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Description of nymphal instars and adult female of *Kermes vermilio* Planchon (Hemiptera, Coccoidea, Kermesidae), with a synopsis of the European and Mediterranean species

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Summary

The morphology of the 1st-instar, 2nd-instar male and female, 3rd-instar female and adult female of *Kermes vermilio* Planchon (Hemiptera Coccoidea Kermesidae) are described and illustrated; micrographs of some morphological details are also provided. An identification key to instars and a table showing the present status of knowledge on the morphology of European and Mediterranean *Kermes* instars is included.

Key words: gall-like scales, morphology, instar descriptions, identification key

Introduction

The genus *Kermes* Boitard, 1828, includes 63 species, distributed throughout the northern hemisphere and strictly linked to Fagaceae of the genus *Quercus*, although some Asiatic *Kermes* have been collected off other fagaceous genera such as *Castanea*, *Castanopsis*, *Pasania*, *Lithocarpus* and two North American species off *Chrysolepis* (Miller *et al*., 2005; Ben-Dov *et al*., 2012). Twenty *Kermes* species have been recorded so far in Europe and the Mediterranean Region, all off deciduous and evergreen oaks (Table 1).

Kermes vermilio Planchon lives on evergreen oaks, mainly on *Quercus ilex* L., and occurs throughout the Mediterranean countries. In the past, it was of great economic importance as a red dye source until it was replaced by the Mexican cochineal insect, *Dactylopius coccus* Costa, 1829.

In Italy, the species has only been reported rarely as a pest but, since 1987, it has become invasive on ornamental *Q. ilex* trees and heavy infestations have been recorded in urban environments, mainly in Central and Southern Italy (Belcari & Minnocci, 1989; Belcari, 1991; Del Bene & Landi, 1992; Andreatta, 1996; Marotta *et al*., 1999). In the small town of Rapolla (South Italy, Basilicata region), the infestation was so heavy in Spring 1993 that up to 750 individuals/m of branch were recorded. This heavy infestation provided the opportunity to study its biology (Marotta *et al*., 1999) and the morphology of the different instars. During this morphological study, the presence of frontal lobes on 2nd-instar males and females, 3rd-instar females and prepupae, previously known only in the Fam. Eriococcidae (Williams, 1985), was observed for the first time in the family Kermesidae (Marotta & Tranfaglia, 1999).

The morphology of *Kermes* species, based on microscopic characters, is still largely unknown. With regard to Mediterranean and European species, Leonardi (1920) gave a description of the first instars of *K. vermilio*, *K. roboris* (Fourcroy), *K. ilicis* (Linnaeus) and *K. bacciformis* Leonardi. Balachoswky (1950) described and illustrated in detail the first instars of *K. vermilio*, *K. roboris*, *K. quercus* (Linnaeus), *K. ilicis* and *K. bacciformis* and, later (1953), the first instars of three new species, namely *K. echinatus*, *K. palestiniensis* and *K. spatulatus*. Borchsenius (1960) described and illustrated the first instar and the adult male and female of *K. quercus*, and also nymphal instars of other *Kermes* species (see Table 1). Tsalev (1964) described and illustrated the first instar of *K. gibbosus*

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Signoret. Sternlicht (1969, 1972) described adult female and nymphal instars of *K. bytinskii* and *K. williamsi* (Table 1). Koteja (1974) studied the morphology of the labium of *K. quercus*. A notable effort in describing the nymphs and young adult females of Nearctic species was made by Bullington and Kosztarab (1985) and Baer and Kosztarab (1985). More recently, Podsiadlo (2005; 2005a, 2012) described the nymphs of *K. quercus* and some morphological peculiarities in the adult female. Williams (2007) gave an account of the *Kermes* species described by Linnaeus and discussed the possible priority of the binomen *K. ilicis* Linnaeus over *K. vermilio* (Planchon), credited by Linnaeus as the species producing red dye.

With regard to *K. vermilio*, the morphology of the 1st-instar nymph, 3rd-instar female nymph and the pre-reproductive adult female were described and illustrated many years ago (Balachowsky, 1950; Borchsenius, 1960), but the 2nd-instars nymphs (male and female), prepupa, pupa and adult male are still undescribed. This paper presents descriptions or redescriptions of the 1st-instar nymph, 2nd-instar male and female nymphs, 3rd-instar female nymph and adult female of *K. vermilio*, based on specimens mostly taken from a single deme, but compared with specimens collected in other Italian locations.

This paper is in memory of our late colleague Salvatore Marotta. Salvatore prepared a first draft of this paper and made the first drawings of the morphology of *K. vermilio* before his untimely death in December 2001. We have compared Salvatore's descriptions with his slide material and have rewritten the text based on his text but including recent observations. In addition, the figures have been redrawn and the key to instars, plates, synopsis of *Kermes* species in the Mediterranean and the comments have been added by Pellizzari, Porcelli and Convertini.

Material and methods

The specimens were collected off *Quercus ilex* in North, Central and South Italy. Those collected in South Italy (Rapolla (PZ), Basilicata region, April 1993 - May 1995, leg. S. Marotta) were mounted according to the procedure described by Bullington and Kosztarab (1985). The specimens collected in North and Central Italy (Toblino, Trento, 15.v.1990, slides n. 290; Verona, 16.v.1994, slides n. 549/1-4; Pescara, 21.viii.2008, slides n.1517/1-7, leg. G. Pellizzari) were mounted according to the procedure described by Kosztarab and Kozár (1988). Some adult females were split into dorsum and venter to provide a clear view on the morphological structures.

Observations were made in bright field and Phase contrast by Axiophot, Photomicroscope III and Standard WL Zeiss microscopes. Details of some uncoated, cold tetrahydrofuran de-waxed, adult post-reproductive females were studied and pictured by Hitachi TM3000 SEM in charge-reduction mode. Measurements were taken on 50 1st-instars specimens and on 20 specimens of each other instar. Morphological details were checked on additional specimens. Measurements are in millimetres or microns and include the average followed by the range in parenthesis. Terminology follows that of Bullington and Kosztarab (1985) and Baer and Kosztarab (1985), except that hair-like setae are referred to as trichoid setae and fleshy setae as chaetic setae (following Snodgrass, 1935). Specific terminology for *K. vermilio* includes the basal protrusion, or frontal swelling, and the frontal lobes, previously defined and described by Williams (1985) and Marotta and Tranfaglia (1999).

Specimens depository: all specimens are deposited in the Scientific Museums of the University of Padova (Italy), at the Department of Agronomy, Food, Natural resources, Animals and Environment - DAFNAE, viale dell'Università 16, 35020 Legnaro, Italy.

Kermes vermilio Planchon, 1864

FIRST INSTAR NYMPH (Fig. 1). **Living specimen**: oval and flat, orange-red (Plate 1: c), with yellow legs. Settled specimens at first covered by mealy-white wax secretion, and then by thin wax threads. In overwintering specimens, the secretion consists of wax tufts regularly arranged on dorsum.

Mounted specimen: derm membranous, body oval, 611 (375–795) µm long, 358 (198–710) µm wide.

Dorsum. Marginal setae conical, spinose and stout, each 9 (8–13) µm long, 5 (4–7) µm wide at base, with 33 (29–36) on each margin. Submedial setae shorter and thinner than marginal setae, with one pair present on head, on each thoracic segment and on abdominal segments I and II. Simple pores not found. Bilocular pores distributed in a single transverse row of 6 pores on second abdominal segment. Anal lobes small, lightly sclerotized, each with two conical setae on inner margin, each about 8–10 µm long.

TABLE 1. Status of knowledge of European and Mediterranean *Kermes* morphology. Where X = description of adult post-reproductive female only, based on macroscopic characters; fifth column shows which instars have been described for each species (description based on microscopic characters). Data on distribution are from Ben-Dov *et al*. (2012).

