosternum; stn_3 = metasternum; tar_3 = tarsus of metathoracic leg; teg = tegula; tegs = tegular setae; tdgt = tarsal digitules; ti_3 = tibia of metathoracic leg; tibs= tibial spur; tp = triangular plate; tr_3 = trochanter of metathoracic leg; vmcr = ventral midcranial ridge; vse = ventral simple eye.

Thorax

Prothorax: membranous; pronotal ridges (*prnr*) well developed, medially fused by weak sclerotisation; pronotal sclerite (*prn*) present; without lateral pronotal setae. Median pronotal setae absent; post-tergite not

detected. Prosternum (stn_1) lightly sclerotised; with base of median ridge and transverse ridge strongly developed; with total of 8–10 *fs* prosternal setae (snt_1s). Anteprosternal setae absent. Antemesospiracular setae: 3 on each side of body.

Mesothorax: mesoprephragma with deep ventral emargination. Prescutum (*prsc*) 78–111 (94) μm long; 126–161 (139) μm wide; strongly sclerotised, with polygonal reticulations; anterior margin curved; laterally bounded by heavily sclerotised prescutal ridges (*pscr*) and posteriorly by prescutal suture (*pscs*). Scutum (*sct*): with median membranous area trapezoidal or sub-rectangular, wider posteriorly; 26–78 (49) μm long; 148–185 (166) μm wide; scutal setae (*scts*): 10–14 (12) *fs* and 6–10 (8) *hs*. Rest of the scutum sclerotised, with fairly well-defined polygonal nodulation, but without setae. Scutellum (*scl*) 33–48 (41) μm long, 133–178 (155) μm wide; tubular, with small ventral foramen; without scutellar ridge or scutellar setae. Prealare (*pra*) and triangular plate (*tp*) well developed. Tegula (*teg*) present, with 1–4 (3) *hs* tegular setae (*tegs*). Mesopostnotum (pn_2) well developed; postnotal apophysis (*pna*) and postalare well developed and strongly sclerotised. Postalare (*pa*) without nodulation and without postalare setae. Mesopostphragma with deep emargination. Mesopleural apophysis and mesopleural wing process well developed. Basalare well developed. Subalare present. Mesepisternum (eps_2) with nodulations; subepisternal ridge well developed. Mesepimeron not seen or not developed. Lateropleurite broad, partly bounded anteriorly by an extension from marginal ridge (*mr*). Basisternum (stn_2) 111–155 (137) μm long, 148–248 (218) μm wide; with a strong medial ridge and bounded anteriorly by strong marginal ridges and posteriorly by strong precoxal ridges (pcr_2); without setae; furca (*f*) well developed, narrow waisted, with arms divergent and extending about ¾ way to marginal ridge anteriorly. Mesothoracic spiracle (sp_2) with well-developed peritreme; width of peritreme 13–22 (17) μm; post-mesospiracular setae (pms_2): 25–35 (27) *fs*, arranged in a band across segment between spiracles.

Metathorax: suspensorial sclerite absent. Metapostnotum not detected; with a single *fs* metatergal seta on each side; dorsospiracular setae (*dss*) 4–6 *fs*. Metapleural ridge and metapleural ridge wing process well developed. Metasternum (stn_3) quite strongly sclerotised; anterior metasternal setae (*amss*) 12–24 (17) *fs*; posterior metasternal setae (*pmss*) 14–19 (17) *fs*. Metepisternum sclerotised, with 6–8 *fs* postmetaspiracular setae; precoxal ridge well developed, with a short, fairly well sclerotised metepimeron produced posteriorly. Metathoracic spiracle similar to mesothoracic one; width of peritreme 15–30 (18) μm.

Wings: hyaline; rather short and comparatively broad; 864–983 (905) μm long and 373–522 (443) μm wide; ratio of width to length 1:1.89–2.32 (2.04); ratio of total body length to wing length 1 : 0.78–0.88 (0.80); alar lobe and alar setae absent. Hamulohalterae absent.

