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A new genus and four new species of felt scales on *Eucalyptus* (Hemiptera: Coccoidea: Eriococcidae) in south-eastern Australia

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Abstract A new Australian eriococcid genus *Fragorbis* gen. n. (Hemiptera: Coccoidea) is described for '*Sphaerococcus*' *pustulans* Green and four new species, *F. fructus* sp. n., *F. pseudopustulans* sp. n., *F. stipites* sp. n. and *F. superfacies* sp. n. Four of the five species are known only from Victoria and the fifth species from the High Country east of Tumut in New South Wales. All species feed on *Eucalyptus* (Myrtaceae), either in blister galls, or under or on the bark. The adult female of each species and the first-instar nymph of *F. pseudopustulans* sp. n. are described and illustrated. Keys are provided to the adult females of the eriococcid genera found on *Eucalyptus* and *Corymbia*, and to the species of *Fragorbis* gen. n.

Key words felt scale, Myrtaceae, *Sphaerococcus pustulans*, taxonomy.

INTRODUCTION

The family Eriococcidae (felt scales) has approximately 550 described species, making it the fourth largest family in the Coccoidea (Miller & Gimpel 2000). Felt scale species occur worldwide, but are most diverse in the southern hemisphere, especially in Australia where many species induce galls (Gullan *et al*. 2005). The most frequently used plant family is Myrtaceae, which is host to about 140 recorded species (Gullan *et al*. 2005). More than two-thirds of this diversity, 94 species in 14 genera, is found on *Eucalyptus* and *Corymbia* (Miller & Gimpel 2006). The numbers above and in the following synopsis refer only to named species, and are substantial underestimates of the true species richness of the fauna. Insects of the genera *Subcorticoccus* Gullan (3 spp.) and *Phacelococcus* Miller (4 spp.) are found under or in eucalypt bark (Gullan & Strong 1997; Gullan 1999). The adult females of *Olliffia* Fuller (1 sp.) are found on stems, enveloped by what has been described as a lac-like test (JW Beardsley, unpubl. data 1971). Adult females of *Ourococcus* Fuller (2 spp. on eucalypts) occur in deep bark crevices, and those of *Eriococcus* Targioni Tozzetti (13 spp. on eucalypts) are covered by a felted test and usually occur in dense aggregations on stems (Froggatt 1921a,b). The remaining eriococcid genera on *Eucalyptus* and *Corymbia* have gall-inducing species: *Ascelis* Schrader (3 spp. on *Corymbia* and *Eucalyptus*), *Cystococcus* Fuller (2 spp. on *Corymbia*), *Sphaerococcopsis* Cockerell (4 spp. on *Eucalyptus*), *Floracoccus* Beardsley (1 sp. on *Eucalyptus*), *Apiomorpha* Rübsaamen (39 spp. on *Eucalyptus*), *Kuwanina* Cockerell (1 sp. on *Eucalyptus*), *Lachnodius* Maskell (4 spp. on *Eucalyptus*), *Opisthoscelis* Schrader (16 spp. on *Eucalyptus*), and an undescribed genus that includes the species '*Sphaerococcus*' *pustulans* Green (Froggatt 1921a,b; Beardsley 1974a,b; Gullan *et al*. 2005).

Cook and Gullan (2004) used molecular data to reconstruct the phylogeny of the Eriococcidae. One feature of their hypothesis was a clade composed of *Lachnodius*, *Opisthoscelis*, and a species of an undescribed genus that includes '*S.*' *pustulans*. The *Lachnodius-Opisthoscelis* group has much greater diversity than indicated by the described species (JW Beardsley and NB Hardy unpubl. data 1972, 2007) and displays wide variation in host–plant interactions, with some species feeding without altering host tissue and other species inducing galls. Gall complexity varies among species, from simple pits, to sexually dimorphic, enclosing structures (Gullan *et al*. 2005). '*Sphaerococcus*' *pustulans*, which induces blister galls on eucalypt trunks, was described by Green (1905), who did not suggest a family placement. The proper placement of this taxon within the Eriococcidae was recognised by Beardsley (1974a) and Miller *et al*. (1998). The quotes around the genus name signify that the species is not congeneric with the type species of *Sphaerococcus* Maskell which belongs to the Pseudococcidae (Miller *et al*. 1998; Gullan *et al*. 2005), but no genus is currently available for its reception.

This paper erects a new genus for '*S.*' *pustulans* and four new species. One of the new species is the undescribed species related to '*S.*' *pustulans* that Beardsley (1974a) said was in his collection. The adult female of each species and the first-instar nymph of one species are described and illustrated. Males are not known for any of the species. A key to adult females of the five species is provided, together with a key to all genera of eriococcids found on *Eucalyptus* and *Corymbia.* At least one of the new species induces blister galls like those of '*S.*' *pustulans*. One species was collected under bark, another species on the surface of the bark and a fourth species was collected

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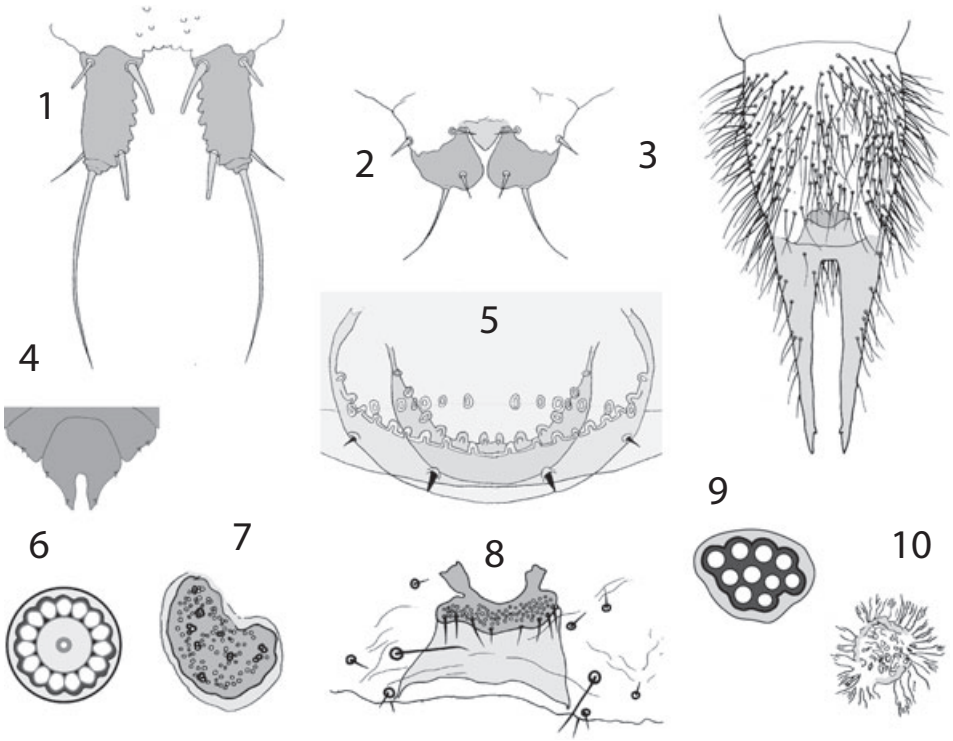

Figs 1–10. Features used in the key to eucalypt-feeding felt scale genera. (**1–4**) Anal lobes: (**1**) *Eriococcus*; (**2**) *Olliffia*, showing cauda between bases of anal lobes; (**3**) *Apiomorpha*; (**4**) *Ourococcus*. (**5**) Posterodorsal abdominal surface of *Kuwanina obscurata* (Maskell) showing papilliform invaginations. (**6**) Multilocular pore. (**7,8**) Undescribed 'genus A': (**7**) pore plate; (**8**) anal area. (**9,10**) *Cystococcus*: (**9**) pore; (**10**) spiracle. Darkness of shading indicates either degree of sclerotisation or overlapping layers of cuticle.

either from within blister-like galls or aborted fruits. All individuals of these species are small and cryptic, and largely have been overlooked, even by collectors of scale insects. They did not go unnoticed by Dr JW Beardsley, who was very successful in collecting these eriococcids while in Australia in 1971–1972 as a Fulbright Research Scholar in the Zoology Department, La Trobe University, Bundoora, Victoria. Dr Beardsley described a number of new gall-inducing species and was working on a substantial revision of *Lachnodius* when he died suddenly in 2001. Three of the five species described in this paper were collected by Dr Beardsley and two of them are known only from his collections.