Species	distribution	host plants	post-reproductive female description	descriptions based on microscopical characters
Kermes bacciformis Leonardi	Austria, France, Hungary, Italy, Morocco, Poland, Sicily, Spain	*Q. cerris, Q. ilex, Q. pubescens, Q. suber, Quercus sp.*	x	1st instar (Leonardi, 1920; Balachowsky, 1950)
Kermes bekiri Bodenheimer	Turkey	*Q. aegilops*	x	
Kermes biblicus (Bodenheimer)	Israel, Lebanon	*Q. coccifera*, *Q. ilex*, *Q. suber*	x	
Kermes bytinskii Sternlicht	Israel	*Q. ithaburensis*	x	1st instar, 2nd instar male and female, ♀, ♂ (Sternlicht, 1969)
Kermes cordiformis Lindinger	Austria, Italy	*Q. pubescens*, *Q. robur*	x	
Kermes corticalis Nasonov	Italy, Georgia, Ukraine	*Quercus* sp.	x	♀ (Borchsenius, 1960)
Kermes echinatus Balachowsky	Israel	*Q. coccifera*	x	1st instar (Balachowsky, 1953)
Kermes gibbosus Signoret	Austria, Bulgaria, Germany, Hungary, Italy, Sicily	*Q. cerris*	x	1st instar (Tsalev, 1964)
Kermes greeni Bodenheimer	Israel	*Q. coccifera*	x	
Kermes ilicis (Linnaeus)	Algeria, Austria, France, Greece, Hungary, Italy, Moldova, Poland, Portugal, Spain	*Q. coccifera*, *Q. ilex*, *Q. pubescens*, *Q. suber*, *Q. toza*	x	1st instar (Balachowsky, 1950; Borchsenius, 1960; Williams, 2007)
Kermes muhlisi Bodenheimer	Turkey	*Quercus* sp.	x	
Kermes nahalali Bodenheimer	Israel	*Q. coccifera*	x	
Kermes palestiniensis Balachowsky	Israel	*Q. coccifera*	x	1st instar (Balachowsky, 1953)
Kermes quercus (Linnaeus)	Widely distributed in Europe	*Q. pendunculata*, *Q. pubescens*, *Q. robur*, *Q. sessiliflora*, *Quercus* sp.	x	1st instar, 2nd instar male and female, ♀, ♂ (Balachowsky,1950; Borchsenius, 1960; Koteja & Zak-Ogaza, 1972; Podsiadlo, 2005; 2005a; 2012; Williams, 2007)
Kermes roboris (Fourcroy)	Widely distributed in Europe	*Q. ilex*, *Q. pendunculata*, *Q. polycarpa*, *Q. pubescens*, *Q. robur*, *Q. sessiliflora*	x	1st instar, ♀ (Balachowsky, 1950; Borchsenius, 1960; Tsalev, 1964)
Kermes sadrii Bodenheimer	Turkey	*Q. aegilops*	x	
Kermes safinazae Ozkok	Turkey	*Q. cerris* ,*Quercus* sp.	x	
Kermes spatulatus Balachowsky	Israel	*Q. ithaburensis*	x	1st instar (Balachowsky, 1953)
Kermes vermilio Planchon	Algeria, Corsica, Crete, France, Greece, Italy, Morocco, Portugal, Sardinia, Sicily, Spain, Turkey	*Q. ballotae* , *Q. coccifera* ,*Q. ilex*, *Q. suber*, *Quercus* sp.	x	1st instar, 2nd instar male and female, 3rd instar female, ♀ (Balachowsky, 1950; Borchsenius, 1960; present paper)
Kermes williamsi Sternlicht	England	*Quercus* sp		♀, 1st instar, 2nd instar male (Sternlicht, 1969)

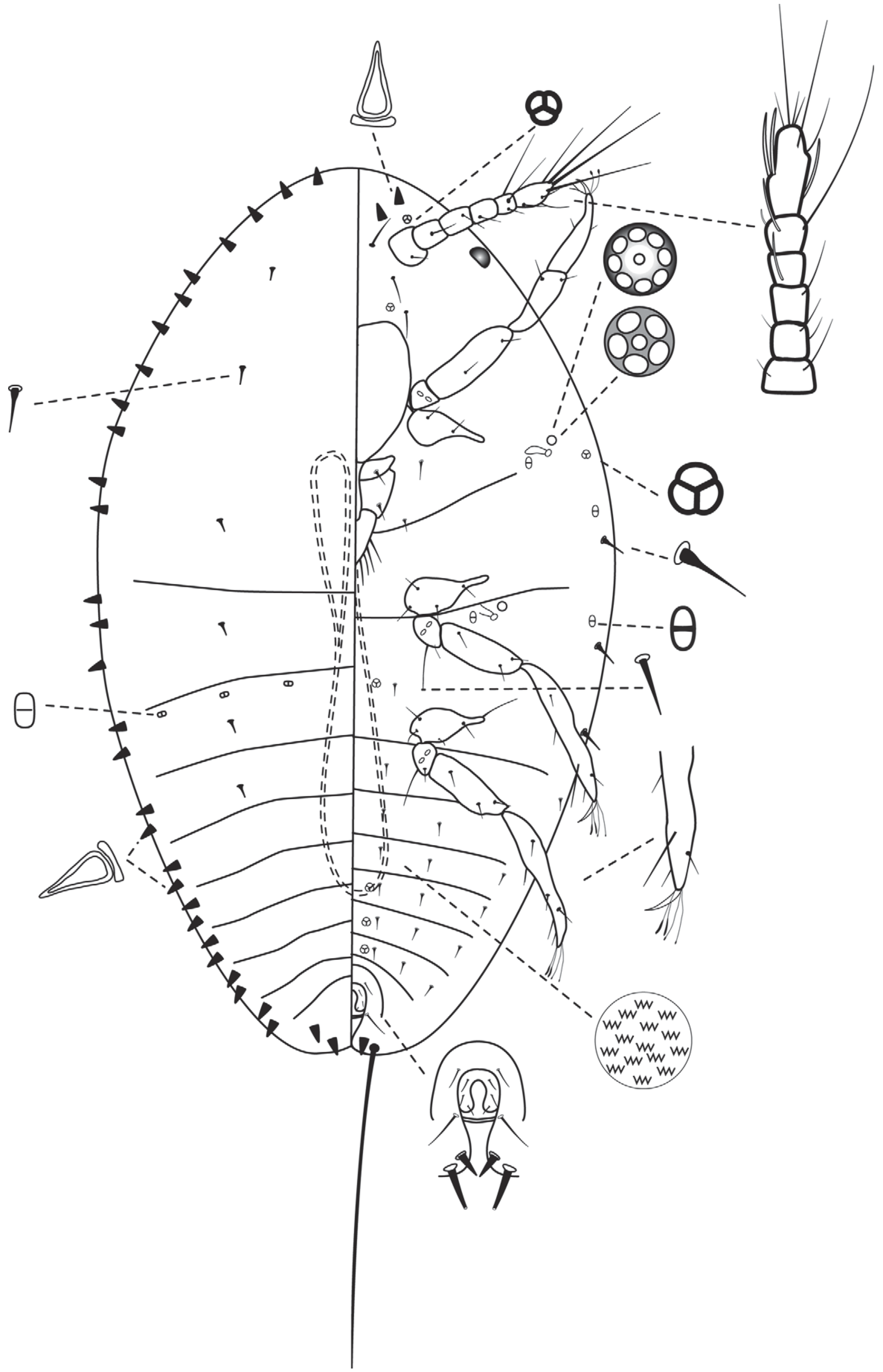

FIGURE 1. *Kermes vermilio* Planchon, 1st-instar nymph.

Venter. Dermal spinules present medially on abdomen and thorax. Antennae 6-segmented, each 127 (105–213) µm long; scape with 1 trichoid seta; pedicel with 4 trichoid setae; 3rd segment with 1 trichoid seta; 4th segment with a chaetic seta; 5th with 2 trichoid and 1 chaetic setae; apical segment with 5 trichoid and 3 chaetic setae. Clypeolabral shield 94 (83–133) µm long. Labium triangular in shape, 3-segmented, 88 (70–95) µm long, basal and second segments each with one pair of setae, third segment with 4 pairs. Stylet loop longer than body. Basal protrusion and frontal lobe not found. Legs well developed, with two dome-shaped sensilla on each trochanter. Thoracic spiracles small and narrow, each about 19 (15–23) µm long and 6 (3–10) µm wide, usually with one, rarely two, disc-pores, each about 3.5 µm wide with 5–7 loculi. Pores: with a trilocular or 4-locular pore present near base of each scape; a bilocular pore, about 2 µm wide, present near base of each spiracle, and one on each margin of meso- and meta-thorax; also pairs of slightly larger trilocular pores, each about 3 µm wide, present medially on head, on margin of prothorax, medially on metathorax and on abdominal segments V–VII. Trichoid setae in 6 longitudinal rows on abdominal segments: medial row setae each 12 (10–17) µm long; submedial row 7 (6–9) µm long; submarginal row 4 (3–5) µm long; a few other short setae present on thorax and head. Anal lobes small and lightly sclerotized, each with one conical seta and one apical flagellate seta, latter 249 (200–288) µm long. Anal ring oval, 19 (15–25) µm long, 20 (18–24 µm) wide, with 6 setae, each 10 (8–15) long; with one pair of fine setae on anterior margin, each 13 (8–18) µm long, and another pair on posterior margin, each 27 (20–38) µm long.