Legs: long and slender, prothoracic leg shortest, metathoracic leg longest; total lengths (μm) : I 844–1027 (946); II 844–1065 (969); III 885–1201 (1089) μm; ratio of hind leg to total body length 1:2–2.2 (1:2.1). Coxae (*cx*): I 44–85 (53); II 59–89 (72); III 59–63 (79) μm long; setae of coxa III 8–19 (15) *fs* and 2–9 (6) *hs*. Trochanter (*tr*) + femur (*fm*) lengths (μm): I 174–215 (197); II 167–200 (185); III 174–218 (194); maximum widths: I 26–44 (35); II 31–41 (37); III 33–44 (39); ratio of maximum width to length of hind femur 1:4.9–5.2 (5); with 2 campaniform sensilla on each side of trochanter. Trochanter III with 7–12 (9) *fs* and 1–3 *hs*; femur III with 14–31 (22) *fs* and 2–8 (5) *hs*. Tibia (*ti*): I 196–251 (228); II 192–263 (230); III 233–315 (284) μm long; tibia III with 42–75 (58) *fs*; 4–15 (9) *hs*; with one tibial spur (*tibs*). Tarsi (*tar*) one-segmented: I 92–111 (101); II 96–111 (103); III 74–122 (107) μm long (ratio of length of tibia III to length of tarsus III 1:0.31–0.39 (0.38)); tarsus III with 12–43 (26) *fs*, 2–4 *hs*; tarsal campaniform pores absent; tarsal digitules (*tdgt*) each 20–22 μm long, with apical knob. Claws (*c*) short, slightly curved, denticle small or absent : length III 15–22 (19) μm, claw digitules (*cdgt*) capitate, each 20–26 (23) μm long.

Abdomen: Segments I–VII: tergites (*at*) I–IV unsclerotised, V–VII slightly sclerotised; sternites (*as*) I–IV weakly sclerotised, V and VII fairly well sclerotised. Caudal extension of segment VII (ce_{VII}) tapering, weakly sclerotised, with 11–17 (12) pleural *fs* and 2 or 3 *hs*. Dorsal abdominal setae (*ads*) (total across segment): I 16–24 (20) *fs*; II 16–24 (20) *fs*; III 4–16 (10) *fs* + 2 *hs*; IV 6–20 (13) *fs* + 2 *hs*; V 2–14 (8) *fs* + 2 *hs*; VI 2–18

(11) fs + 2–4 *hs*; VII 6–10 (8) *fs* + 2–6 (4) *hs*. Pleural setae: dorsopleural setae (*dpls*) (on each side): I 2 or 3 *fs* and generally 1 *hs*; II 1–4 (2) *fs* + 1 *hs*; III 1–4 (2) *fs* + 1 or 2 *hs*; IV 2–4 *fs* + 1 *hs*; V 2–6 (3) fs + 1–2 *hs*; VI 2–4 (3) *fs* + 1–4 (2) *hs*, and VII 1–3 *fs* + 1 or 2 *hs*. Ventropleural setae (*vpls*) (on each side): I 2–8 (4) *fs* + 0 or 1 *hs*; II 1–4 (2) *fs*; III 2–6 (3) *fs* + 0 or 1 *hs*; IV 1–6 (3) fs + 1 *hs*; V 1–4 (2) + 1 or 2 *hs* ; VI 1–3 (2) *fs* + 1 or 2 *hs*; VII 1–4 (2) *fs* + 1 or 2 *hs* on VII. Ventral abdominal setae (totals): I 10–21 (16) *fs*; II 10–22 (17) *fs*; III 12–16 (14) *fs* + 2 *hs*; IV 10–16 (12) *fs* + 2–4 *hs*; V 7–16 (11) *fs* + 2–6 (3) *hs*; VI 4–10 (8) *fs* + 2–4 *hs*; and VII 4–10 (8) *fs* + 2–6 (4) *hs.*

Segment VIII: tergite (*at*) and sternite (*as*) sclerotised; tergite sometimes with a pair of short *fs* dorsal abdominal setae (*ads*); sternite without ventral abdominal setae; caudal extension of segment VIII (ce_{VIII}) weakly sclerotised, semi-circular lobe; cicatrix absent; with 0–2 *hs* ventral abdominal setae; glandular pouches absent, but with about 4 long *hs* in this position.

Genital segment: anus present just anterior to penial sheath on dorsal surface, 27–42 (37) μm wide. Penial sheath (*ps*) long, anteriorly with parallel sides, posteriorly with a pointed apex; covered by a membranous extension from segment IX; penial sheath with a group of small sensilla near apex; also with 10–17 (14) *fs* and 8–21 (14) minute *hs* penial sheath setae (*gfs*); *fs* mainly on basal portion of penial sheath margin. Penial sheath 244–310 (267) μm long and 63–111 (75) μm wide at base; ratio of total body length to penial sheath length about 1:4. Basal rod (*bra*) distinct, positioned just posterior to basal membranous area of aedeagus, 248–315 (291) μm long and 15–19 μm wide; aedeagus (*aed*) with parallel sides; 178–296 (233) μm long, lying within penial sheath, membranous extension of aedeagus absent.