MATERIALS AND METHODS

Freshly collected specimens were mounted one adult female per microscope slide but several nymphs per slide, as indicated in the descriptions. The slide-mounting method of Gullan (1984) was used. Slide-mounts prepared by JW Beardsley usually have more than one insect per slide. Measurements were made using an ocular micrometer attached to a compound microscope. Values given for leg segments are lengths in micrometre. All specimens listed for each species were measured and descriptions are based on all available material for each species. The morphological terms for Eriococcidae follow those of Williams (1985) and Miller and McKenzie (1967). Illustrations of the adult female of each species and one first-instar nymph were prepared with a drawing tube and the Adobe programs Photoshop CS and Illustrator CS. Following the convention for scale insects, each figure displays the dorsal body surface on the left side of the page, and the ventral body surface on the right. Enlargements of diagnostic features are located around the margin of each main figure; the sizes of these structures are provided in the text. Depositories are abbreviated as follows: ANIC, Australian National Insect Collection, CSIRO Entomology, Canberra, Australian Capital Territory, Australia; BMNH, the Natural History Museum, London, UK; BPBM, Bernice P. Bishop Museum, Honolulu, HI, USA; NMV, Museum Victoria, Melbourne, Victoria; USNM, National Museum of Natural History, Entomological Collection, Washington, DC, USA (Coccoidea collection held at USDA, Beltsville, Maryland). This work is based largely on the collection of the late Dr JW Beardsley, which is housed in the BPBM. The BPBM has allowed the holotype of any new Australian species from Dr Beardsley's collection to be deposited in the ANIC (in correspondence of PJ Gullan 1996).

SYSTEMATICS

Key to the adult females of genera of felt scales on *Eucalyptus* and *Corymbia* (Figs 1–10)

Note. A considerable diversity of undescribed species has been recorded, some of which may constitute new genera. Most of these are relatively uncommon, but one taxon* occurs commonly in collections from eucalypt bark. This is included in the key as 'undescribed genus A' and the use of this code name is not intended as a nomenclatural action.

1 Anal lobes present (Figs 1–4), usually sclerotic but if membranous, lobe setae conspicuous; tentorial box without anterior extensions (e.g. Fig. 13)..... 2
– Anal lobes absent; tentorial box with (e.g. Fig. 16) or without anterior extensions..... 6
2 Anal lobes not connected by sclerotisation (Fig. 1); anal ring not invaginated; multilocular disc pores always with fewer than 7 loculi, usually quinquelocular (e.g. Fig. 13f)..... 3
– Anal lobe sclerotisation broadly connected (Figs 3,4) or joined via dorsal triangular protuberance (cauda, or dorsal plate) (Fig. 2); anal ring usually invaginated; some multilocular disc pores with more than 7 loculi (Fig. 6)..... 4
3 Anal lobes sclerotic (Fig. 1); anal ring entire; enlarged dorsal setae present; ventral multilocular disc pores not aggregated into distinct clusters on posterior abdominal segments..... *Eriococcus* Targioni Tozzetti
– Anal lobes membranous; anal ring incomplete, either open or divided; enlarged dorsal setae absent; ventral multilocular disc pores usually aggregated into distinct clusters on posterior abdominal segments..... *Phacelococcus* Miller
4 Dorsal triangular protuberance (cauda) present between anal lobes (Fig. 2); multilocular disc pores aggregated in distinct clusters; legs either well developed or absent; forming lac-like test... *Olliffia* Fuller
– No dorsal, triangular protuberance between anal lobes; multilocular disc pores evenly scattered; legs reduced or absent;..... 5
5 Legs 3-segmented due to fusion of trochanter with femur, and tibia with tarsus; anal lobes elongate and tapering (Fig. 3); tubular ducts absent; found within woody galls..... *Apiomorpha* Rübsaamen
– Legs absent; anal lobes forming a pygidial structure (Fig. 4); tubular ducts present or absent; found in bark crevices..... *Ourococcus* Fuller
6 Legs absent..... 7
– Legs present, sometimes reduced..... 10
7 Dorsal surface of posterior abdomen with deep intersegmental constrictions lined with papilliform invaginations (Fig. 5); dorsum with short, stout, conical spines..... *Kuwanina* Cockerell
– Abdominal segmentation obscure, intersegmental areas not lined with papilliform invaginations; dorsum with minute, slender setae..... 8
8 Anal ring (Fig. 8) invaginated, U-shaped, with numerous small pores, and a pair of apodemes extending anterolaterally; pore plates (hind legs reduced to flattened plates bearing translucent pores) present; (Fig. 7); bilocular pores present..... undescribed genus A*
– Anal ring absent, or if present circular, not invaginated, without pores or apodemes; pore plates absent; bilocular pores absent..... 9
9 Multilocular disc pores with irregular outline and 5–30 loculi (Fig. 9), clustered around vulva and spiracles; each spiracle composed of broad, irregular atrium with tangled mass of radiating, sclerotic tracheal trunks, spiracular apodemes absent (Fig. 10); cuticle around vulva striated or smooth; caudal end of body forming sclerotic operculum..... *Cystococcus* Fuller
– Multilocular disc pores quinquelocular (similar to Fig. 13f) or with irregular outlines and 5–15 loculi (*Ascelis praemollis*), irregular pores not clustered around vulva; spiracular apodemes distinct, roughly rectangular (similar to Fig. 13) or absent (*A. praemollis*); cuticle around vulva nodulose; dorsal disc with sclerotic operculum..... *Ascelis* Schrader
10 Legs reduced to unsegmented protuberances, each bearing a claw; dorsum with sclerotic boss formed by cluster of roughly conical invaginations; inducing blister galls on bark..... *Floracoccus* Beardsley
– Legs not so reduced, if lobe-like then lobes constructed of ring-like segments; dorsum with or without sclerotic disc, if disc elaborations are present, these never composed of conical invaginations; inducing galls or not..... 11
11 Hind legs distinctly larger than fore or mid legs... 12
– Hind legs subequal to fore and mid legs..... 14
12 Anal ring situated at base of sclerotic invagination (short in *Sphaerococcopsis simplicor* (Maskell)); marginal fringe of enlarged setae distinct at least caudally; dorsal shield composed of discrete sclerotic nodules..... *Sphaerococcopsis* Cockerell
– Anal ring not invaginated, or if slightly invaginated then surrounding cuticle membranous; marginal fringe of enlarged setae present or absent, if dorsal shield present, then not as above..... 13
13 Frontal lobes always present (more obvious than in Fig. 17i); fore and mid legs extremely reduced, usually shorter than length of hind trochanter; hind legs elongate, hind tibiae often curved; anal ring variable..... *Opisthoscelis* Schrader
– Frontal lobes usually absent; fore and mid legs not so reduced, longer than hind trochanter; hind legs stocky, hind tibiae straight; anal ring either open posteroventrally or fragmented (Figs 13,14,16–18).... *Fragorbis* gen. n.
14 Anal ring acellular, with a single pair of setae; head with longitudinal band of conspicuous microtrichia; microtubular ducts absent..... *Subcorticoccus* Gullan
– Anal ring cellular, with numerous setae; head without longitudinal band of microtrichia; microtubular ducts present..... *Lachnodius* Maskell

Fragorbis gen. n.

