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Description of the immature female instars of *Ceroplastes rusci* (Linnaeus) (Hemiptera: Coccidae)

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Abstract

The immature female instars of the fig wax scale, *Ceroplastes rusci* (L.), are redescribed and illustrated here with the aim of improving our knowledge on its morphology and phenology by the correct identification of the pest stages present on the host plant. A key to different instars is also provided. The biology of this species, which has recently increased in abundance in fig cultivation areas in Messinia (Greece), is briefly discussed.

Key words: Soft scales, fig wax scale, identification key, female nymphs morphology

Introduction

Recently, several studies have been devoted to the *Ceroplastes* species (Hemiptera, Coccidae) with the aim of clarifying their native areas, present distribution, morphology (mainly of young stages and males) and describing new species (Pellizzari & Camporese 1994; Camporese & Pellizzari 1994; Qin & Gullan 1994; 1995; Qin *et al*. 1994; 1998; Wakgari & Giliomee 1998; Ben-Dov *et al*. 2000; Rainato & Pellizzari 2008, 2009; Peronti *et al*. 2008). The genus *Ceroplastes* has a worldwide distribution, possibly assisted by human activity, and includes several notorious plant pests. Among the latter is the fig wax scale, *Ceroplastes rusci* (Linnaeus), which is considered to be native to the Afrotropical region (Qin *et al*. 1994; 1998), where it is recorded in several countries, but is widespread in the Palaearctic Region and is also known in the Neotropics and in a very few Oriental countries (Irian Jaya and Vietnam) (Ben-Dov *et al*. 2009).

Ceroplastes rusci (Linnaeus) is widely distributed throughout coastal areas of the Mediterranean, and was the first *Ceroplastes* species recognized in this area, where it has been known since Theophrastus' times (370 B.C.–285 B.C.)[1] (Silvestri & Martelli 1908). *C. rusci* has a wide range of host plants, and is occasionally a pest in Citrus groves and tropical fruit orchards, but appears to be most abundant on such common Mediterranean maquis plants as *Ficus carica, Myrtus communis, Nerium oleander, Pistacia lentiscus* and *P. terebinthus* (Balachowsky & Mesnil 1935). However, the favourite host plant is the fig (thus its common name) on which heavy infestations are quite common (Bodkin 1927; Balachowsky & Mesnil 1935; Khasawinah & Talhouk 1964; Argyriou & Santorini 1980).

This paper was stimulated by the heavy infestations of *C. rusci* on fig cultivations presently occurring in Messinia, District of Kalamata (Greece), where fig is the second most important fruit crop after olive. In Messinia, the fig cultivation areas approach 1800 hectares, with about 80.000 fig trees and the annual fig production reaches roughly 4000 tons/year; dried figs are usually exported to American, Canadian, Australian, European and Arabian markets.

1. According to Silvestri & Martelli (1908) Theophrastus described the symptoms of *C. rusci* infestation on fig in his book "De causis plantarum".

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In Messinia, *C. rusci* infestations are kept under unsatisfactory control by the use of insecticides such as Insect Growth Regulators (IGRs). Successful use of these chemicals needs precise timing as they are most effective against the youngest stages and so a knowledge of the pest phenology and the correct identification of the pest stages present on the host plant is essential. Female *Ceroplastes* go through four development stages. Teneral adult females are macroscopically indistinguishable from 3rd instars and, at present, the identification of the other young instars is also unreliable due to the absence of detailed microscopic descriptions and illustrations of mounted specimens. It is possible, therefore, that the failure of chemical control is due to a lack of understanding of the life stages in the field. Because of this problem, the young instars of *C. japonicus* Green and *C. destructor* were described some years ago (Camporese & Pellizzari 1994; Wakgari & Giliomee 1998). Despite its wide distribution and pest status in many countries, nymphal female *C. rusci* have not yet been described in detail. Previous old descriptions by Silvestri & Martelli (1908) and Khasawinah & Talhouk (1964) are useless. This paper, therefore, redescribes all nymphal female stages and provides an identification key to instars. Descriptions of *C. rusci* adult female are provided by Hodgson (1994) and Pellizzari & Camporese (1994). The description of adult male and nymphal male instars of *C. rusci* is the subject of another paper (Rainato & Pellizzari, 2010).