Comments. Among the Mediterranean and European *Kermes* species, the 1st instar of *K. vermilio* is easily distinguishable by the presence of conical, spine-like marginal setae. The 1st instar of *K. echinatus* also has spine-like marginal setae, but the latter are longer and slightly bent.

SECOND-INSTAR FEMALE (Fig. 2). **Living specimen**: oval, red, with white wax tufts regularly arranged on dorsum and thin wax threads on margin.

Mounted specimen: body oval, 1 (0.8–1.4) mm long, 0.7 (0.4–1) mm wide.

Dorsum. Marginal setae conical, spinose and stout, each 14 (11–15) µm long, 6 (5–7) µm wide at base; with 36 (34-37) on each margin. A few small conical setae, each about 8–10 long, similar to marginal setae, sometimes bent, present mainly along body submargins of meso- and metathorax and first abdominal segments but also in a transverse single row on metathorax. Anal lobes fused.

Venter. Dermal crenules present medially on abdomen and thorax. Antennae usually 5-segmented, each 72 (63–83) µm long; scape usually with 2 very short setae, 4th segment with one chaetic seta; 5th segment with 4 trichoid and 3 chaetic setae. Clypeolabral shield 136 (113–163) µm long. Labium triangular, 126 (103–142) µm long, 3-segmented, basal and second segments each with one pair of setae, third segment with 4 pairs. Frontal lobes present, "sausage-shaped", sometimes about as long as antennae; basal protrusion, or frontal swelling, not fully developed. Legs short, tubercle-like, two-segmented, usually with some short setae and a small, misshapen claw. Spiracles well developed, sclerotized; each anterior spiracle 38 (32–45) µm long and 13 (11–13) µm wide, usually with 3 (rarely 2 or 4) five-locular pores, each 4 µm wide; each posterior spiracle 40 (35–45) long and 13 (10–15) µm wide, with 1 or 2 five-locular pores. Bilocular pores, each about 2 µm wide, distributed in a submarginal row on abdomen, with 1–3 near each spiracle, 1 or 2 on head and on each thoracic segment. Occasional specimens with up to three 5-locular pores, each about 4 µm wide, on submargin of last abdominal segments. Tubular ducts, each 10 µm long and 4 wide with a thin inner filament, distributed in 2 submarginal, 2 submedial and 2 medial longitudinal rows on abdomen, and sparse throughout thorax and head. Body setae distributed in 6 longitudinal rows on abdomen: with a pair of flagellate setae, each 22 (15–25) µm long present medially on each abdominal and thoracic segment; a pair of submedial setae, smaller than medial, on each abdominal segment, and a short seta, 5 µm long, on submargin of each abdominal segment; some flagellate setae also present medially on thorax and head. Anal lobes small, each with one conical seta and one quite long apical seta, 52 (38–63) µm long. Anal ring oval, 35 (25–40) µm long, 30 (23–38) µm wide, with 6 setae, each 28 (15–38) µm long; also with a pair of setose setae, each 18 (13–25) µm long, in front of anterior margin of anal ring.

Comments. Descriptions of 2nd-instar *Kermes* females are very few, probably because this stage is present on the host plant for a very short time. Among the Palaearctic species, the only other described 2nd-instar females are of *K. bytinskii* (Sternlicht, 1969) and *K. quercus* (Podsiadlo, 2012). *K. bytinskii* differs from *K. vermilio* as follows (characters of *K. vermilio* in brackets): marginal setae hair-like (spine-like); presence of well developed legs (legs tubercle-like); tubular ducts present on dorsum and venter (on venter only); trilocular and 5-locular pores present on dorsum (on venter only). *K. quercus* differs from *K. vermilio* mainly by the presence of tubular ducts on dorsum and of numerous 5-locular pores on venter.

Some Nearctic 2nd-instar females have been described and all have well-developed legs and 5-locular pores restricted to the venter only. In addition, *K. cockerelli* Ehrhorn has few dorsal setae and rare dorsal simple pores which, according to Baer & Kosztarab (1985), are easily missed; *K. rimarum* Ferris has only 2 dorsal longitudinal rows of small submedial setae and no dorsal pores; and *K. concinnulus* Cockerell has 2 dorsal longitudinal rows of small submedial setae and scattered simple pores on dorsum, each 2 µm wide (Baer & Kosztarab, 1985).

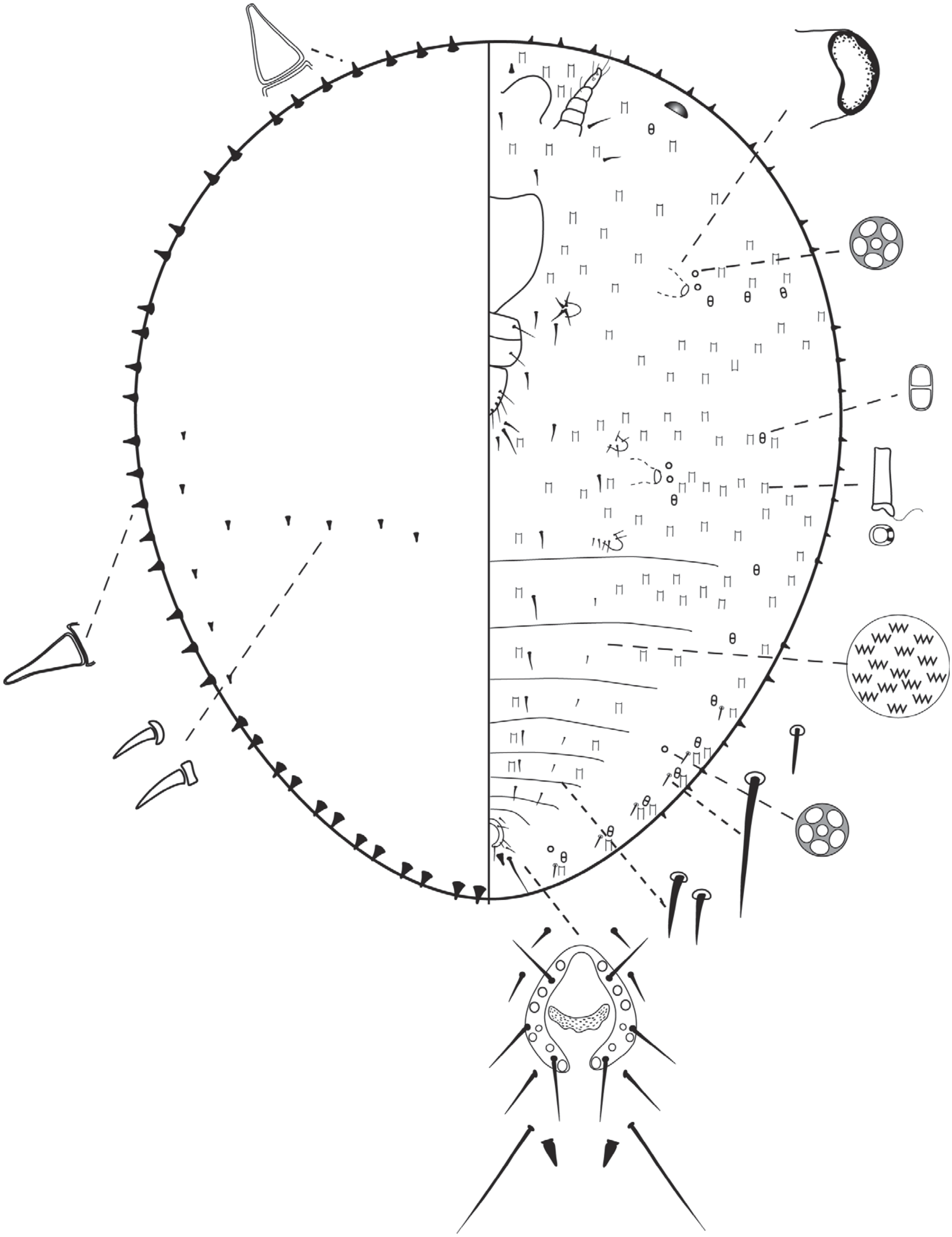

FIGURE 2. *Kermes vermilio* Planchon, 2nd-instar female nymph.