Type species: *Sphaerococcus pustulans* Green, here designated.

Habit in life. Females of all species of *Fragorbis* are small and live cryptically on eucalypts, either in blister-like galls (Figs 11,12), under or on the surface of bark, or possibly in aborted fruits.

Figs 11,12. Blister galls of adult females. (**11**) *Fragorbis pseudopustulans* on bark of *Eucalyptus camphora* ssp. *humeana*, Micalong Swamp, New South Wales (scale line = 4 mm). (**12**) *Fragorbis pustulans* on bark of *Eucalyptus goniocalyx*, Myrniong, Victoria, dry paralectotype material from EE Green in USNM (National Museum of Natural History, Entomological Collection, Washington, DC, USA) (scale line = 3 mm), with two galls (right side) cut open.

Description, adult female. Body outline ovate to circular. Eyes marginal. Antennae 3- to 6-segmented. Frontal (interantennal) lobes present or absent. Labium composed of 2 fused segments, with 5 pairs of setae: 3 pairs on ventral surface, 1 apical pair of setae, 1 pair on dorsal surface. Anterior extensions of tentorial box present or absent. Legs reduced; hind leg always much larger than fore or mid leg. Claw stout and slightly recurved. Anal opening either apical or slightly dorsal. Anal ring incomplete, either open posteroventrally or divided into a number of fragments; anal ring pores small and few, adjacent to ring setae; with 6–10 anal ring setae. Anal lobes absent. A pair of caudal setae present, longer than other setae on margin or dorsum. Lateral and posteromedial vulvar apophyses strong. Dorsal derm either evenly membranous or with central sclerotic disc. Macrotubular ducts with distinct oral rims; always present dorsally, present or absent ventrally. Microtubular ducts absent. Dorsal setae small (5–20 μm long), robust, tapering to acute apex; arranged in transverse bands across each segment; ventral setae 8–15 μm long; in a transverse band across each abdominal segment, scattered along margin and submargin, a few medial of each coxa and between antennae. Multilocular disc pores all quinquelocular; present or absent dorsally, always present ventrally.

Diagnostic comments. Adult females of species of *Fragorbis* have small stout legs, no anal lobes, and strong vulvar apophyses. The single most diagnostic feature of the group is the incomplete or fragmented anal ring having only a few small pores near the bases of the ring setae. The anal ring is also incomplete or fragmented in *Phacelococcus*, but if the ring is dorsal, it is interrupted anterodorsally in *Phacelococcus*, whereas in *Fragorbis* the anal ring is intact anterodorsally and open posteroventrally. In addition, in *Phacelococcus* the anal ring pores are large and occur both around the bases of the anal ring setae and in areas between setae. *Fragorbis* also differs from *Phacelococcus* in the following ways: (1) anal lobes completely absent; (2) both lateral and posterior vulvar apophyses strong and conspicuous; (3) multilocular disc pores not arranged in ventral clusters; (4) legs stout, length of posterior margin of hind femora subequal to or shorter than length of hind coxa; (5) hind legs much larger than fore or mid legs; (6) bilocular pores absent; and (7) microtubular ducts absent. A number of features of the adult females suggest a close relationship between *Fragorbis* and *Subcorticoccus*, a genus not included in the phylogenetic work of Cook and Gullan (2004). These shared features are: (1) dorsal microtubular ducts absent; (2) legs reduced; (3) anal ring atrophied and not invaginated; (4) anal lobes absent; and (5) marginal setal fringe absent. *Subcorticoccus* differs from *Fragorbis* in the following: (1) hind legs approximately same size as fore and mid legs; (2) anal ring simple and complete, with a single pair of ring setae and no ring pores; and (3) a conspicuous longitudinal band of microtrichia on head.

Etymology. The genus name is derived from the Latin words *orbis*, meaning 'ring', and *frango* meaning 'to break', and is masculine in gender. The name refers to the variously broken or fragmented anal ring, which characterises species in this group.

Key to the adult females of species of *Fragorbis*

1 All legs extremely reduced, either hemispherical lobes composed of ring-like segments (Fig. 17e) or with hind tibia + tarsus about as long as hind trochanter; frontal lobes present but indistinct (Fig. 17i); anal ring U-shaped (Fig. 17d), all anal ring setae arising from a single sclerite…… *F. stipites* sp. n.

– Legs not so reduced; frontal lobes absent; anal ring fragmented, at least one pair of ring setae arising from detached portions of anal ring (e.g. Fig. 13d)…… 2

2 Antenna 3- to 5-segmented, roughly triangular (segment widths evenly diminishing towards apex) (Figs 14a,16a); central dorsal sclerotic disc present (may be undeveloped in younger females)…… 3

– Antenna 5- or 6-segmented, not triangular (segment widths approximately subequal after first) (Figs 13a,18a); dorsal sclerotic disc absent, dorsum entirely membranous…… 4

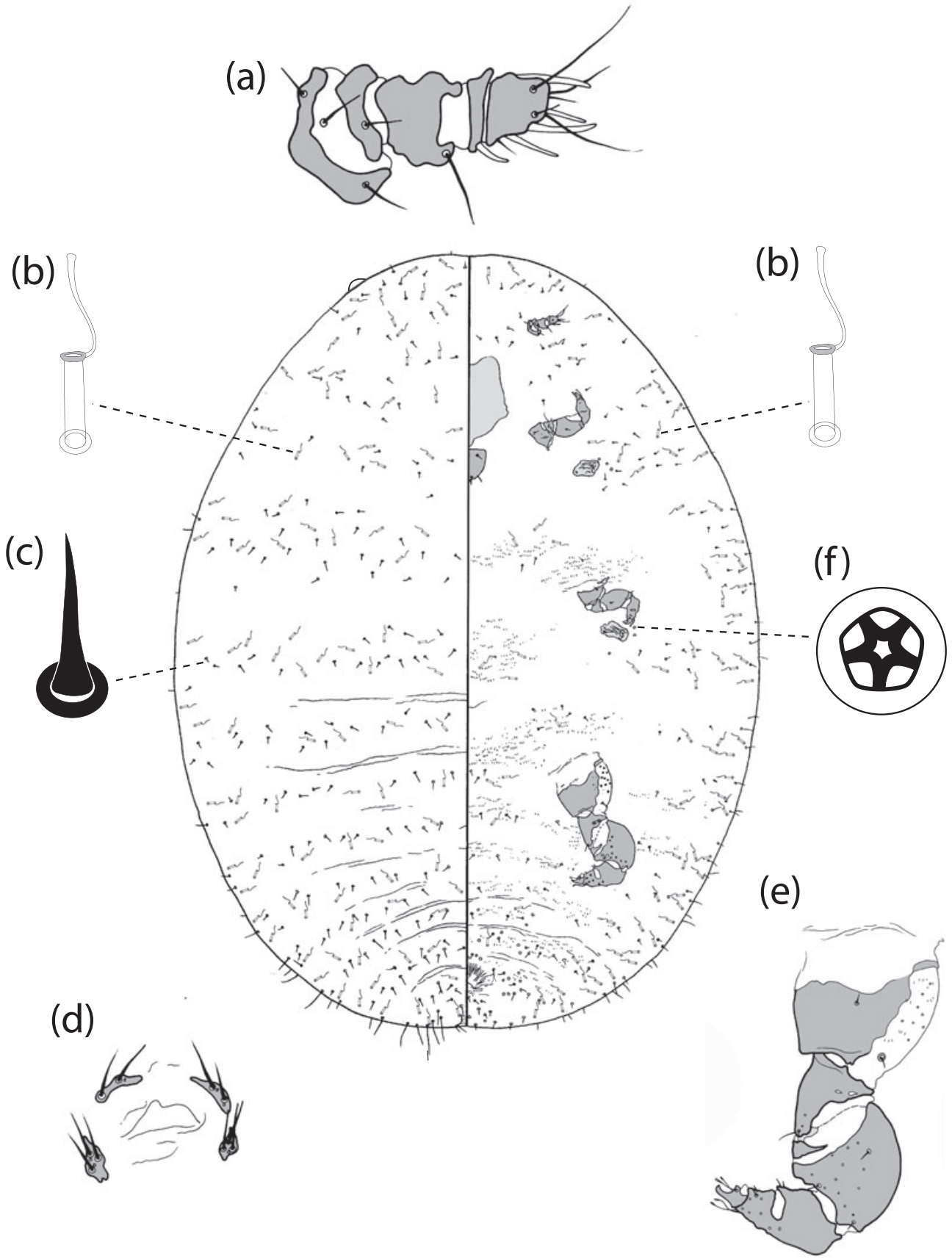

Fig. 13. Adult female of *Fragorbis fructus.* Enlargements show: (a) antenna; (b) macrotubular duct; (c) dorsal seta; (d) anal ring; (e) ventral surface of hind leg; (f) quinquelocular pore.