Notes of the biology of *C. rusci*

According to bibliographic sources, *C. rusci* has 1 or 2 generations/year, depending on climate. In the French Riviera and in some Italian localities, *C. rusci* has only 1 generation/year (Benassy & Franco, 1974) whereas in warmer countries (southern Italy, Greece, Israel, Lebanon, Turkey, Egypt, Algeria) 2 generations/year occur (Balachowsky & Mesnil 1935; Inserra 1970; Argyriou & Santorini 1980; Ozsemerci & Aksit 2003). Overwintering is carried out mostly by the 3rd-instar nymphs and young adult females that have settled on the twigs. In areas where this species is bivoltine, egg laying occurs mainly from mid April to May and maximum egg hatch is in May–early June; the reddish 1st instars settle on the upper surface of the leaves, along the midribs. In June, after the first moult, part of the population migrates from the leaves and settles on the leaf stalks and annual shoots until the adult stage. The new adult females and males appear mainly in July and the second generation 1st instars appear mainly in August (Inserra 1970; Tzanakakis & Katsoyannos 1998; present authors' observations). The above summarized phenology can vary in different regions of the same country and also depends on the annual meteorological conditions, with a difference in crawlers emergence of 2–4 weeks (Inserra 1970; Benassy & Franco 1974; Argyriou & Santorini 1980).

Material and methods

Egg-laying females, previously collected in April 2007 off *Ficus carica*, near Kalamata city (province Aristomenes: 37º04'N–21º49'E), Greece, were placed on *Ficus carica* growing in the Experimental Farm of the Faculty of Agriculture, University of Padua, Italy (45º20'50''N–11º57'35''E), and their offspring reared during the summer to obtain all the instars. Specimens were slide mounted according to the procedures of Ben-Dov and Hodgson (1997). Measurements and frequencies are given as ranges, followed by the mean in parentheses. Terminology follows that of Hodgson (1994).

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.

First-instar nymph

(Fig. 1)

Described from 8 specimens in good condition.