SECOND-INSTAR MALE (Fig. 3). **Living specimen**: similar to first-instar nymphs, but more elliptical; dorsum with white wax tufts regularly arranged and without thin wax threads.

Mounted specimen: body oval, 1.3 (0.9–1.6) mm long, 0.7 (0.5–0.9) mm wide.

Dorsum. Marginal setae conical, short and stout, mostly 14 (11–17) µm long, 6 (4–7) µm wide at base, but with some smaller and thinner setae interspersed; with 35 (33–37) on each margin. Submedial conical setae, shorter and thinner than marginal setae, in 6–8 pairs, distributed in submedial rows from head to metathorax, each 7 (5–10) µm long, 3 µm wide; also with 2–4 pairs forming a short longitudinal row medially on frons. Simple pores absent. Bilocular pores few, each 2 µm wide, sparse on head, thorax and across first abdominal segments. Tubular ducts, each 10 µm long and 4 wide with a thin inner filament, present in irregular transverse bands across abdominal segments and thorax; sparse on head. Anal lobes small, lightly sclerotized and partially fused.

Venter. Dermal crenules present medially on venter of thorax and head. Antennae 7-segmented, each 192 (120–255) µm long. Scape with 2 trichoid setae; pedicel with 2 trichoid setae; 4th segment with 1 trichoid seta; 5th segment with 1 chaetic seta; last segment with 5 trichoid and 3 chaetic setae. Single preantennal pore present just anterior to each scape. Clypeolabral shield 125 (90–160) µm long. Labium triangular, 117 (105–135) µm long, 3-segmented, basal and second segments each with one pair of setae, third segment with 4 pairs. Frontal lobes present, shorter than antennae. Legs well developed, each trochanter with 2 dome-shaped sensilla; claw with a small denticle. Spiracles: each anterior spiracle 40 (35–43) µm long and 13 (10–14) µm wide, usually with 3 (rarely 2 or 4) spiracular pores, each 4 µm wide with 5–6 loculi; each posterior spiracle 41 (38–45) µm long and 14 (13–15) µm wide, usually with one (rarely 2) spiracular pores. Quinquelocular pores forming four longitudinal submarginal and submedial rows on abdomen, with 5 pores in each submedial row, and 6 or 7 in each submarginal row. Bilocular pores few, of two slightly different shapes, each about 3 µm wide, in a single submarginal row on abdomen and thorax. Tubular ducts similar to those on dorsum, present along body margin and submargin and in irregular transverse bands on thorax; sparse on head; also with 4-6 ducts across each abdominal segment. Body setae, each usually 42 (39–44) µm long, present on head and thorax, in groups between legs, and forming 6 longitudinal rows on abdomen; each medial setae about 35 (24–39) µm long, submedial setae 7 (6–9) µm long, and submarginal setae 5 (5–6) µm long. Anal lobes poorly developed, each with one conical seta 30 (23–38) µm long, on inner margin and one fairly long apical seta, 92 (880–105) µm long. Anal ring round, 37 (33–40) µm long, 36 (32–40) wide, with pores and 6 setae, each 43 (28– 48) long.

Comments. Among the Palaearctic species, the only other 2nd-instar *Kermes* males described are those of *K. bytinskii, K. williamsi* (Sternlicht, 1969; 1972) and *K. quercus* (Podsiadlo, 2012).They clearly differ from *K. vermilio* because their marginal setae are long and hair-like, whereas those of *K. vermilio* are spinose.The Nearctic 2nd-instar males of *K. cockerelli*, *K. rimarum* and *K. concinnulus* also have long, hair-like marginal setae, and also tubular ducts and 5-locular pores scattered on both the dorsum and venter (Baer & Kosztarab, 1985).

THIRD-INSTAR FEMALE (Fig. 4). **Living specimen**: body largely oval or hemispherical, red or brown; dorsum covered with glassy wax with some protruding conical waxy tufts regularly distributed (Plate 1: d).

Mounted specimen: body rounded, 1.8 (1–2.4) mm long and 1.6 (0.9–2.8) mm wide.

Dorsum. Marginal setae conical, thick, with 88 (66–111) setae on each margin, of three different size randomly placed: 1) large setae, each 17 (15–19) µm long, 7 (9–11) µm wide at base; 2) medium-sized setae, each 13 (11–14) µm long, 3.5 µm wide at base; and 3) small setae, each 8 (7–9) µm long and 3 µm wide at base; also with submarginal groups of 1-3 conical setae similar to medial and small marginal setae. Other conical setae, each 15 µm long and 3.5 µm wide at base, present in a submedial line from head to metathorax; also very small conical setae, each 7 (6-8) µm long and 2 µm wide, irregularly distributed submarginally and over abdominal segments, mingled with small thin setae. Small bilocular pores sparse over dorsum. Tubular ducts and anal lobes absent.

Venter. Dermal crenules present medially on abdomen and thorax. Antennae short, each 2 or 3 segmented, but often with unclear segmentation, each 75 (55–88) µm long; penultimate segment usually with one chaetic seta; apical segment with 4 trichoid and 3 chaetic setae. Frontal lobes well developed. Clypeolabral shield 180 (138–213) µm long. Labium subtriangular, 168 (130–190) µm long, 3-segmented, basal and second segments each with one pair of setae, third segment with 4 pairs. Legs small, tubercle-like, possibly two-segmented, usually with 4 short setae and a short, misshapen claw. Spiracles well developed, sclerotized, each anterior spiracle 73 (55–100) µm long and 35 (25–55) µm wide, with 3–5 associated spiracular disc-pores, each about 4 µm wide and with 2–-6 loculi (usually 5 or 6); each posterior spiracle 84 (63–100) µm long and 39 (25–55) µm wide, with 2 or 3 associated disc-pores; some specimens with 1 or 2 disc-pores also present in middle of thorax or on last abdominal segment.