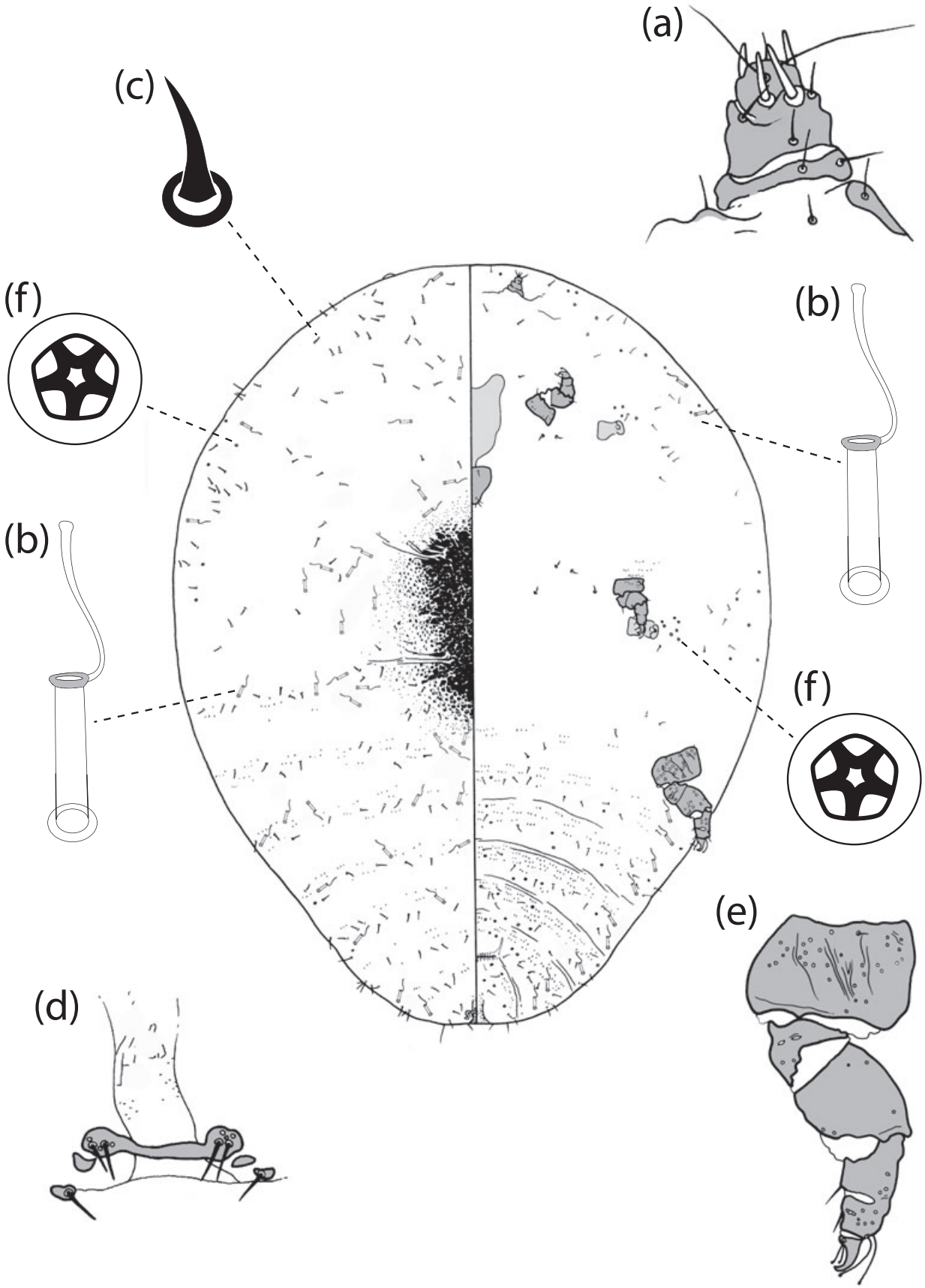

Fig. 14. Adult female of *Fragorbis pseudopustulans.* Enlargements show: (a) antenna; (b) macrotubular duct; (c) dorsal seta; (d) anal ring; (e) ventral surface of hind leg; (f) quinquelocular pore.