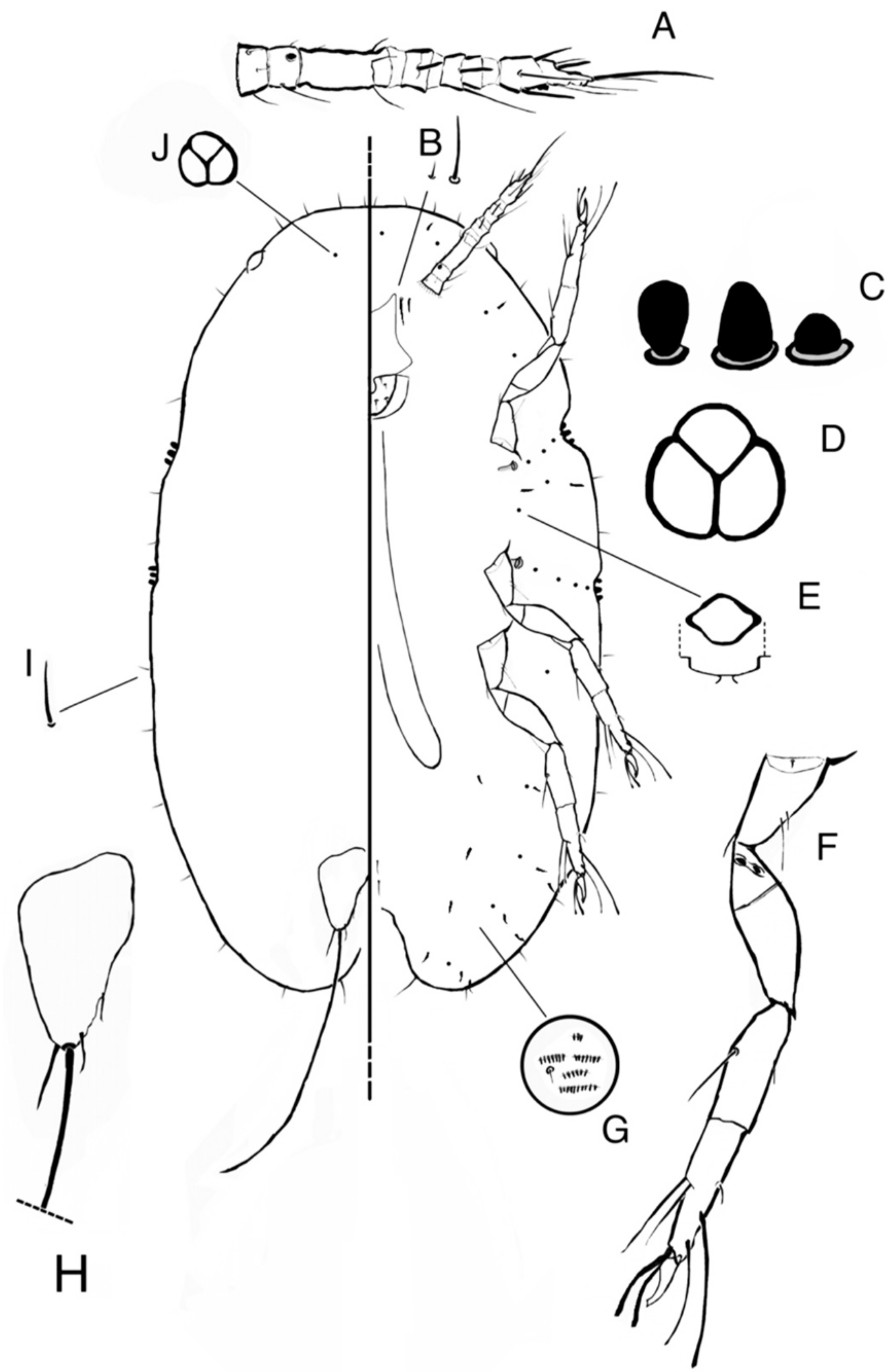

FIGURE 1. *C. rusci* first-instar nymph. Where: A = antenna; B = interantennal setae; C = shape of stigmatic spines; D = spiracular disc-pores; E = ventral microduct with cruciform pore; F = metathoracic leg; G = ventral dermal spinules; H = dorsal view of anal plate; I = marginal seta; J = dorsal trilocular pore.

Unmounted material: body oval, widest across abdomen; derm reddish in colour, with a thin covering of dry white wax over the thorax and over the abdomen and a marginal fringe of short white wax fingers.

Mounted material: body elongate oval; 137–159 (148) µm long; 74–100 (88) µm wide; anal cleft short.

Dorsum: derm membranous. Dorsal simple pores and dorsal setae absent. One pair of trilocular pores, each about 1.5 µm wide, situated near the head apex. Anal plates each sub-triangular, with inner margins diverging, posterior margin slightly convex, with apex rounded; dimensions of each plate: 22–23 µm broad, anterior margin 22–30 (26) µm long, posterior margin 30–32 (31) µm long, interior margin 43–48 (46) µm long. Each plate with 1 apical seta, about 145 µm long, 2 inner margin setae, of which one in subapical position, and 1 posterior margin seta.

Margin: Marginal setae setose, each seta 6–10 (8) µm long; with 8 or 9 setae between eyespots, 2 between eyespot and anterior stigmatic area, 2 between stigmatic areas and 7 or 8 between posterior stigmatic area and anal lobe, plus 1 longer seta, 23–28 (26 µm) long, on each anal lobe. Stigmatic clefts shallow, each with 3 stigmatic spines, conical or often globular or truncate and bullet-like; each spine about 3 µm long, but central spine sometimes slightly larger than others. Eyespots set slightly onto dorsum, width of each lens 12–15 (12) µm.

Venter: derm membranous, with dermal spinules present on posterior abdominal segments. Ventral microducts with cruciform opening, present along submargins in a single line, with 1 pair per segment on abdomen. Preanal loculate pores absent. Ventral setae very short, each 2–4 µm long, distributed in fairly definite medial, sub-medial and sub-marginal lines; also with two pairs of interantennal setae, longest 20–30 (25) µm long and shorter 7–9 (8) µm long. Antennae 6-segmented, each 115–133 (124) µm long, segments III and VI longest; segment lengths in µm: segment I: 10–17 (13) ; II: 13–16 (15); III: 26–33 (30); IV: 9–12 (10); V: 12–15 (13); VI: 32–33 (31); antennal setae: segment I: 3 setose setae, longest 9–17 (12) µm; II: 2 setose setae, longest 16–29 (23) µm; III: 3 setose setae, longest 28–42 (33) µm; IV: 1 fleshy seta, 10–16 (13) µm long; V: 1 setose seta, 20–41 (32) µm long, and 1 fleshy seta 13–16 (15) µm long; VI: 3–5 setose setae and 3–5 fleshy setae, longest fleshy seta 16–19 (18) µm, apical seta 46–58 (52) µm long. Spiracles: peritremes all about 7 µm wide; spiracular disc-pores usually with 3 loculi forming a single pore band from each spiracle to body margin; with 3 pores in each anterior band and 4 pores in each posterior band; each pore 2 µm wide. Legs well developed, without a tibio-tarsal sclerosis. Coxae: 33–41 (93) µm long and 23–29 (26) µm wide; with 5 setose setae; trochanter + femur: 62–68 (65) µm long; trochanter with 1 setose seta; femur with 2 short setose setae; tibia 43–48 (45) µm long, with 2 setose setae; tarsus 36–41 (40) µm long, with 4 or 5 setose setae; tarsal digitules unequal, 38–46 (42) µm and 29–32 (30) µm long respectively. Claw 15–16 µm long; claw digitules slender and knobbed at apex, each 17–22 (20) µm long. Ano-genital fold with 1 pair of setae along anterior margin and 1 lateral margin seta plus 2 pairs of hypopygial setae.

Second-instar female nymph

(Fig. 2)

Described from 10 specimens in good condition.