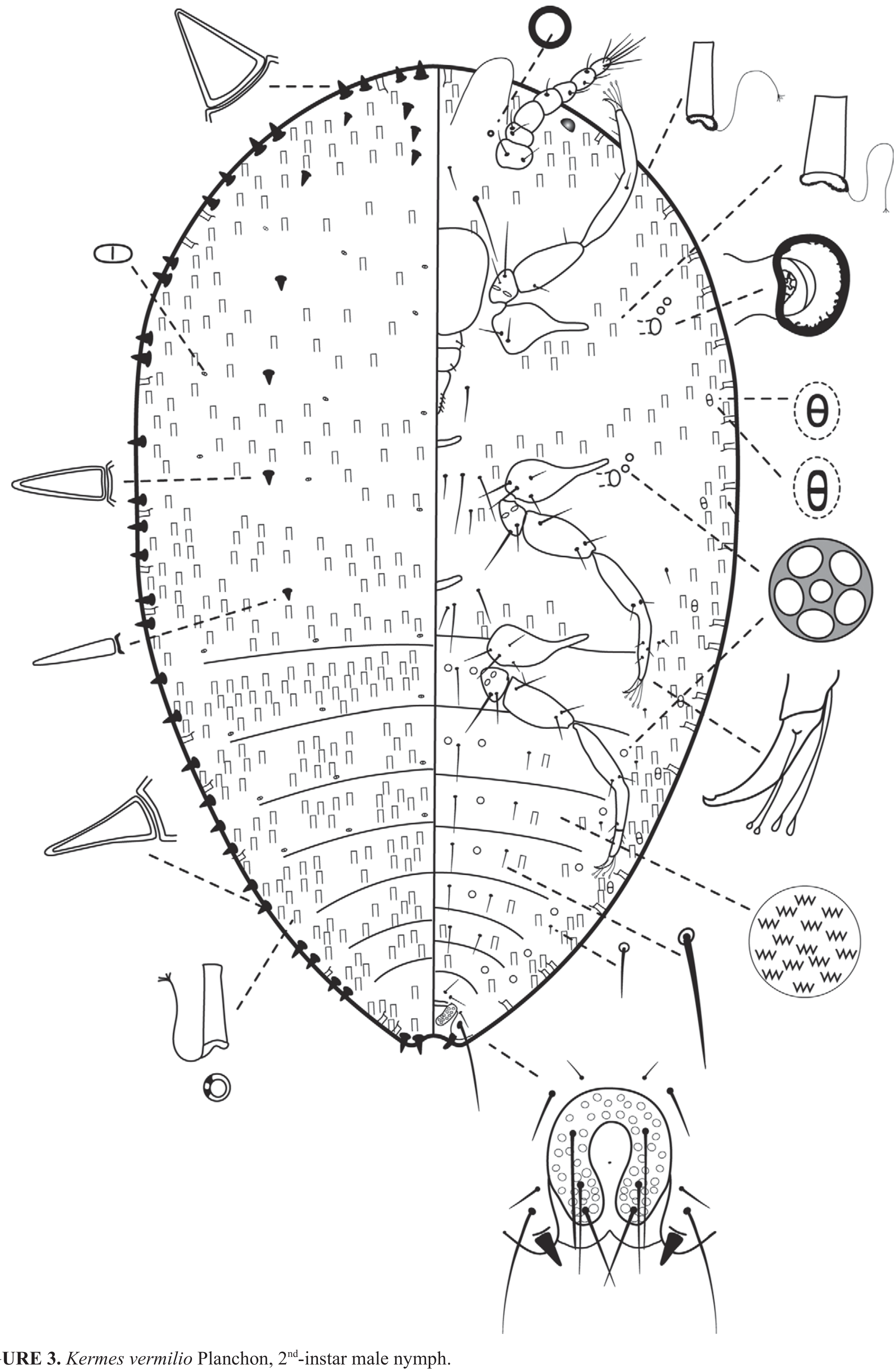

FIGURE 3. *Kermes vermilio* Planchon, 2nd-instar male nymph.

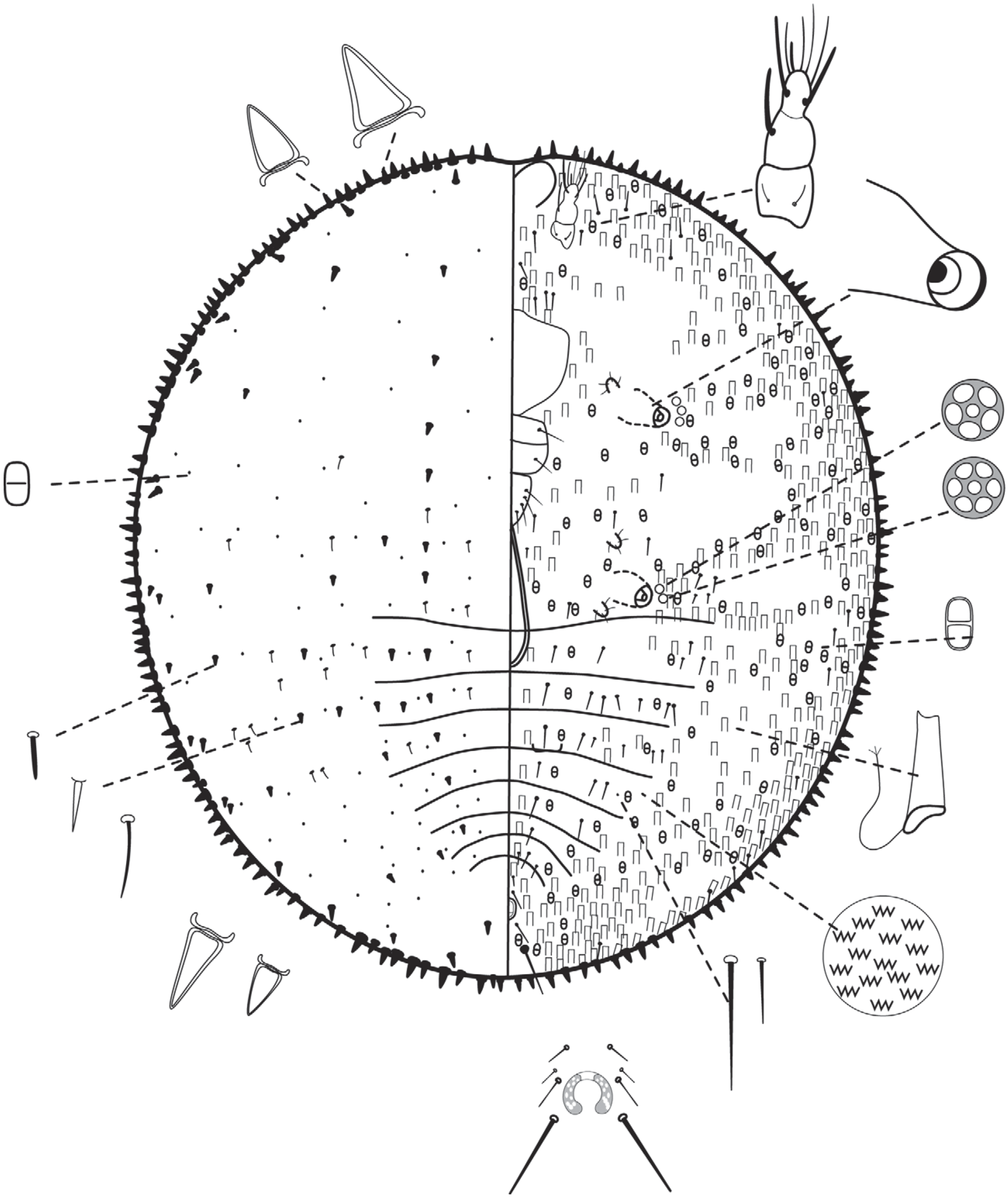

FIGURE 4. *Kermes vermilio* Planchon, 3rd-instar female nymph.

Bilocular pores, each about 3 µm wide, present throughout venter, most numerous on submargin. Tubular ducts each 15 (14–16) µm long, 3–4 µm wide, present in a wide marginal band and forming an irregular single row across each abdominal segment; sparse medially on thorax and head. Ventral trichoid setae in transverse rows on abdominal segments, plus a few on thorax and head. Anal lobes fused; longest apical seta 65 (50–80) µm long and auxiliary seta 21 (15–30) µm long. Anal ring almost circular 42 (37–43) µm long and 38 (25–40) µm wide; anal ring with pores, anal setae not seen; with three pairs of suranal setae, each 16 (10–23) µm long.

Comments. Borchsenius (1960) described and illustrated the 3rd-instar nymph ("older larval stage") of *K. vermilio.* His description is similar to ours although he did not recognise the presence of dorsal and ventral bilocular pores. Borchsenius (1960) also provided a description and drawing of the 3rd instar of *K. globosus* Borchsenius. From his drawing, we can infer that this Asiatic species has segmented legs, a ventral submarginal band of tubular ducts, simple pores and 5-locular pores scattered throughout the dorsum. Among the Nearctic *Kermes*, only the 3rd instar of *K. sylvestris* (Cockerell & King) has been described and illustrated: it has a ventral submarginal band of tubular ducts, marginal spine-like setae and 5-locular pores sparse on body margin and venter (Bullington & Kostzarab, 1985). No other 3rd instars of *Kermes* species have been described. It should be noted that the description and illustration of the 3rd instar of the *K. bytinskii* by Sternlicht (1972) is clearly a pre-reproductive adult female.

ADULT FEMALE (Fig. 5). **Living specimen**: fully-grown reproductive females sub-spherical, dark red or brown, covered with a fine white or pale grey mealy wax; body 5 (3–7) mm long, 4.7 (2.7–6.6) mm wide and 4.6 (2.6–6) mm high (Plate 2: a, b, c). Due to their heavily sclerotized cuticle, these are unsuitable for a reliable identification based on microscopic morphological characters. The following description is based on young pre-reproductive females.

Mounted specimen: body of young pre-reproductive rounded, 3.3 (1.7–3.5) mm long and 3 (1.3–3.4) mm wide.

Dorsum. Marginal setae all similar and spine-like, conical, stout, blunt (Plate 2: a), each 18 (13–20) µm long, 7.5 (7–12) µm wide at base, with 92 (73–133) setae on each margin. Dorsal setae spinose, conical, unevenly distributed, each about 12 (7–14) µm long and 3–6 µm wide. Small bilocular pores, each about 1.7 µm wide, sparse in a wide submarginal band. Tubular ducts, each 12 µm long and 4 µm wide, present throughout dorsum, most numerous along body margin and submargin.