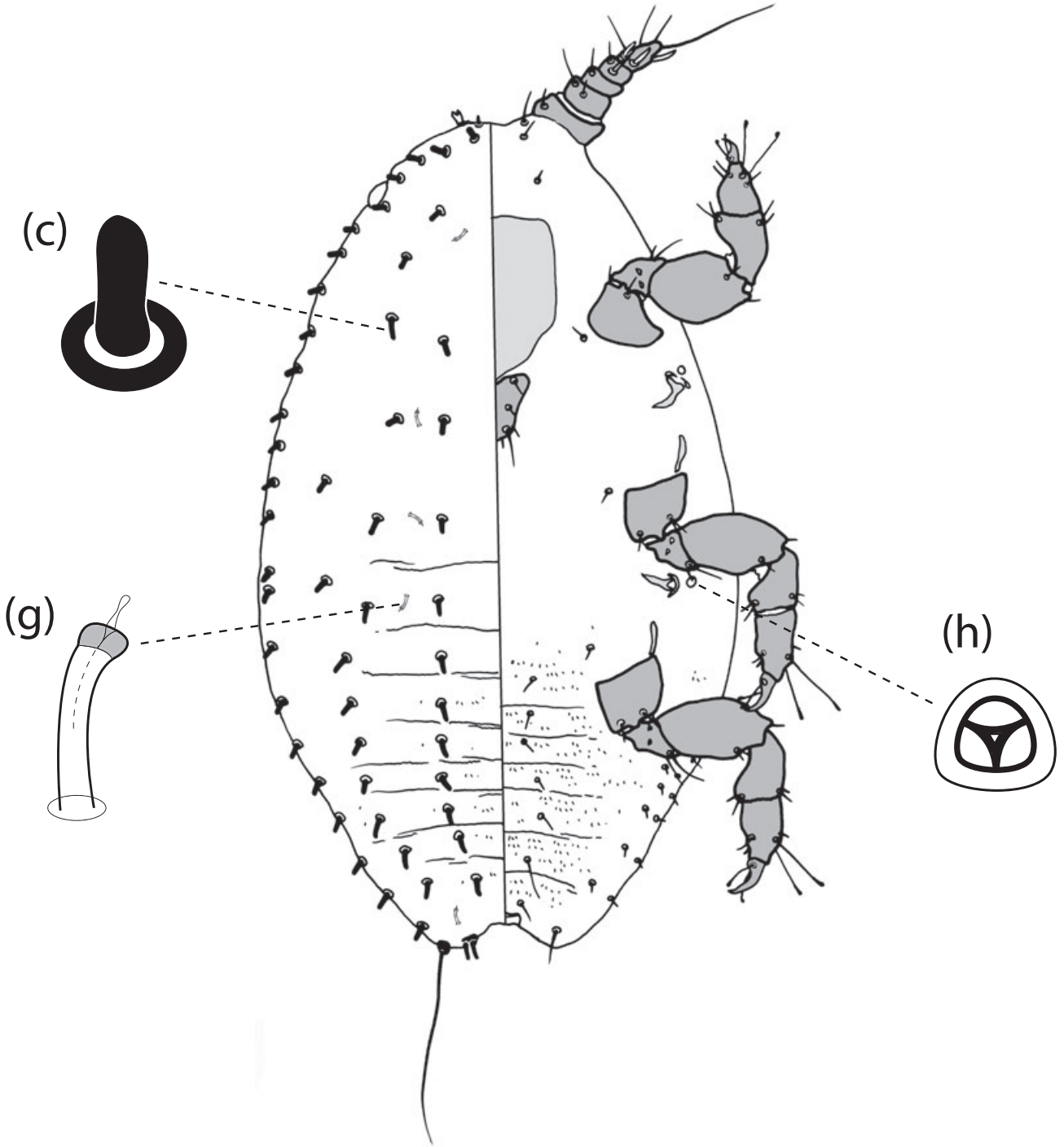

Fig. 15. First-instar nymph *Fragorbis pseudopustulans*. Enlargements show: (c) dorsal seta; (g) microtubular duct; (h) trilocular pore.

3 Macrotubular ducts confined to area near sclerotic dorsal disc (Fig. 16); quinquelocular disc pores densely distributed on dorsum and venter, several pores between labium and fore coxa…… *F. pustulans* sp. n.

– Macrotubular ducts broadly distributed on dorsum (Fig. 14); quinquelocular disc pores sparse, no pores between labium and fore coxa….. *F. pseudopustulans* sp. n.

4 Dorsal macrotubular ducts of 2 size classes (Fig. 18j,k); hind leg with many more setae than fore or mid legs; translucent pores small and inconspicuous (may appear absent), confined to dorsodistal portion of hind femur; anterior extensions of tentorium well developed; quinquelocular disc pores present on dorsum…… *F. superfacies* sp. n.

– Dorsal macrotubular ducts of a single size class (Fig. 13b); hind leg with *ca*. same number of setae as

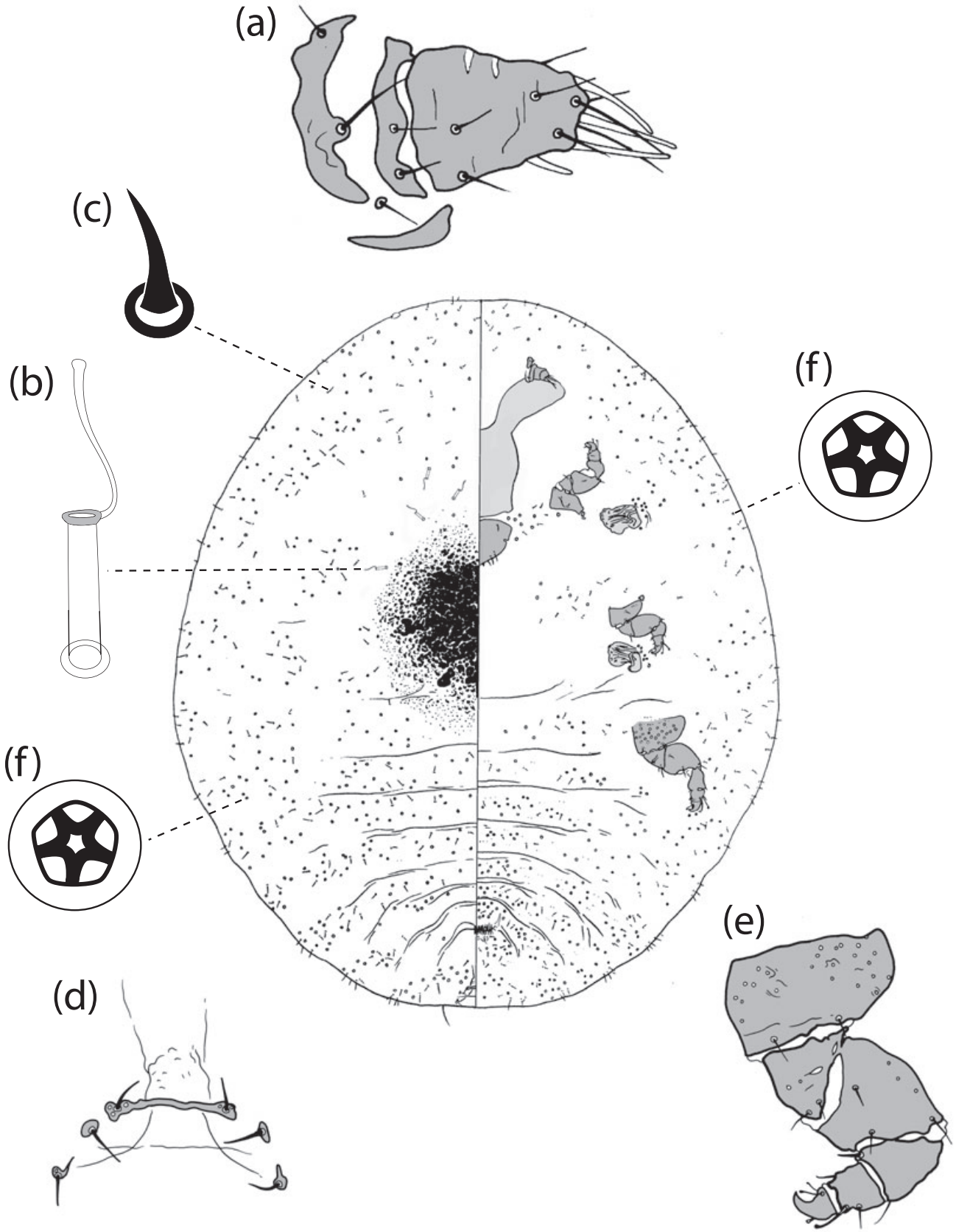

Fig. 16. Adult female of *Fragorbis pustulans.* Enlargements show: (a) antenna; (b) macrotubular duct; (c) dorsal seta; (d) anal ring; (e) ventral surface of hind leg; (f) quinquelocular pore.