Comments: the membranous area of the scutum of *C. japonicus* has 10–14 (12) *fs* and 6–10 (8) *hs* scutal setae (*scts*) which is fewer than the 45 reported for *C. ceriferus* by Gimpel *et al*. (1974). On the other hand, *C. cirripediformis* apparently has about 23 scutal setae and glandular pouches and associated setae, that are absent on both *C. japonicus* and *C. ceriferus* (Gimpel *et al.*, 1974). The penial sheath has unusual fleshy setae (*gfs*) on the margins of the basal part, a character shared with *C. cirripediformis*. Fleshy setae are absent from the penial sheaths of *W. berliniae* and *Waxiella* sp. (Giliomee, 1967). Our description is similar to the drawings of *C. japonicus* penial sheath by Borchsenius (1957, p. 30, figs 58, 59).

Key to *Ceroplastes* species based on adult males

1 Penial sheath with fleshy setae 2
- Penial sheath without fleshy setae ..... *Waxiella* species
2 Penial sheath apex rounded; fleshy setae absent on basal portion of penial sheath; glandular pouch absent .....*C. ceriferus*
- Penial sheath apex pointed; fleshy setae present on basal portion of penial sheath; glandular pouches present or absent. 3
3 Penial sheath long (ratio of total body length to penial sheath length 1: 0.24); membranous area of scutum with 10–14 (12) *fs* and 6–10 (8) *hs* scutal setae; glandular pouches absent ..... *C. japonicus*
- Penial sheath shorter (ratio of total body length to penial sheath length 1:0.15); membranous area of scutum with about 23 (*fs*+*hs*) scutal setae; glandular pouches present. .....*C. cirripediformis*

SECOND-INSTAR MALE NYMPH (Fig. 2)

Described from 6 specimens in good condition.

Unmounted material: body oval, lightly convex dorsally, brown.

Mounted material: body elongate oval; 924–1147 (1058 μm) long; 551–671 (626 μm) wide; anal cleft short.