Venter. Dermal crenules present medially on abdomen and thorax (Plate 2: b). Antennae short, tubercle-like, with unclear segmentation, each 88 (50–115) µm long, usually with 2 short setae near base, 2 chaetic setae medially and 7 or 8 setae at apex. Basal protrusion and frontal lobes absent. Clypeolabral shield 234 (213–250) µm long. Labium subtriangular, 217 (188–250) µm long, 3-segmented, basal and second segments each with one pair of setae, third segment with 4 pairs. Legs absent. Spiracles well developed and sclerotized, each anterior spiracle 150 (125–175) µm long and 109 (95–125) µm wide, each posterior spiracle 151 (125–190) µm long and 120 (100–138) µm wide. Bilocular pores (Plate 2: e), each about 3 µm wide, scattered on head and thorax, most numerous along body submargins; rare medially on abdominal segments. Multilocular pores (Plate 3: c, f), each with 10–12 loculi and about 7 µm wide, present in wide transverse bands on abdominal segments and forming groups near each spiracle and antennae. Tubular ducts (Plate 2: a, g), each about 21–25 µm long and 3.2–4µm wide, forming a wide, dense, marginal band (Plate 3: d), but sparse over remaining venter and in single rows across abdominal segments. Ventral setae each 12 (10–17) µm long distributed across abdominal segments, plus a few also medially and submedially on head and thorax, these 17 (14–20) µm long. Longest apical seta each 73 (65–85) µm long; with 3 pairs of suranal setae, each 19 (13–25) µm long. Anal ring roughly oval, 40 (30–55) µm long and 36 (30–48) µm wide, with pores, without setae.

Comments. Our description of the adult female of *C. vermilio* agrees well with that of Borchsenius (1960) although he did not record the tubular ducts across the ventral segments nor the presence of dorsal bilocular pores.

The structure of the multilocular disc-pores in the adult female was studied under a SEM microscope (Plate 2, f) and proved to be different from their appearance under the phase-contrast microscope (Plate 3, c) and as usually represented in scientific drawings. The structure suggests that a ridged waxy tube rather than several wax filaments is extruded through this kind of pore. Possibly this pore structure is similar throughout the Kermesidae and SEM studies could show a similar morphology in other *Kermes* species.

In comparison with other adult female *Kermes*, those of *K. vermili*o lack legs (i.e. not even reduced to tubercles), whereas the adult females of other Palaearctic or Oriental *Kermes* species (i.e. *K. bacciformis, K. corticalis*, K. *quercus, K. roboris*, *K. williamsi*, *K. bytinskii*, *K. punctatus* Borchsenius, *Kermes macrantherae* Borchsenius, *K. miyasakii* Kuwana, *K. orientalis* Liu & Shi, *K. flavus* Liu, *K. bannaensis* Liu) (Leonardi, 1920; Kuwana, 1931; Borchsenius, 1960; Liu, 1995; Liu and Shi, 1995) have segmented legs, even if the segments are reduced or partially fused. This is also true of the Nearctic species (Bullington and Kosztarab, 1985).

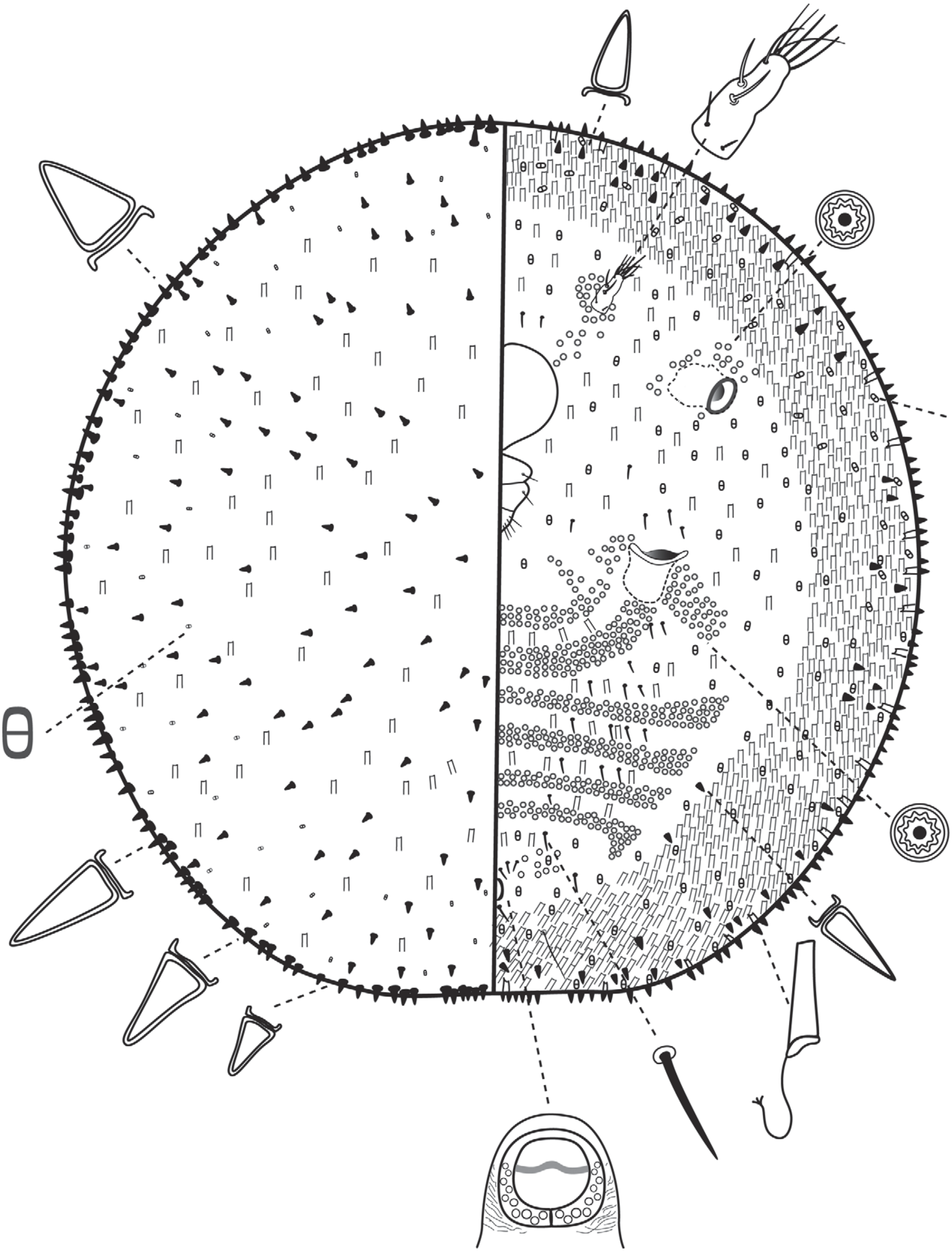

FIGURE 5. *Kermes vermilio* Planchon, adult female.