Unmounted material: body elongate oval, widest across abdomen; derm red-brown in colour, with a fairly dense covering of white wax over the head and thorax and another over the abdomen, marginal fringe pronounced, composed of quite long, rather triangular dry wax fingers, with one anteriorly and seven on each side, those in the middle of each side largest and most triangular.

Mounted material: body elongate oval; 581–924 (725) µm long; 373–551 (457) µm wide; anal cleft short.

Dorsum: derm membranous. Dorsal pores and setae not detected. Anal plates each sub-triangular, with apex rounded and inner margins diverging, posterior margin slightly convex; dimensions of each plate in µm: 32–39 (36) broad, anterior margin 33–41 (36) long, posterior margin 45–52 (48) long, inner margin 55–59 (57) long. Each plate with 1 apical seta 19–26 (22) µm long, 2 inner margin setae, each 15–17 (16) µm long, plus 1 posterior margin seta, 15–16 µm long .

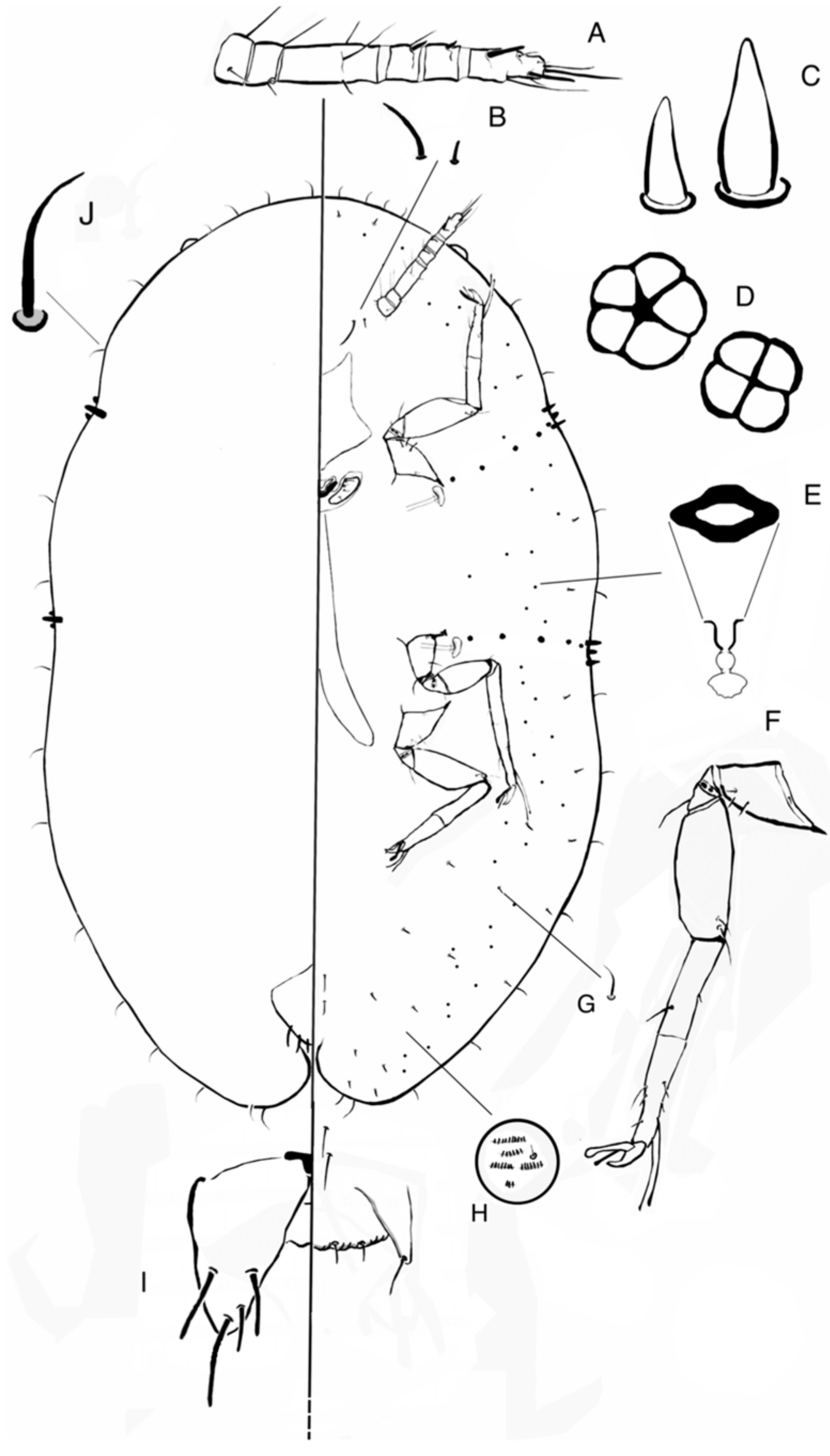

FIGURE 2. *C. rusci* second-instar female nymph. Where: A = antenna; B = interantennal setae; C = stigmatic spines; D = spiracular disc-pore; E = ventral microduct with cruciform pore; F = metathoracic leg; G = ventral seta; H = ventral dermal spinules; I = dorsal view of anal plate (left) and view of the ano-genital fold (right); J = marginal seta.