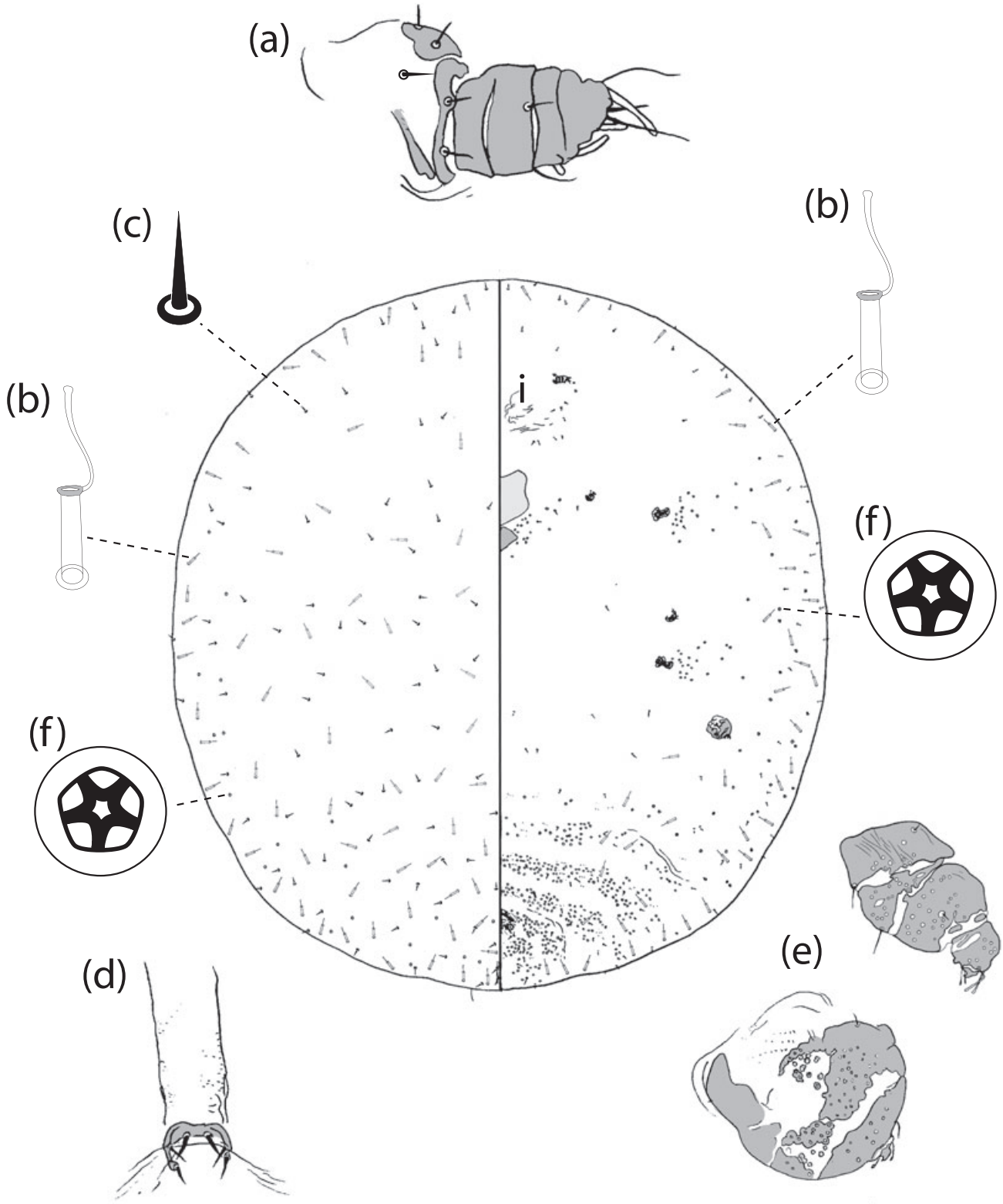

Fig. 17. Adult female of *Fragorbis stipites.* Enlargements show: (a) antenna; (b) macrotubular duct; (c) dorsal seta; (d) anal ring; (e) ventral surface of hind leg; (f) quinquelocular pore; (i) frontal lobes.

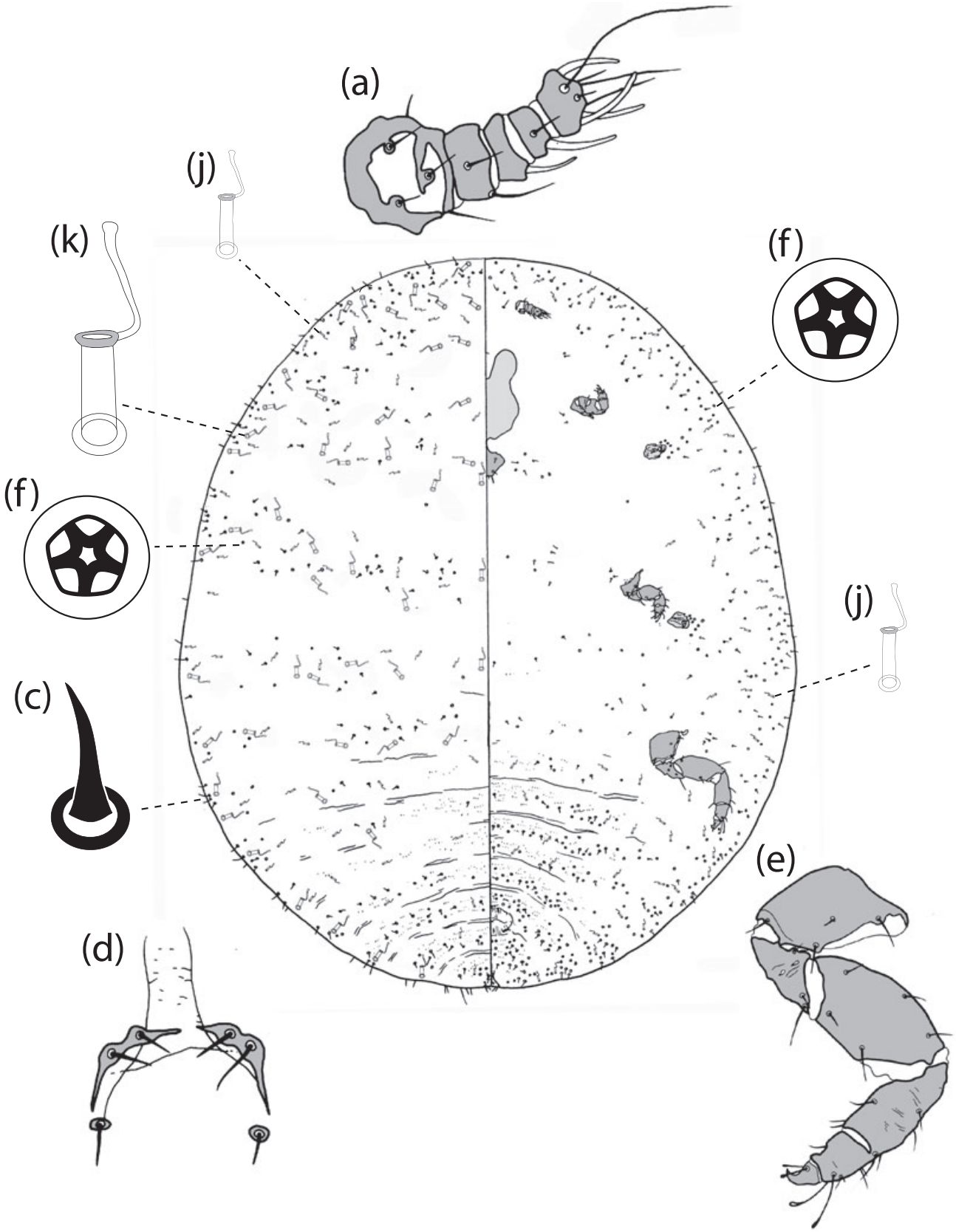

Fig. 18. Adult female of *Fragorbis superfacies*. Enlargements show: (a) antenna; (c) dorsal seta; (d) anal ring; (e) ventral surface of hind leg; (f) quinquelocular pore; (j) small macrotubular duct; (k) large macrotubular duct.

fore or mid legs; translucent pores conspicuous, present on all segments of hind leg; anterior extensions of tentorium poorly developed; quinquelocular disc pores absent on dorsum…… *F. fructus* sp. n.

Fragorbis fructus sp. n. (Fig. 13)

Types. Victoria. Holotype adult female, Lower Plenty, on fruit of *Eucalyptus goniocalyx*, JW Beardsley, V-46, 11.ix.1971 (ANIC); holotype female is on same slide as 1 paratype female and is farthest from the data label and circled.

Paratypes: Victoria, 8 adult females (3 slides, including 1 with holotype), same data as holotype (1 slide ANIC, 2 slides BPBM).