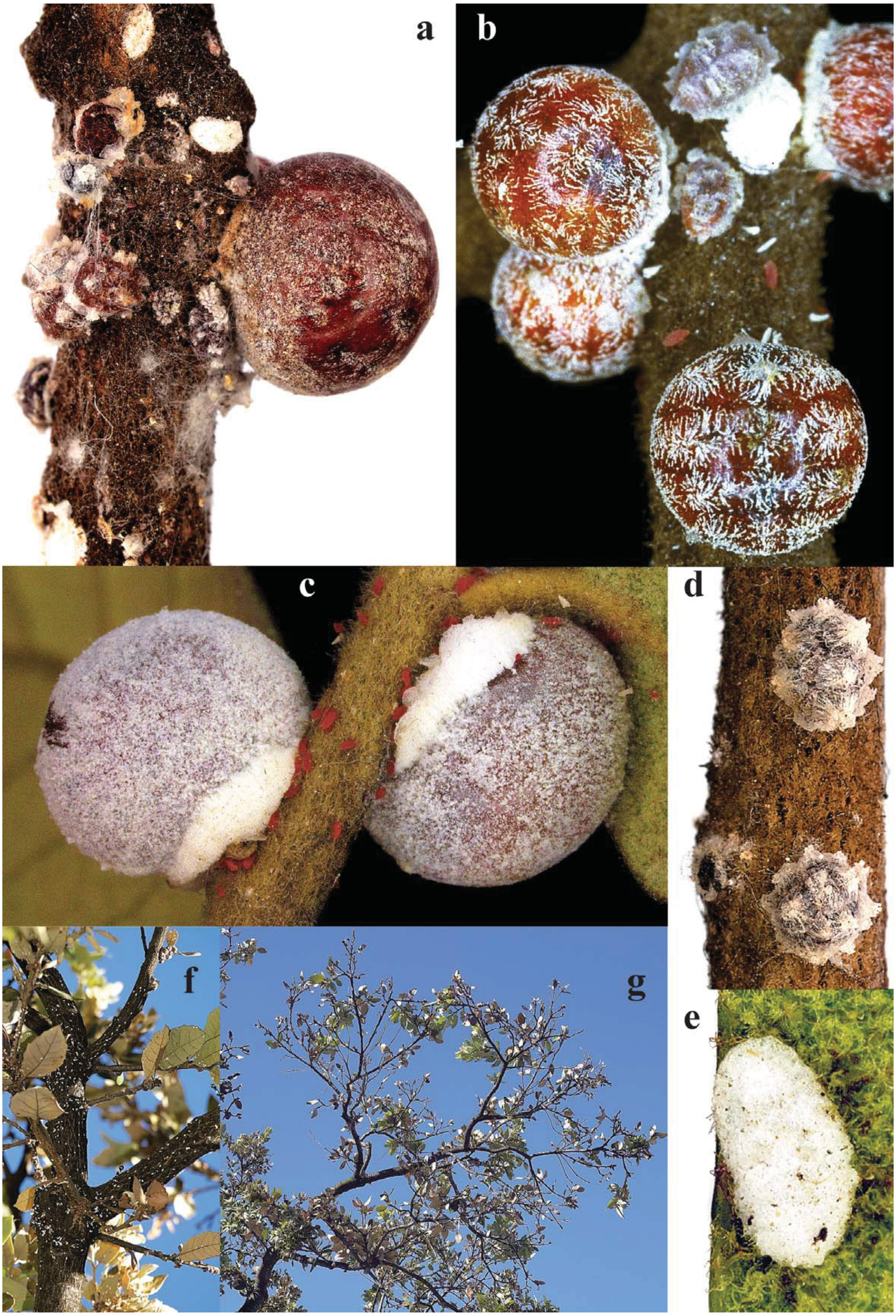

PLATE 1. *Kermes vermilio* Planchon, macroscopic appearance and damage to *Quercus ilex*: a) adult post-reproductive female and nymphs (Bitonto (BA), April 2009, Italy); b) young reproductive females, third-instar female nymphs and crawlers (Bari, July 2008, Italy); c) fully-mature reproductive female with crawlers (Lecce, July 2012, Italy); d) third-instar female nymphs (Lecce, July 2010, Italy); e) male test under a leaf; (f) branch infested by tests (Bari, May 2010, Italy); and g) dieback due to *K. vermilio* outbreak in an urban environment (Bari, May 2010, Italy).

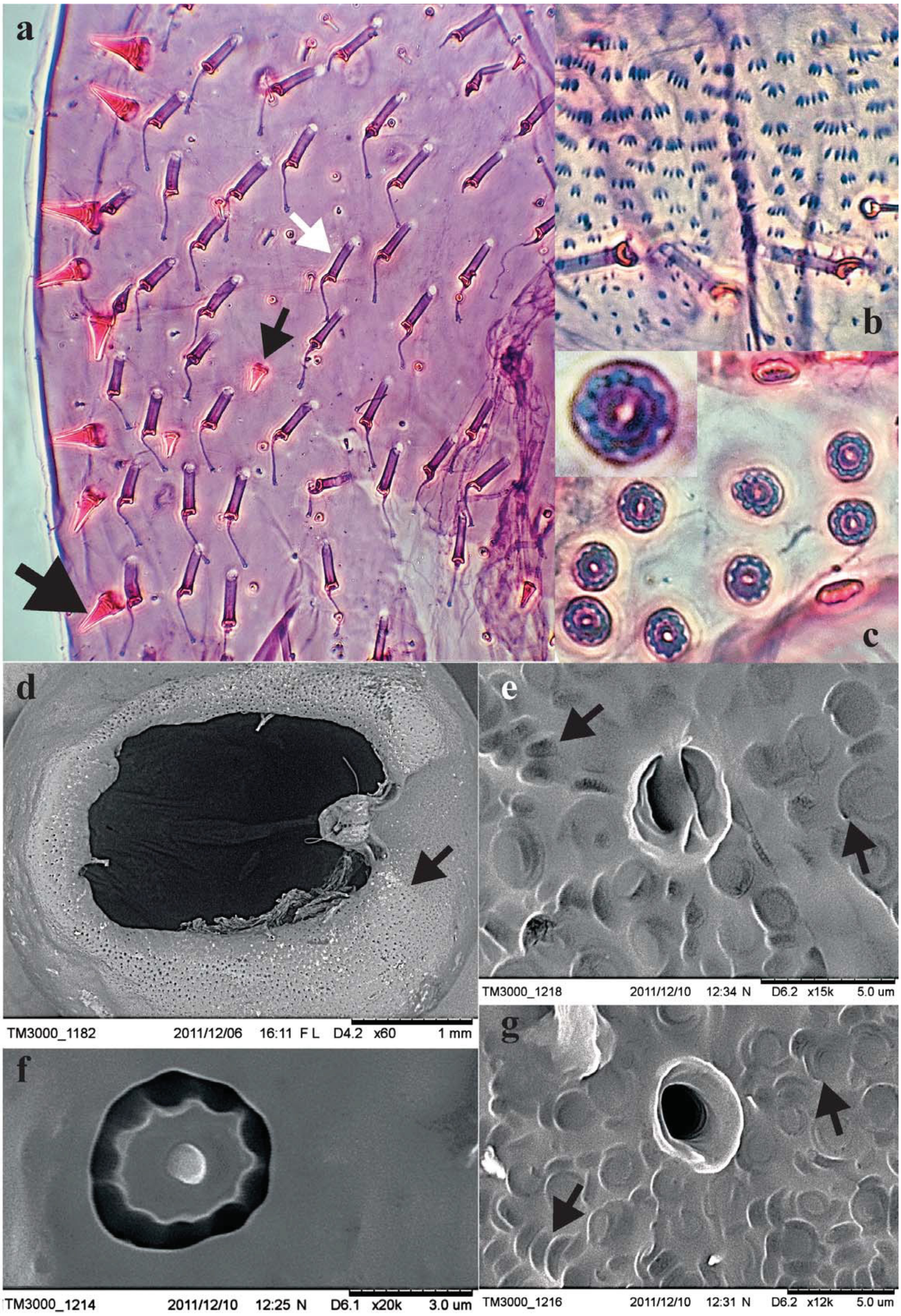

PLATE 2. *Kermes vermilio* Planchon 1864, microscopic details of adult female: a) large black arrow: marginal spines; small black arrow: dorsal spine; white arrow: tubular ducts b) foreground: adult female ventral dermal crenules background: tubular ducts; c) multilocular-disc pores; inset: one enlarged multilocular disc-pore; d) arrow: marginal band of tubular ducts in a postreproductive female; e) dorsal bilocular pore; arrows: imprint of coiled wax threads; f) multilocular-disc pore; g) orifice of tubular duct; arrow: imprint of coiled wax threads. Pictures a, b & c: phase-contrast of stained mounted specimens; d, e, f, g: SEM of uncoated specimen in charge-reduction mode.

Key to *Kermes vermilio* instars (prepupa, pupa and adult male not included)

1	Legs present, fully developed	2
-	Legs, if any, small, with indistinct segmentation	3
2	Antennae 6-segmented; without tubular ducts	1st instar
-	Antennae 7-segmented; tubular ducts abundant on dorsum and venter	2nd instar male
3	Antennae 5-segmented; with 34-37 marginal setae on each side	2nd instar female
-	Antennae very short, unsegmented or with obscure segmentation; with more than 70 marginal setae on each side	4
4	Multilocular disc-pores absent	3rd instar female
-	Multilocular disc-pores distributed in wide bands ventrally on abdomen and in groups near each antenna and spiracle	adult female

Comments on genus *Kermes*

Ferris (1955) pointed out the extreme difficulty that students of *Kermes* morphology face when trying identify or describe them, due to the heavy sclerotization that the mature adult develops, referring to this as an "almost impossible situation". It is well known that the descriptions, and the subsequent identification of *Kermes* species, are mainly based on the external appearance of post-reproductive females, and this can vary depending on several factors (age, exposure to meteorological agents, etc).

Balachoswky (1950) provided the first identification keys to European and West Mediterranean species (*K. vermilio*, *K. roboris*, *K. ilicis* and *K. bacciformis*) based on first-instar nymphs, whose morphological characters are stable and reliable. Later, the same author (1953) gave a short description based on the external appearance of post-reproductive females of three new species from Israel, namely *Kermes echinatus*, *K. palestiniensis* and *K. spatulatus*, and also provided detailed descriptions of their first instars, so making possible a reliable identification. However, he also observed that these three new species could be junior synonyms of *K. biblicus* (Bodenheimer), *K. greeni* Bodenheimer, and *K. nahalali* Bodenheimer, also described from Israel, but based on post-reproductive females only (Bodenheimer, 1926; 1931). According to Ben-Dov & Harpaz (1985), no type material of *K. biblicus* is available and so its status may never be clarified.