Margin: Marginal setae setose, each seta 7–9 (8) µm long; with 8 between eyespots, 2 between eyespot and anteri or stigmatic area; 2 between stigmatic areas and 8 or 9 between posterior stigmatic area and anal lobe; plus 2 longer setae on each anal lobe, longest seta 30–32 (31) µm long; shortest seta 15–19 (17) µm long.; stigmatic clefts shallow; each cleft with 3 conical stigmatic spines; central spine larger than laterals, 10–12 (11) µm long and 4–6 (5) µm wide at base. Width of each eyespot lens 15–22 (17) µm.

Venter: derm membranous. Dermal spinules present mainly on posterior abdominal segments. Ventral microducts heavily sclerotised, each with a cruciform pore, distributed in a submarginal band 2 pores broad along body margin. Preanal loculate pores absent. Ventral setae: with 1 pair of moderately long pregenital setae; with two pairs of interantennal setae, longest pair each 28–33 (31) µm long and shortest pair 4 µm long; other ventral setae very short, each 2–4 µm long, distributed in medial, sub-medial and sub-marginal lines on abdomen. Submarginal short setae also distributed on thorax and headfrom abdomen. Antennae 6-segmented, each 133–178 (146) µm long, segment III longest; lengths of segments in µm : I: 15–17 (17); II: 15–22 (17); III: 29–38 (32); IV: 12–13 (12); V: 12–16 (13); VI: 26–29 (28); antennal setae: segment I: 3 setose setae; II: 2 setose setae; III: 3 setose setae; IV: 1 fleshy seta, 13–14 µm long; V: 1 setose seta and 1 fleshy seta 10–19 (13) µm long; VI: 4–5 setose setae, longest 30–55 (45) µm, and 4–6 fleshy setae, longest 17–25 (20) µm. Spiracles: peritremes each 12–13 µm wide; spiracular disc-pores, mainly with 5 loculi, rarely with 4, in a single pore band from each spiracle to body margin, with 4–7 (6) pores in each anterior band and 6 or 7 pores in each posterior band; each pore 3–4 µm wide. Legs well developed, without a tibio-tarsal sclerosis. Coxa: 44–49 (46) µm long and 36–41 (38) µm wide; with 3 or 4 setose setae; trochanter + femur: 78–80 (79) µm long; trochanter with 1 setose seta; femur with 1 short setose seta; tibia 49–55 (52) µm long; with 2 setose setae; tarsus 35–48 (44) µm long, with 4 or 5 setose setae; tarsal digitules similar, each 38–41 (39) µm long. Claw with a small denticle; claw digitules unequal, one broad and 19–20 µm long, other slender and knobbed at apex and 16–19 (18) µm long.

Third-instar female nymph

(Fig. 3)

Described from 8 specimens in good condition.

Unmounted material: body oval, widest across abdomen, lightly convex dorsally; derm brown in colour, with the wax test somewhat similar to that of the late second-instar.

Mounted material: body elongate oval; 789–954 (854) µm long; 536–954 (854) µm wide; anal cleft short.

Dorsum: Derm membranous. Anal process not formed, represented by a clear area. Dorsal clear areas present and distributed as follows: 1 anterior, 1 mediodorsal and 3 pairs laterally. Dorsal setae, short and bluntly spinose, almost parallel-side, each about 4–6 µm long; sparsely distributed throughout dorsum except absent in clear areas; most frequent along margin and on head. Dorsal pores of *Ceroplastes*-type, each with a large central loculus with one or, rarely, two satellite loculi; each central loculus 4–6 µm wide; each pore with a long branched inner filament; pore opening heavily sclerotised; pores abundant throughout dorsum, rare on anal lobes and all absent in clear areas. Preopercular pores absent. Anal plates each sub-triangular, with a rounded apex, inner margins diverging, posterior margin convex; dimensions of each plate in µm: 118–144 (131) broad, anterior margin 144–163 (154) long, posterior margin 170–185 (176) long, inner margin 203–210 (206) long. Each plate with 1 apical seta 23–30 (25) µm long, 2 inner margin setae, that in subapical position 36–46 (41) µm long and other 22–39 (33) µm long respectively; plus 1 posterior margin seta, 22–39 (33) µm long. Anogenital fold with 3 or 4 pairs of setae along anterior margin and 1 lateral margin seta plus 2 hypopygial setae. Anal ring with 3 pairs of setae.