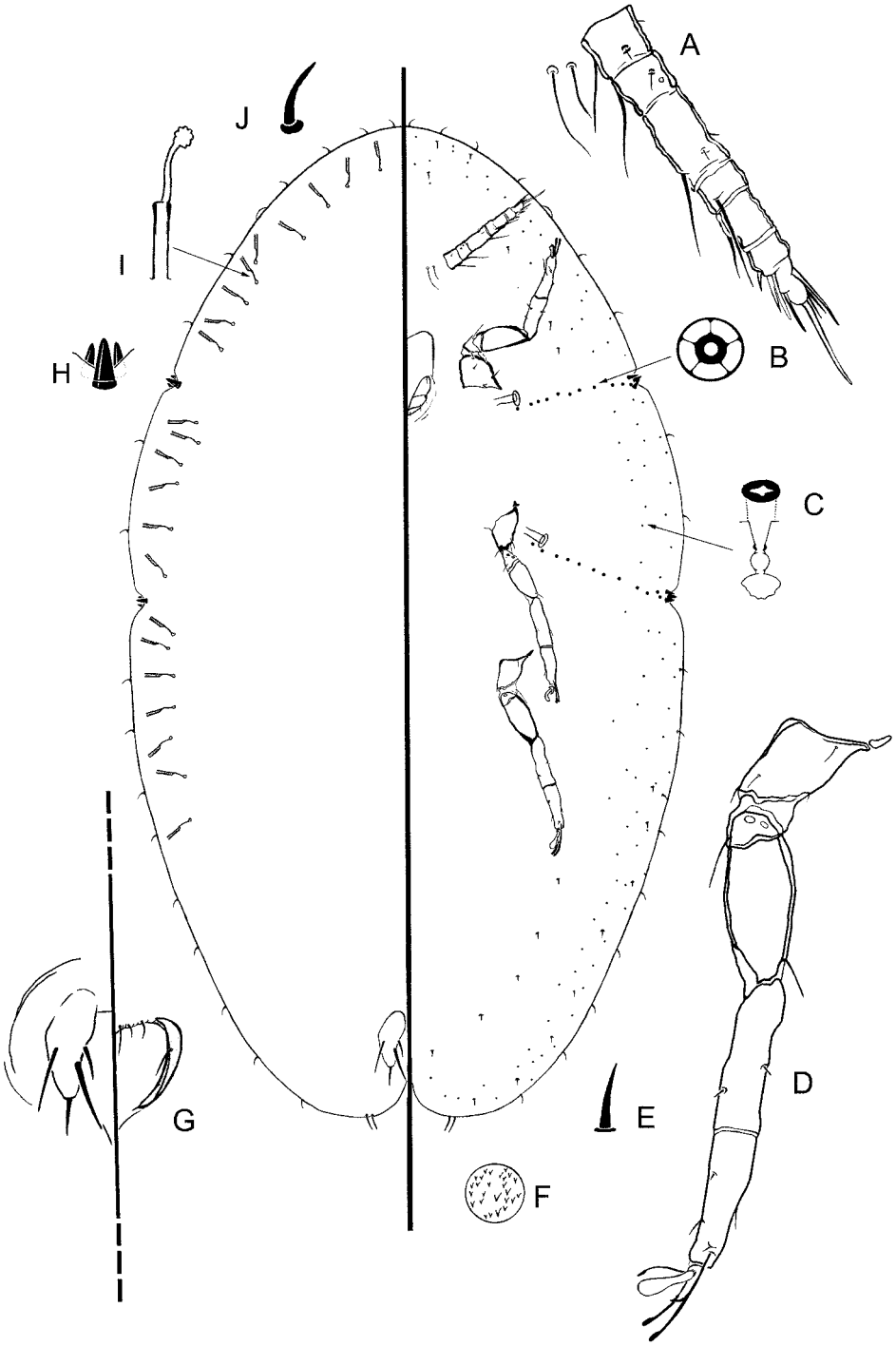

FIGURE 2. *Ceroplastes japonicus* Green, 2nd-instar male nymph. Where A = antenna and interantennal setae; B = spiracular quinquelocular disc-pore; C = ventral microduct with cruciform pore; D = metathoracic leg; E = abdominal ventral seta; F = ventral dermal spinules; G = dorsal view of anal plates (left) and view of ano-genital fold (right) ; H = view of stigmatic cleft; I = dorsal tubular duct; J = marginal seta.

Dorsum: derm membranous. Preopercular pores absent, other dorsal pores not seen. Tubular ducts each duct with cup-shaped invagination, 3–5 μm wide; outer ductule 16–25 (21 μm) long; inner ductule 14–19 (17 μm) long, terminal gland, 3–6 (5 μm) wide; ducts distributed in a single row along body margin, but absent from posterior 1/5 of margin; 6–11 (9) anteriorly between eyespots, 2–6 (4) between eyespot and anterior spiracular furrow, 4–8 (6) anteriorly between anterior and posterior spiracular furrows, and 5–7 posterior each

posterior spiracular area. Anal plates each subtriangular, broad, with inner margins slightly diverging; dimensions of each plate 26–39 (31) μm broad; anterior margin 35–46 (41) μm long; posterior margin 42–55 (47) μm, inner margin 49–64 (58) μm long; each plate with 1 posterior margin seta, 25–32 (28) μm long, 2 inner margin setae, anterior 9–13 (10) μm long and posterior 20–25 (22 μm) long respectively, and with one apical seta 9–12 (10) μm long. All anal plate setae slightly spinose. Anogenital fold with 3 pairs of anterior margin setae and 1 pair of lateral margin setae. Anal ring with 6 setae.

Margin: marginal setae in a single line, each curved and setose, and 9–10 μm long; with 5–6 anteriorly between eyespots, and, on each side, 2 between eyespot and anterior spiracular area, 2 between anterior and posterior spiracular area, and 6 between posterior spiracular area and anal cleft; with two longer setae on at apex of each anal lobe, 22–30 (26) μm and 16–22 (19) μm long respectively. Stigmatic clefts shallow, each with 3 short, conical stigmatic spines, median spine longest and slightly set onto dorsum, 13–19 (18 μm) long and 4–7 (6 μm) wide at base; lateral setae 9–12 (10 μm) long and 4–6 μm wide at base.

Venter: derm membranous, segmentation obscure; minute dermal spinules most frequent around anal cleft. Ventral microducts, each less than 1 μm wide, sparsely distributed in a submarginal band. Ventral setae bristle-like, each 1–2 μm long, present in submarginal and submedial rows on abdominal segments. Two pairs of interantennal setae present, shorter pair 9–19 (15 μm) long and longer pair 26–39 (33 μm) long respectively. Antennae 6-segmented, each 107–126 (117) μm long, third segment longest. Spiracles: all peritremes 10–13 (11) μm wide; spiracular disc-pores quinquelocular, each about 3 μm wide, with 8–12 (10) forming a narrow band about 1 pore wide from each spiracle to body margin. Legs well developed, without tibio-tarsal scleroses; claws without denticles; claw digitules unequal, one broad apically and 12–17 (15) μm long, other slender, with a knobbed apex and 12–17 (15) μm long. Coxae: 43–48 (46) μm long, 28–39 (34) μm wide; with 4 *ss*, longest 25–38 (29) μm long. Trochanter + femur: 71–78 (75) μm long, 23–29 (25) μm wide; trochanter with 1–3 (2) *ss*, longest 29–42 (36) μm long; femur with 1 or 2 short *ss*. Tibia 46–51 (49) μm long, 12–14 (13 μm) wide; with 1 or 2 *ss*. Tarsus 39–42 (41) μm long, 10–13 (12) μm wide; with 2 or 3 *ss*, longest 9–16 (12) μm long; tarsal digitules each 25–41 (29) μm long.