This situation is complicated by the fact that several *Kermes* species have been described from just one country: i.e. a total of 7 *Kermes* species are known only from Israel. Of these, *K. biblicus*, *K. echinatus*, *K. greeni*, *K. nahalali*, *K. palestiniensis*, are known only off *Quercus coccifera* whereas the other three species are known off *Q. ithaburensis* and *Q. aegilops*. In addition, 4 other *Kermes* species are known only from Turkey (see Table 1). Altogether 9 species have been described using the external appearance of the post-reproductive female only (see Table 1). In the absence of descriptions of their 1st-instar nymphs, misidentifications or synonymies are to be expected. The present status of knowledge on the morphology of European and Mediterranean *Kermes* instars is reported in Table 1. A revision of the species and the description of the first instars of most of these species are greatly needed and would help to clarify their systematic position.

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References

Andreatta, G. (1996) Attacchi di *Kermococcus vermilio* Planch. su leccio (*Quercus ilex* L.) nella pineta di Lido di Volano. *Monti e Boschi*, 47, 38–41.

Baer, R.G. & Kosztarab, M. (1985) Studies on the morphology and systematics of scale insects - No. 12. II. A morphological and systematic study of the first and second instars of the family Kermesidae in the Nearctic region (Homoptera: Coccoidea). *Bulletin of the Virginia Polytechnic Institute and University Research Division*, 85, 119–261.

Balachowsky, A.S. (1950) Les *Kermes* (Hom. Coccidea) des chênes en Europe et dans le bassin Méditerranéen. *Proceedings of the International Congress of Entomology* (Stockholm, 8, 739–754.

Balachowsky, A.S. (1953) Sur les *Kermes* Boitard (Hom. Coccoidea) des chênes du bassin oriental de la Méditerranée. *Revue de Pathologie Végétale et d'Entomologie Agricole de France*, 32, 181–189.

Belcari, A.& Minnocci, A. (1989) Attacchi di *Kermes vermilio* (Planchon) (Rynchota: Kermesidae) su *Quercus ilex* L. in Toscana. *Disinfestazione*, 6 (5), 45–52.

Belcari, A. (1991) Ulteriori acquisizioni sulla biologia e sulle possibilità di controllo in Toscana di *Kermes vermilio* (Planch). (Rynchota: Kermesidae). *Disinfestazione*, 8 (6), 23–26.

Ben-Dov, Y. & Harpaz, I. (1985) An annotated list of taxa of Coccoidea (Homoptera) described by F.S. Bodenheimer (1897-1959). *Israel Journal of Entomology*, 19, 23-36.

Ben-Dov, Y., Miller, D.R. & Gibson, G.A.P. (2012) *ScaleNet: a database of the scale insects of the World*. Available in: http://www.sel.barc.usda.gov/Scalenet/Scalenet.html (accessed 16. 01.2012).

Bodenheimer, F.S. (1926) Première note sur les cochenilles de Syrie. *Bulletin de la Société Entomologique de France*, 31, 41–47.

Bodenheimer, F.S. (1931) Zur kenntnis der Paläarktischen kermesàrten (Rhy. Cocc.). *Konowia,* 10, 241-247.

Boitard, P. (1828) Les gallinsectes , 169–172. In: *Manuel d'entomologie ou histoire naturelle des insectes*, II., Imprimerie de Crapelet, Paris, 417 pp

Borchsenius, N.S. (1960) *Fauna of USSR, Homoptera, Kermococcidae, Asterolecaniidae, Lecaniodiaspididae, Aclerdidae* (in Russian). Akademiia Nauk SSSR, Zoologicheskii Institut (Series), Leningrad, 282 pp.

Bullington, S.W. & Kosztarab, M. (1985) Studies on the morphology and systematics of scale insects - No. 12.I. Revision of the family Kermesidae (Homoptera) in the Nearctic region based on adult and third instar females. *Bulletin of the Virginia Polytechnic Institute and State University Agricultural Experiment Station*, 85, 1–118.

Costa, O.G. (1829) Famiglia de' coccinigliferi, o de' gallinsetti. Emitteri. In: *Fauna del Regno di Napoli*, Tip. Tramater, Napoli. 23 pp.

Del Bene, G. & Landi, S. (1992) *Kermes vermilio* (Planchon) e i suoi nemici naturali in Toscana. *Atti Giornate Fitopatologiche*, 229–236.

Ferris, G.F. (1955) *Atlas of the Scale Insects of North America, v. 7, the Families Aclerdidae, Asterolecaniidae, Conchaspididae Dactylopiidae and Lacciferidae*. iii. Stanford University Press, Palo Alto, California, 233 pp.

Kosztarab, M. & Kozár, F. (1988) *Scale Insects of Central Europe*. Akademiai Kiado, Budapest. 456 pp.

Koteja, J. (1974) Comparative studies of the labium in the Coccinea (Homoptera). *Scientific Papers Agr. Univ. Krakow*, 89, 1–160 pp.

Koteja, J. & Zak-Ogaza, B. (1972) Morphology and taxonomy of the male *Kermes quercus* (L.) (Homoptera, Coccoidea). *Acta Zoologica Cracoviensia*,17, 193–215.

Kuwana, S.I. (1931) On the genus *Kermes* in the eastern Asia. *Kontyu*, 5, 47–51.

Leonardi, G. (1920) *Monografia delle cocciniglie Italiane*. Della Torre, Portici, 555 pp.

Liu, Y. (1995) A new species of *Kermes* (Homoptera: Coccoidea: Kermesidae) from China (In Chinese). *Entomotaxonomia*, 17, 267–270.

Liu, Y. & Shi, Y. (1995) Two new species of *Kermes* (Homoptera: Coccinea: Kermesidae), with a key to the young adult females of known species of *Kermes* from China. *Insecta Mundi*, 9,155–163.

Marotta, S. & Tranfaglia, A. 2001 (1999). A new morphological structure on *Kermes vermilio* (Planchon) (Hemiptera: Coccoidea: Kermesidae). *Entomologica*, 33, 133–138.

Marotta, S., Ripullone, F. & Tranfaglia, A. (1999) Osservazioni bio-etologiche su *Kermes vermilio* (Planchon) (Homoptera Coccoidea Kermesidae) dannoso ai lecci in Basilicata. *Phytophaga*, 9, 63–83.

Miller, D.R., Gimpel, M.E. & Rung, A. (2005) *A systematic catalogue of the Cerococcidae, Halimococcidae, Kermesidae, Micrococcidae, Ortheziidae, Phenacoleachiidae, Phoenicococcidae and Stictococcidae (Hemiptera: Coccoidea) of the world*. Intercept Limited, Wimbourne, UK. 554 pp.

Podsiadlo, E. (2005) Morphological peculiarities in adult females of *Kermes quercus* (Linnaeus) (Hemiptera: Coccinea: Kermesidae). *Polskie Pismo Entomologiczne*, 74, 43–46.

Podsiadlo, E. (2005a) Morphology of the first instar of *Kermes quercus* (Linnaeus) (Hemiptera: Coccinea: Kermesidae). *Polskie Pismo Entomologiczne,* 74, 47–52.

Podsiadlo, E. (2012) Morphology of second instar nymphs of *Kermes quercus* (Linnaeus) (Hemiptera: Kermesidae). *Polskie Pismo Entomologiczne,* 81, 35–42.

Snodgrass R.E. (1935) *Principles of insect morphology*. McGraw-Hill Book Company, New York, 667pp.

Sternlicht, M. (1969) *Kermes bytinskii* n. spec. (Coccoidea, Kermesidae) in Israel and observations on its life history. *Israel Journal of Entomology*, 4, 251–270.

Sternlicht, M. (1972) A new species of *Kermes* Boitard (Coccoidea, Kermesidae) from England on oak. *Entomologist's Gazette,* 23, 259–266.

Tsalev, M. (1964) *Kermes* new for the fauna of Bulgaria. *Zashchita Rastenii*, 12, 23–26.

Williams, D.J. (1985) The British and some other European Eriococcidae (Homoptera: Coccoidea). *Bulletin of the British Museum (Natural History) Entomology*, Ser. 51, 347–393.

Williams, D.J. (2007) Carl Linnaeus and his scale insects (Hemiptera: Coccoidea). *Zootaxa*, 1668, 427–490.