Margin: Marginal setae setose, sometimes slightly bent, each 10–14 (13) µm long; with 6–9 (8) setae between eyespots, 2 or 3 between eyespot and anterior stigmatic area; 2 between stigmatic areas and 8–12 (10) between posterior stigmatic area and anal lobe; plus a group of 3 longer setae on each anal lobe; longest seta 43–55 (50 µm) long, shortest 23–40 (32) µm long. Stigmatic cleft shallow or sometimes absent; with a group of conical or bullet-like stigmatic spines along margin of each stigmatic cleft; with 7–11 (8) spines in each anterior cleft and 5–8 (7) in each posterior cleft; central spine clearly larger than others, 9–13 (12) µm long and about 7–8 µm wide at base. Width of each eyespot lens 23–26 (25) µm.

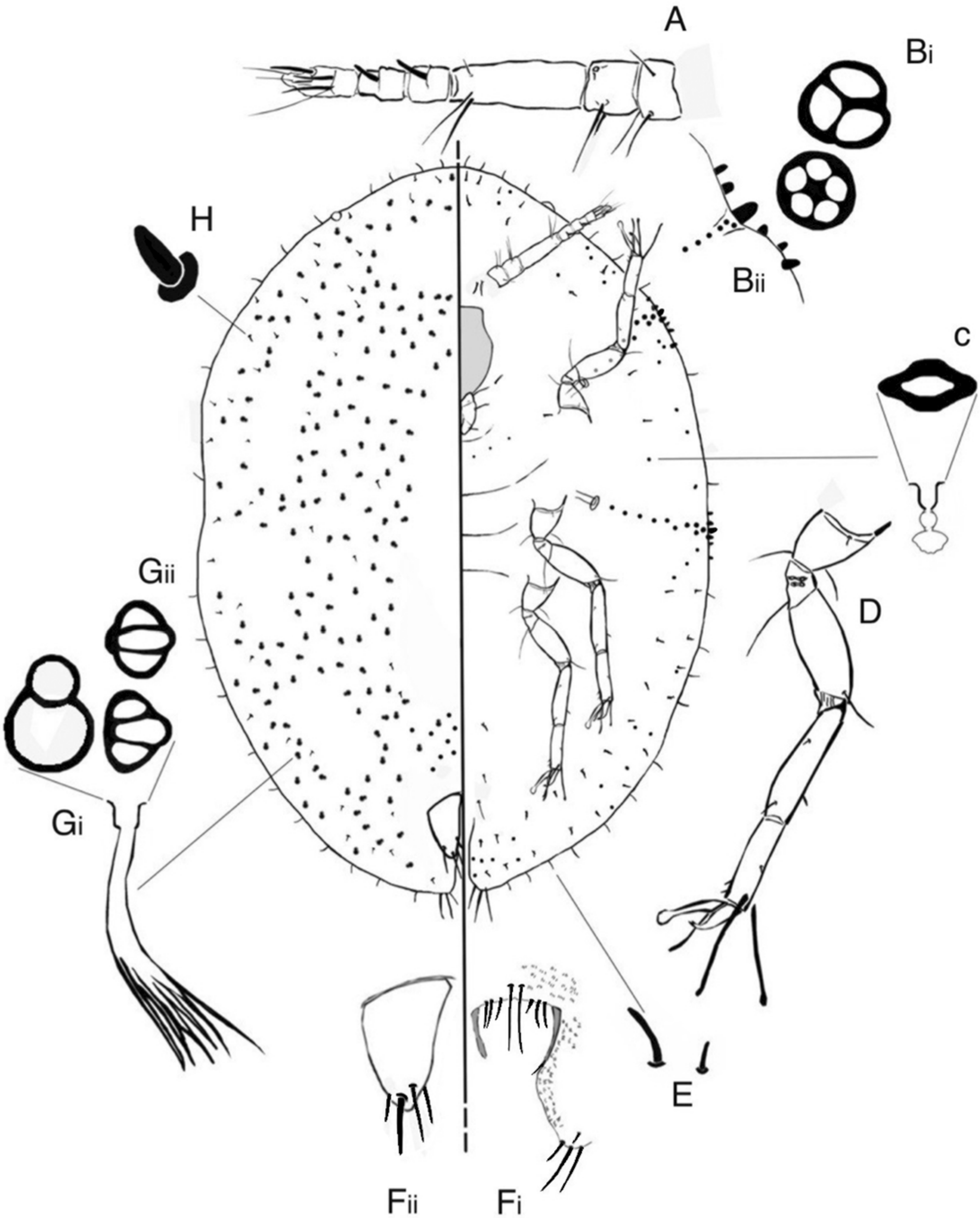

FIGURE 3. *C. rusci* third-instar female nymph. Where: A = antenna; B_i = spiracular disc-pores; B_{ii} = stigmatic cleft with stigmatic spines; C = ventral microduct with cruciform pore; D = metathoracic leg; E = marginal setae; F_i = view of the ano-genital fold; F_{ii} = dorsal view of anal plate; G = *Ceroplastes*-type pores, with one (G_i) or two (G_{ii}) satellite pores; H = dorsal spinose seta.