Comments: the only described 2nd-instar male nymph of a *Ceroplastes* species is that of *C. sinensis* (Qin & Gullan, 1994). The 2nd-instar male nymphs of *C. japonicus* and *C. sinensis* are very similar, the main difference appearing to be the number of spiracular disc-pores, with an average of 10/band in *C. japonicus* and 6/band in *C. sinensis.*

PREPUPA (Fig. 3)

Described from 9 specimens in good condition.

Mounted material: body elongate, narrowest at head, widest across abdomen, length 775–1132 (855 μm), width across abdomen 402–566 (469 μm). Division into head, thorax and abdomen not clear. Segmentation fairly distinct on abdomen.

Head: lacking mouthparts and simple eyes. Antennae fairly well sclerotised, elongate, each 174–211 (188 μm) long, with 9 poorly defined segments; antennal length to body length ratio 1:4.45–5.36 (4.55); antennal setae: IX: with 4 minute fleshy setae (*fs*); VIII and VII each with 1 minute *fs*. With 2 pairs of minute interantennal setae ventrally plus 2 minute setose dorsal head setae, each 3–4 μm long.

Thorax: prothoracic legs directed anteriorly, only reaching to base of each antenna; other pairs directed posteriorly; claws and digitules extremely reduced; metathoracic legs each 120–196 (160 μm) long. Wing buds each 155–207 (183) μm long, 70–104 (92) μm wide, ratio of length to width 1: 0.45–0.50. Spiracles: width of peritremes 15–20 (17) μm, each with 6–12 (8) spiracular disc-pores near atrium; pores mainly quinquelocular and about 4 μm wide, but some with many more loculi. Setae: with 2 minute thoracic setae postero-laterally to each procoxa + 1 minute fleshy ventropleural seta on mesothorax.

Abdomen: segmentation fairly well defined; minute dermal spinules most dense on posterior segments; dermal spinules with a different pattern on dorsum with respect to venter. Setae: pairs of minute dorsal

abdominal setae (*ads*) present medially on segments IV–VII, each about 4 μm long; with a pair of ventral abdominal setae (*avs*), each 6 μm long, on segments II–VII. Margins with minute ventropleural setae (*vpls*), each 4–12 (7 μm) long, segmentally arranged, with a single seta on each side of segments I–IV and 2 or 3 fleshy setae on segments V–VIII. Caudal extension VII (ce_{VII}) sclerotised, 58–112 (94) μm long, 41–83 (59 μm) wide, with 2 apical hair-like setae, 16–23 (20) μm long and 9–19 (15) μm long respectively, 1 short seta 4–7 (6) μm long + 1 dorsopleural seta at base of $ce_{VII,}$ 6–9 (7) μm long. Caudal extension VIII (ce_{VIII}) poorly developed and slightly sclerotised, with 3 minute setae. Penial sheath sclerotised, roundly triangular in shape, 55–78 (69) μm long and 55–78 (69) μm wide, ratio of length to width 1:1, with 2 ante-anal setae on segment VIII, and 2 pairs of minute setae dorsally on penial sheath.