Description. Adult female: Body outline ovate; length 0.92–1.68 (1.68 for holotype) mm, greatest width 0.70–1.30 (1.30 for holotype) mm. Eyes 18–23 μm wide. Antennae (Fig. 13a) 5-segmented, apex composed of 2 incompletely fused segments; length 58–75 μm; with 3 hair-like setae on segment I, 1 or 2 hair-like setae on segment II, 2 hair-like setae on segment III, 1 fleshy seta on segment IV, 6 or 7 hair-like setae + 4 fleshy setae on segment V. Frontal lobes absent. Tentorial box 168–200 μm long, 130–180 μm wide. Labium 75–112 μm long, 87–112 μm wide. Spiracles 50–62 μm long, 20–25 μm wide across atrium. Legs moderately reduced, tibia and tarsus partly fused; fore and mid legs: trochanter + femur 68–100 μm, tibia + tarsus 43–57 μm; hind legs (Fig. 13e): trochanter + femur 125–153 μm, tibia + tarsus 75–95 μm; claw 15–22 μm; coxa with 6 setae, trochanter with 4 setae, femur with 5 setae, tibia with 4 setae, tarsus with 5 setae; tarsal digitules 20–28 μm long, claw digitules 12–18 μm long; translucent pores *ca*. 2 μm in diameter, on every segment of hind leg, *ca*. 125 pores on dorsal surface and *ca*. 35 pores on ventral surface. Anal ring (Fig. 13d) 38–57 μm wide, composed of 4 isolated fragments, surrounding anal opening, each anterodorsal ring fragment bearing a pair of setae, each posteroventral fragment bearing a tight cluster of 1–3 setae; ring setae 15–22 μm long. Pair of elongate caudal setae 50–67 μm long.

Dorsum. Derm membranous. Dorsal setae (Fig. 13c) 12–20 μm long, in a transverse band or row across each body segment. Macrotubular ducts (Fig. 13b) *ca*. 13 μm long, each with distinct oral rim *ca*. 4 μm in diameter; distribution similar to dorsal setae. Quinquelocular disc pores absent.

Venter. Ventral setae 10–15 μm long. Macrotubular ducts same as those on dorsum, dense near margin, sparsely scattered bands across each body segment. Quinquelocular disc pores (Fig. 13e) 5 μm in diameter; a few associated with each spiracle and scattered on posterior abdominal segments with modest concentration near vulva.

Etymology. The species name is from the Latin *fructus*, referring to Beardsley's supposition that the insects were feeding within aborted fruits (see below). It is a noun in apposition.

Notes. *Fragorbis fructus* is most similar to *F. superfacies* sp. n. The only collection for both species was that of JW Beardsley from a single location and host species. In his field notebook, Beardsley recorded his uncertainty as to whether his material of *F. fructus* came from 'small woody galls, or aborted fruit (one with cap-like top)'. His specimens of *F. superfacies* were extracted from crevices in the bark. It is unlikely that the observed morphological differences between *F. fructus* and *F. superficies* are the result of intraspecific polymorphism caused by different host tissue use. The adult female of *F. fructus* can be distinguished from that of *F. superfacies* by its (1) numerous large translucent pores on all segments of the hind legs (*F. superfacies* has only a small cluster of inconspicuous translucent pores on the dorsodistal portion of the hind femur; (2) hind legs with no more setae than fore or mid legs (*F. superficies* has twice as many setae on the hind femur and tibia); (3) absence of quinquelocular pores from dorsum, and scarcity of these pores on venter (*F. superficies* has numerous quinquelocular pores on the dorsum and venter); (4) single size class of macrotubular duct (*F. superfacies* with 2 macrotubular duct size classes); (5) setae up to 45 μm long along posterior body margin (not longer than 25 μm in *F. superfacies*); and (6) absence of conspicuous anterior extensions of the tentorial box (well developed in *F. superficies*). This level of morphological divergence far exceeds that routinely employed to delimit species of scale insects.

Fragorbis pseudopustulans sp. n. (Figs 11,14,15)

Types. New South Wales. Holotype adult female, Micalong Swamp, Tumut-Canberra Road, 35°17′29′S, 148°31′56′E, ex gall on stem of *Eucalyptus camphora* ssp. *humeana*, PJ Gullan, 4.i.2001 (ANIC).

Paratypes: New South Wales. One damaged adult female and 16 first-instar nymphs (2 slides), same data as holotype (ANIC). Victoria. 12 adult females (4 parasitised, one other is DNA voucher NH44), 6 fed first-instar nymphs (3 slides), Tyabb, corner of Whitneys Road and Pikes Road, 38°15′11′S, 145°14′06′E, ex blister gall on stem of *Eucalyptus viminalis*, NB Hardy & PJ Gullan, 15.ii.2005 (ANIC, 2 females in NMV); 2 adult females (DNA vouchers NH37 (parasitised) and NH132), Tyabb, corner of Katandra Road and Lumeah Road, 38°14′54′S, 145°14′26′E, ex *E. viminalis*, NB Hardy & PJ Gullan, 15.ii.2005 (ANIC).

Description. Adult female (Fig. 14)**:** Body outline ovate to oval; length 0.76–1.51 (1.51 for holotype) mm, greatest width 0.58–1.11 (1.11 for holotype) mm. Eyes 14–17 μm wide. Antennae (Fig. 14a) 3- to 4-segmented, 30–43 μm long; 2 or 3 hair-like setae on segment I, 2 or 3 hair-like seta on segment II, 2 hair-like setae on segment III, and *ca*. 6 hair-like setae + 4 fleshy setae on segment IV. Frontal lobes absent. Tentorial box 140–150 μm long, 115–145 μm wide, with anterior extensions each *ca*. 50 μm long. Labium 55–80 μm long, 63–90 μm wide. Spiracles 50–65 μm long, 25–30 μm wide across atrium. Legs moderately reduced, tibia and tarsus partly fused; fore and mid legs: trochanter + femur 35–65 μm, tibia + tarsus 25–45 μm; hind legs (Fig. 14e): trochanter + femur 80–112 μm, tibia + tarsus 42–71 μm; claw 11–20 μm; tarsal digitules increasing in size caudad, 12–31 μm long; claw digitules *ca*. 12. μm long; translucent pores 1–3 μm in diameter: 30–50 pores on dorsal surface of hind coxa, 20–50 pores on ventral

surface of hind coxa, 10–35 pores on dorsal surface of hind femur, 5–15 pores on ventral surface of hind femur, *ca*. 15 on dorsal surface of tibia + tarsus. Anal ring (Fig. 14d) composed of 4–6 fragments, with 6 ring setae, 10–25 μm long, position of the setae on ring fragments variable; anal opening 43–58 μm wide. Elongate caudal setae 30–45 μm long.

Dorsum. Derm of dorsal disc rugose and sclerotic. Dorsal setae (Fig. 14c) 5–20 μm long. Macrotubular ducts (Fig. 14b) 13–16 μm long, oral rim *ca*. 4 μm in diameter. Quinquelocular disc pores (Fig. 14f) *ca*. 5 μm in diameter, very few, on margins only.

Venter. Ventral setae *ca*. 10 μm long. Macrotubular ducts same as those on dorsum, found along margin. Quinqeulocular disc pores 5 μm in diameter; sparsely scattered on abdominal segments, in small clusters around each spiracle.

First-instar nymph (Fig. 15)**:** Body length 235–290 μm, greatest width 140–180 μm. Antennae 5-segmented, 55–60 μm long; 3 hair-like setae on segment I, 2 hair-like setae on segment II, 1 hair-like seta on segment III, 1 hair-like seta + 1 fleshy seta on segment IV, and *ca*. 4 hair-like setae + 3 fleshy setae on segment V. Tentorial box 55–62 μm long, 45–57 μm wide. Labium 32–34 μm long, 25–33 μm wide. Legs well developed: trochanter + femur *ca*. 50 μm, tibia + tarsus *ca*. 45 μm, claw *ca*. 11 μm, tarsal digitules 18–22 μm long, claw digitules 11–14 μm long. Anal ring 11–13 μm wide, simple, without setae or pores. Anal lobes membranous, anal lobe setae as follows: 1 lateral lobe seta similar to those on margin, 2 medial lobe setae more slender than those on margin, close-set, bases contiguous, 1 caudal setae 73–90 μm long, 1 ventral lobe seta *ca*. 10 μm long.