Venter: derm membranous. Dermal spinules present mainly on posterior abdominal segments. Ventral microducts each heavily sclerotised, with a cruciform opening, sparsely distributed along body in a submarginal band and near labium. Setae: with one pair of moderately long pregenital setae; two pairs of interantennal setae, longest pair each 40–60 (50) µm long and shortest pair 4–12 (8) µm long; other ventral setae minute, each 4–10 µm long, distributed in fairly definite sub-medial and sub-marginal rows and sparsely elsewhere on head, thorax and abdomen. Antennae 6-segmented, each 152–178 (170) µm long; segmental lengths in µm: I: 17–26 (22); II: 25–35 (32); III: 55–70 (59); IV: 14–17 (16); V: 16–17; VI: 29–32 (31); antennal setae: segment I: 3 setose setae; II: 2 setose setae, longest 39–55 (49) µm; III: 3 setose setae; IV: 1 fleshy seta, 16–22 (19) µm long; V: 1 setose setae and 1 fleshy seta; VI: 4–6 setose setae and 3 fleshy setae, apical seta 30–55 (41) µm long. Spiracles: all peritremes 19–20 (20) µm wide; spiracular disc-pores, each mainly with 5 loculi and 2–4 µm wide; in a band from each spiracle to body margin, with 7–9 (8) pores in each anterior band and 10 or 11 pores in each posterior band. Legs well developed, without a tibio-tarsal sclerosis; coxa: 90–99 (93) µm long, with 4 setose setae; trochanter + femur: 96–113 (107) µm long; trochanter with 1 seta; femur with 1 or 2 short setae; tibia 70–78 (74) µm long, with 2 setose setae; tarsus 52–57 (54) µm long, with 4 setose setae; tarsal digitules similar, each 39–48 (42) µm long. Claw with a small denticle; claw digitules both 22–30 (26) µm long but unequal, one broad, other slender and knobbed at apex.

PLATE 1. High infestation by *C. rusci* on fig.

Key to immature instars of *C. rusci*

Usually male 2nd-instar nymphs are intermingled with female 2nd-instar nymphs on the host plant. For this reason, the following key also includes 2nd-instar males.

1 With 3 stigmatic spines in each stigmatic cleft 2
- With more than 3 stigmatic spines in each stigmatic cleft.. 4
2 With 3 or 4 spiracular disc-pores in each spiracular pore band, each with 3 loculi; stigmatic spines subequal in size, usually globular or bullet-like; claw digitules both slender... .first-instar nymph
- With 4–7 spiracular disc-pores in each spiracular pore band, each mainly with 5 loculi; stigmatic spines conical, median stigmatic spine distinctly longer than other two; claw digitules dissimilar, one broad and other slender 3
3 Ventral tubular ducts present in a single row of 28–30 ducts around body margin, except posterior 1/3 of margin. .... 2nd instar male
- Ventral tubular ducts absent .... 2nd instar female
4 With 7–11 spiracular disc-pores in each spiracular pore band; each stigmatic cleft with 7 or 8 stigmatic spines. Pregenital disc-pores absent .... 3rd instar female
- With an average of 60 spiracular disc-pores in each spiracular pore band; each stigmatic cleft with about 20 stigmatic spines. Pregenital disc-pores present.. .adult female