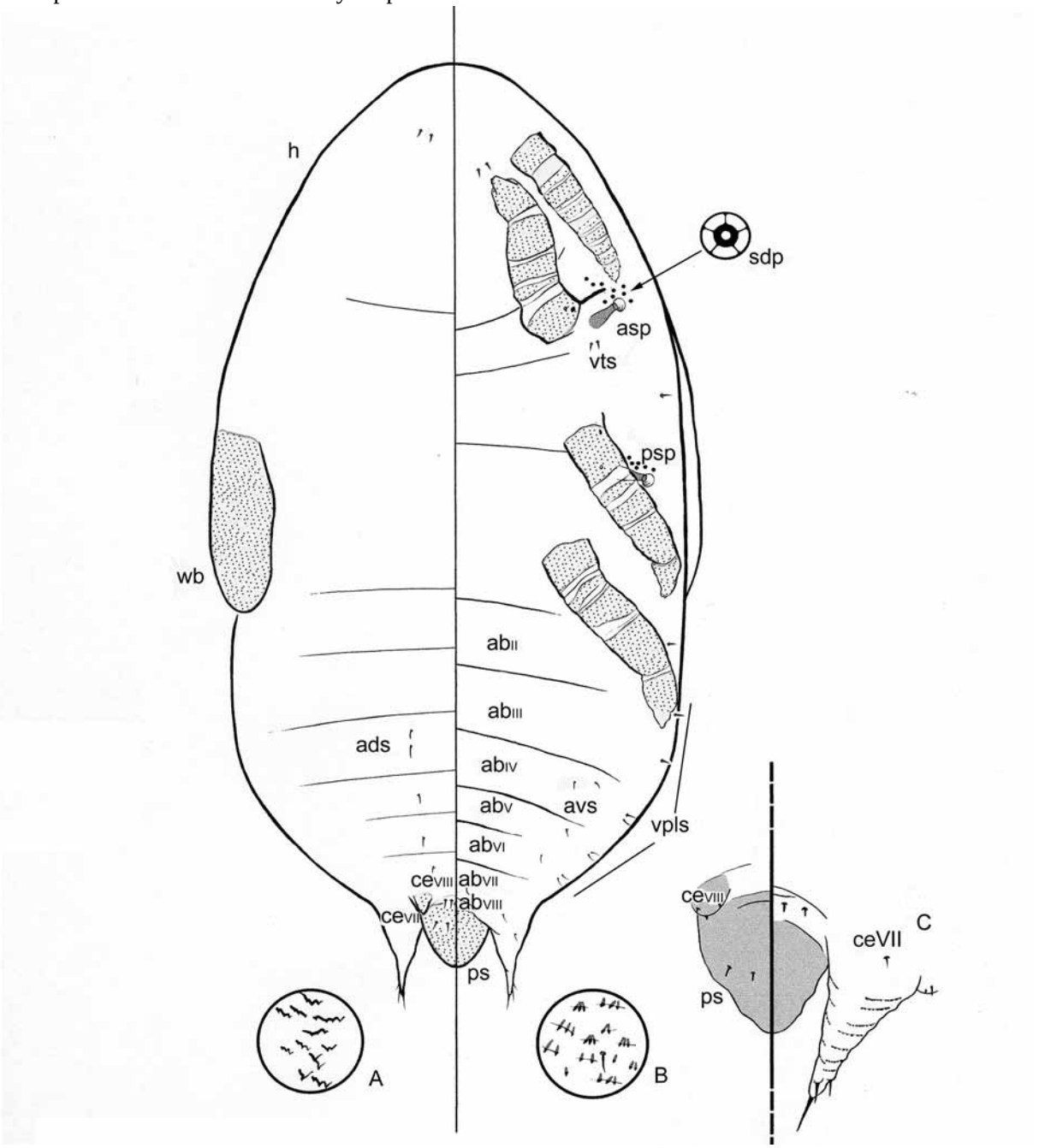

FIGURE 3. *Ceroplastes japonicus* Green, prepupa. Where: A = dorsal dermal spinules; B = ventral dermal spinules, and C = dorsal (left) and ventral (right) views of posterior end of abdomen. And where: ab II–VIII = abdominal segments II–VIII; ads = dorsal abdominal setae; asp = anterior spiracle; avs = ventral abdominal setae; ce_{VII}= caudal extension of segment VII; ce_{VIII} = caudal extension of segment VIII; h = head; ps = penial sheath; psp = posterior spiracle; sdp = spiracular disc-pore; vpls = ventropleural setae; vts = ventral thoracic setae; wb = wing bud.

PUPA (Fig. 4)

Described from 8 specimens in good condition.

Mounted material: elongate oval, tapered anteriorly, widest across abdomen, length 819–983 (926) μm, maximum width across abdomen 343–417 (376) μm. Derm membranous. Division into head, thorax and abdomen not clear. Segmentation not well defined, most distinct on abdomen.

Head: fairly well sclerotised, sometimes dorsal derm with circular sclerotisation, lacking mouthparts and simple eyes. Antennae slightly sclerotised, elongate; directed postero-laterally, each antenna with 9 fairly well-defined segments, 333–429 (363 μm) long; antennal length to body length ratio 1:2.29–2.46 (2.55); antennal setae distribution: IX: 6; VIII: 1, VII: 1; each about 3 μm long; segments IX and VIII each with 1 *fs* about 3 μm long. With 1 or 2 minute dorsal setae anteriorly on head, each about 3 μm long; ventrally with 2 very short head setae.