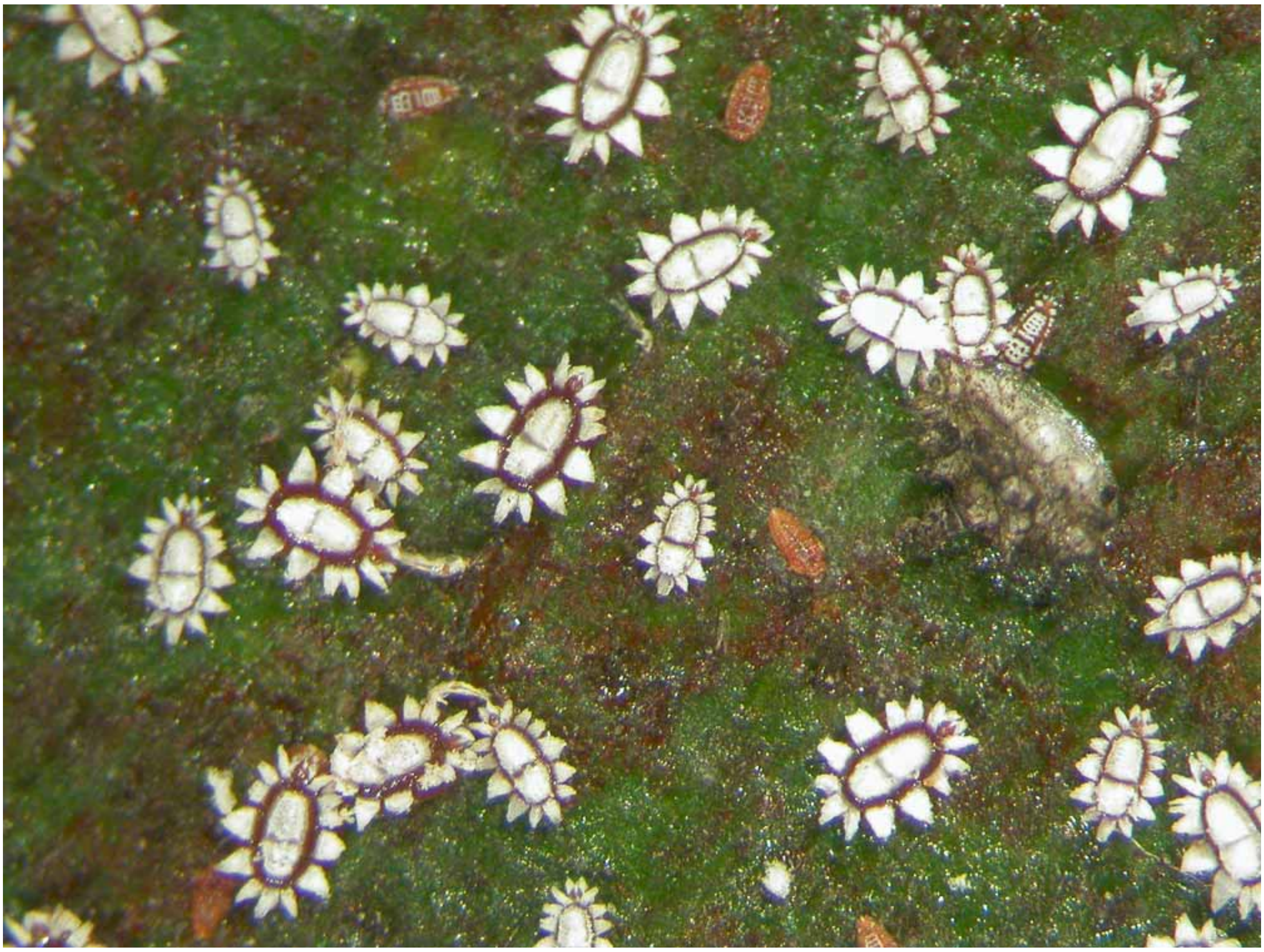

PLATE 2. Young instars on the upper side of fig leaf .

Discussion

The immature instars of female *C. rusci* can easily be separated by observation of slide mounted specimens on the basis of the morphological characters given in the key.

The main differences that distinguish the female instars is the number and arrangement of the stigmatic spines and stigmatic disc-pores, the shape of claw digitules, and the occurrence and distribution of pores and ducts on the body surface. Both first- and second-instar nymphs have 3 stigmatic spines on each stigmatic furrow: this is a general characteristic of these instars of most *Ceroplastes* species, as highlighted by Gimpel *et al.* (1974) but, in 2nd instars, the central spine is conical and clearly larger than the others, whereas in 1st instars they are subequal. Dorsal pores were not detected on *C. rusci* 2nd-instar nymphs. This was reported also for 2nd-instar *C. sinensis* (Qin & Gullan 1994), whereas minute dorsal pores are present on 2nd-instar *C. pseudoceriferus, C. japonicus* and *C. destructor* (Kawai & Tamaki 1967; Camporese & Pellizzari 1994; Wakgari & Giliomee 1998). Third-instar nymphs have more than 3 stigmatic spines, usually 5–11; furthermore they have the *Ceroplastes*-type dorsal pores present sparsely throughout the dorsum, except in the clear areas. Macroscopically, the 3rd-instar nymphs could be confused with teneral adult females which are about the same size just after the last moult; but the latter are easily recognizable on slide mounted specimens due to the presence of pregenital loculate disc-pores around the genital opening; besides the stigmatic spines and stigmatic pores are much more numerous in the adult females than in 3rd instars.

As the phenology of the fig wax scale can vary from year to year, it is important to be able to distinguish the most susceptible stages for a proper timing of chemical control, usually the 1st or 2nd instar nymphs. The structure of the wax test secretions and the presence of cast exuviae can also aid in distinguishing the different instars in the field when they are regularly surveyed (Wakgari & Giliomee 1998) but it should be kept in mind that field observations may lead to misidentifications, whereas instar identification is reliable when based on microscopical morphological characters.

PLATE 3. *C. rusci* egg-laying females.

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