Thorax: legs well developed, each with clear segmentation; prothoracic legs directed anteriorly, extending anteriorly to head; other pairs directed posteriorly; metathoracic legs each 389–499 (435) μm long. Wing buds each 377–429 (404) μm long, 118–140 (128) μm wide; ratio of length to width 1:0.31–0.33 (0.32). Spiracles: width of peritremes 14–20 (18) μm, each anterior spiracle with 10–16 (13) spiracular disc pores near atrium, each about 4 μm wide, and each posterior spiracle with 7–10 (9) disc pores; number of loculi highly variable. Setae: ventrally with 1 minute seta near each coxa.

Abdomen: segmentation fairly well defined. Setae: with 2 pairs of minute dorsal abdominal setae (*ads*), each 4 μm long, on segments IV–VII; 1 minute dorsopleural seta (*dpls*) on segments V–VII; 1 or 2 minute ventral abdominal setae (*avs*) on segments III–VII, each about 1.5 μm long, + 1 or 2 ventropleural setae (*vpls*) on each side of segments II–VII, each seta 4–8 (7) μm long; ante-anal setae not detected. Caudal extensions on segment VII (ce_{VII}) well developed, each 52–87 (67) μm) long and 29–39 (34) μm wide at base; each with 2 spinose setae, 19–22 (21) μm and 10–19 (14) μm long respectively, + 1 minute hair-like seta, 4–7 (6) μm long; each ce_{VII} also with 1 *hs* ventrally near base, 4–6 μm long. Caudal extensions on segment VIII (ce_{VIII}) poorly developed, with 3 *hs* and 1 *fs* minute setae. Penial sheath (*ps*) elongate-triangular, sclerotised, 110–123 (116) μm long, 61–68 (142) μm wide at base, ratio of length to width 1 : 0.55; dorsally with 3 pairs of *hs*. Anal opening at base of penial sheath, 19–22 (20 μm) wide.

Conclusions

With the present descriptions and illustrations, all the instars of *C. japonicus* are now described and illustrated. Good descriptions and illustrations of the adult female are provided by De Lotto (1969), Tang (1991) and Pellizzari & Camporese (1994); the 1st-instar nymph, 2nd- and 3rd-instar female nymphs have been described by Camporese & Pellizzari (1994) and further descriptions and illustrations of some female instars and the 1st-instar nymph can be found in Xie *et al*. (2006).

With regard to *Ceroplastes* adult males, detailed descriptions are available for very few species. In addition to *C. japonicus*, the other described adult males are: *C. cirripediformis* Comstock, *C. ceriferus* (Gimpel *et al*., 1974), *C. berliniae* (Hall), and a *Ceroplastes* sp. (probably *C. mimosae* Signoret, according to Giliomee, 1967). The last two species are presently placed in the genus *Waxiella*. Qin & Gullan (1995), at the end of their cladistic analysis of wax scales, concluded that "Cladistically, all wax scale should be included in one genus *Ceroplastes*"; moreover, with regard to male morphology of *C. berliniae* (= *W. berliniae*), *C. ceriferus*, *C. cirripediformis* and *C. sp.* (= *Waxiella* sp.), they stated that "The morphological differences among species are small, although they represent two currently recognized genera (*Ceroplastes* and *Waxiella*)". For the above reasons, the morphological characters of the described *Waxiella* males are here compared with those of *Ceroplastes*. The main differences appear to be:

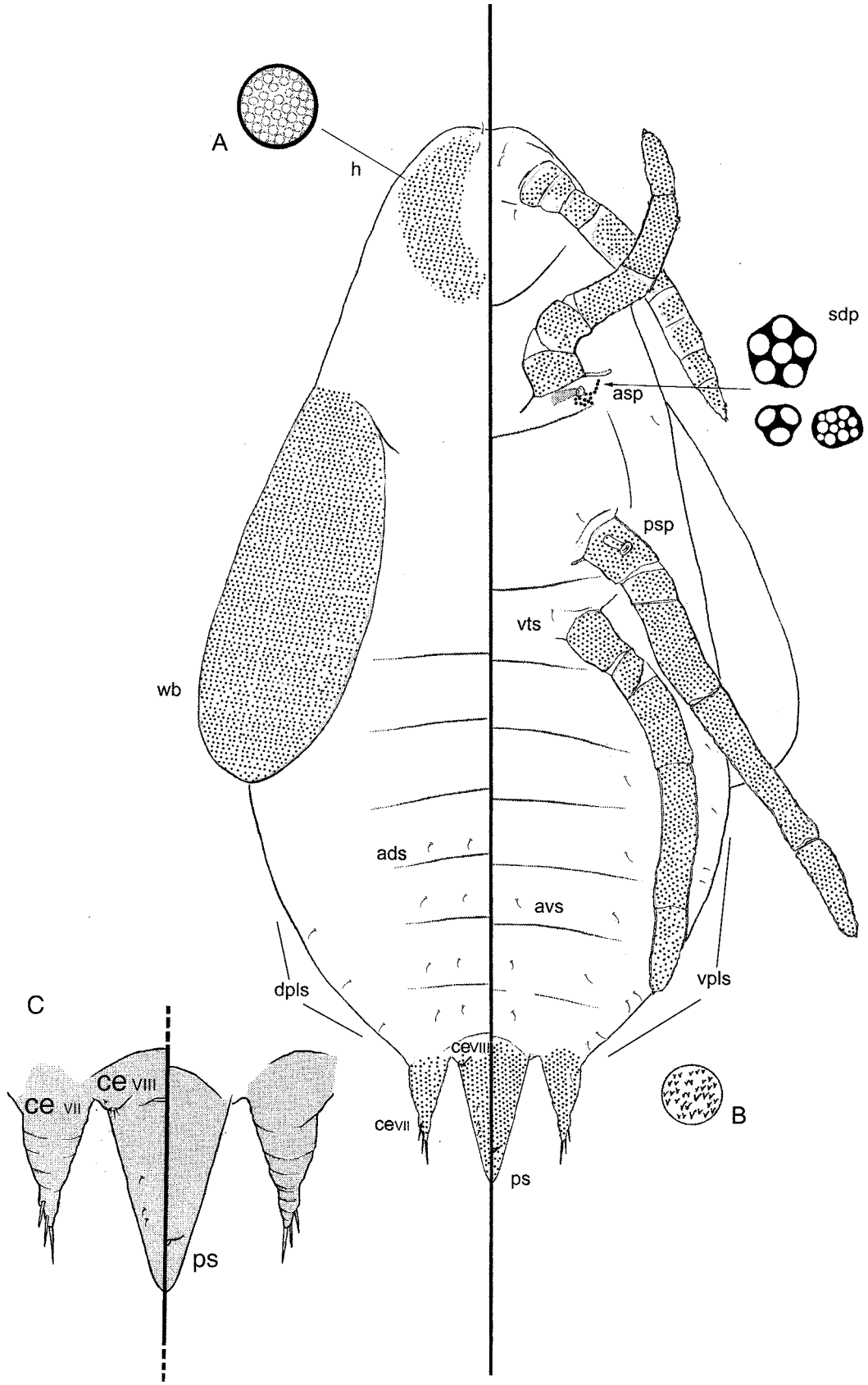

FIGURE 4. *Ceroplastes japonicus* Green, pupa. Labels as fig 3, except A = pattern of dorsal head sclerotisation; dpls = dorsal pleural setae.

1) *distribution of fleshy setae on penial sheath*: the presence of fleshy setae on the basal portion of penial sheath is an unusual character that *C. japonicus* shares with *C. cirripediformis*, a Neotropical species. *C. ceriferus* does not have fleshy setae near the basal portion of penial sheath.

W. berliniae and *Waxiella* sp., both African species, don't have any fleshy setae on penial sheath.

2) *shape of penial sheath apex*: the penial sheath apex is pointed in *C. japonicus*, *C. cirripediformis*, *W. berliniae* and *Waxiella* sp. The penial sheath apex is broadly rounded in *C. ceriferus*, a species considered by Qin *et al*. (1998) to be native to the Neotropical region.

C. japonicus shares with *C. cirripediformis* the distribution of the penial sheath fleshy setae and the shape of the penial apex. In addition, the number of scutal setae is nearly the same. With regard to penial sheath length, the penial sheath is clearly longer on *C. japonicus* (length: 244–310 (267) μm) than on *C. cirripediformis* (length: 186 μm). *C. japonicus* has been considered to be an oriental species (Borchsenius, 1957) and is widely distributed in China, Korea and Japan, whereas in Abkhazia, Georgia and European countries it is clearly an alien species (Borchsenius, 1957; Japoshvili, 2001, *pers. com*.). However, Qin *et al*. (1998) considered it unlikely to be native to Asia. On the basis of this small study, the results suggest that, the male of *C. japonicus* shares more important morphological characters with *C. cirripediformis* (which is believed to be a Neotropical species (Qin *et al*., 1998)) than with other known *Ceroplastes* or *Waxiella* males.

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