Dorsum. Derm membranous. Dorsal setae (Fig. 15c) *ca*. 10 μm long, digitate; 2 longitudinal rows on each side of body, with 1 seta per row on each body segment, abdominal segment I and metathorax each with an additional seta laterad of longitudinal rows; marginal setae similar to those on dorsum, with *ca*. 10 setae between eyes, *ca*. 10 setae on each side of thorax, 2 setae on each side of abdominal segment I, and 1 seta on each side of abdominal segments II–VIII. Microtubular ducts (Fig. 15g) *ca*. 5 μm long; 1 microtubular duct anterior to close-set setae on each side of abdominal segment VIII, 1 microtubular duct between median and submedian rows of setae on each side of abdominal segment I, metathorax, mesothorax and head.

Venter. Ventral setae 5–12 μm long, in 3 longitudinal rows on each side of abdomen, 1 seta mesad of each coxa. Head with 3 pairs of elongate (15–20 μm) setae posteromedial of antennae. One trilocular disc pore (Fig. 15h) near each spiracle.

Etymology. The species epithet is based on the resemblance of this species to *F. pustulans*. It is a noun in apposition.

Notes. Females of *F. pseudopustulans* live in blister-like galls, each 3–5 mm in diameter, on the trunks, stems, branches or twigs of eucalypt trees and saplings (Fig. 11). *F. pseudopustulans* is very similar to *F. pustulans*. The features used to distinguish between the 2 species are quantitative, namely: (1) the relative numbers of disc pores and macrotubular ducts (*F. pseudopustulans* has many dorsal macrotubular ducts and relatively few quinquelocular disc pores, whereas *F. pustulans* has at most a few dorsal macrotubular ducts confined to areas surrounding the rugose dorsal disc and many disc pores); and (2) the degree to which the dorsal disc is sclerotised (*F. pseudopustulans* has the dorsal disc more heavily sclerotised, whereas younger females of *F. pustulans* may appear to have a membranous dorsum). Both species have been collected from galls on *E. viminalis* at sites within 20 km of each other at similar altitude to the east of Melbourne. Thus, the above morphological differences are unlikely to be either host-related or a consequence of geographical variation.

The first-instar nymph of *F. pseudopustulans* is similar to that of *Subcorticoccus beardsleyi* Gullan in a number of respects, namely: (1) anal ring simple; (2) multilocular disc pores limited to a single trilocular disc pore adjacent to each spiracle; and (3) dorsal setae, at least on margin, with broad apices (Gullan 1999). The first-instar nymph of *F. pseudopustulans* differs in having: (1) dorsal setae digitate (short and conical in *S. beardsleyi*), with a pair of close-set medial lobe setae on either side of the anal ring (absent in *S. beardsleyi*); (2) microtubular ducts present (absent in *S. beardsleyi*); and (3) antennae 5-segmented (6-segmented in *S. beardsleyi*). Close-set medial lobe setae also have been observed on the first-instar nymphs of one undescribed species of *Lachnodius* (NB Hardy, unpubl. data 2007).

An adult eulophid wasp was collected from one of the galls and is slide-mounted (ANIC).

This is the species in Cook and Gullan (2004) referred to as '*Sphaerococcus*' *pustulans.*

Fragorbis pustulans (Green) comb. n. (Fig. 16)

Sphaerococcus pustulans. Green, 1905: 7,8; Miller *et al*., 1998: 298,299; Gullan *et al*., 2005: 205.

Types. Victoria. Lectotype adult female, Myrniong, ex *E. goniocalyx*, J Lidgett, no. 52 (BMNH); this specimen is here designated as the lectotype in order to fix and stabilise the current concept of the name; the slide has been examined and labelled, with the lectotype circled and closest to the parasitoid larva farthest from the data label.

Paralectotypes: Victoria, 5 adult females and 2 parasitoid larvae, same data and slide as lectotype (BMNH), 1 adult female and dry material consisting of galls on a piece of bark (Fig. 12), Myrmiong[sic], on bark of *E. goniocalyx*, J Lidgett, ex coll. EE Green (slide also with #14642) (USNM). The lectotype is a mature adult female but was selected in preference to one of the younger females on the slide because it provided the best view of the anterior extensions of the tentorial box and the dorsal sclerotisation.

Additional material examined. Victoria. 2 adult females, Mt Eliza, ex blister gall on bark of *E. viminalis*, JW Beardsley, 22.v.1972 (BPBM); 3 adult females (including DNA vouchers NH35 and NH126) and 2 second-instar females, Cranbourne, Royal Botanic Gardens Cranbourne, Possum Gully Track, 38°08′00′S, 145°16′45′E, ex blister galls on bark of *E. viminalis*, PJ Gullan, 9.ii.2005 (ANIC).

Description. Adult female: Body outline ovate; length 1.20–3.10 (2.0 for lectotype) mm, maximum width 0.99–2.56

(2.11 for lectotype) mm. Eyes *ca*. 17 µm wide. Antennae (Fig. 16a) 3- to 5-segmented, 35–70 µm long; 3 hair-like setae on segment I, 2 hair-like seta on segment II, 2 hair-like setae on segment III, 1 fleshy seta on segment IV and *ca*. 6 hair-like setae and 3 fleshy setae on segment IV. Frontal lobes absent. Tentorial box 150–230 µm long, 137–178 µm wide, with anterior extensions each *ca*. 100 µm long. Labium 80–95 µm long, 92–133 µm wide. Spiracles 52–75 µm long, 30–50 µm wide across atrium. Legs moderately reduced; fore and mid legs: trochanter + femur 57–92 µm, tibia + tarsus 40–58 µm; hind legs (Fig. 16e): trochanter + femur 105–125 µm, tibia + tarsus 65–80 µm; claw 15–27 µm; tarsal digitules 20–30 µm long, claw digitules 15–20 µm long; translucent pores *ca*. 3 µm in diameter on hind coxa, *ca*. 1 µm in diameter on other segments of hind leg, *ca*. 30 pores on dorsal surface of hind coxa, *ca*. 25 pores on ventral surface of hind coxa, *ca*. 20 pores on dorsal surface of hind femur, *ca*. 10 pores on dorsal surface of hind tibia + tarsus. Anal ring (Fig. 16d) divided into 3 or 5 fragments, with 6 anal ring setae 15–39 µm long, position of setae on ring fragments variable; anal opening 50–90 µm wide. Pair of caudal setae each *ca*. 35 µm long.

Dorsum. Derm of dorsal disc rugose and sclerotic, may appear membranous in younger females. Dorsal setae (Fig. 16c) 10–23 µm long. Macrotubular ducts (Fig. 16b) *ca*. 14 µm long, oral rim *ca*. 4 µm in diameter, sparse, confined to area near sclerotic disc (may be completely absent). Quinquelocular disc pores (Fig. 16f) evenly distributed.

Venter. Ventral setae 7–18 µm long. Macrotubular ducts absent. Quinquelocular disc pores dense and evenly distributed.

Etymology. The name of this species clearly was derived from 'pustula', which is Latin for 'blister' (see below).

Notes. Green (1905: 7) provides the following description of the species in life: 'Female insects living beneath flattish blister-like swellings on surface of bark. An isolated pustule measures 4–5 mm in diameter, is roughly circular, with a small median pore. The walls of the cell are stout, and of a corky nature. The cavity is comparatively small, and lined with a whitish film. When crowded the pustules become confluent, and lose their circular form.' Figure 12 is a photograph of some of the original galls studied by Green. *Fragorbis pustulans* is most similar to *F. pseudopustulans* (see comments under that species). The species in Cook and Gullan (2004) referred to as '*Sphaerococcus*' *pustulans* is actually *F. pseudopustulans.*

Fragorbis stipites sp. n. (Fig. 17)

Type. Victoria. Holotype adult female: Cardinia Reservoir, Crystal Brook Park, Narre Warren East, under bark of *Eucalyptus cephalocarpa*, DJ Williams & PJ Gullan, W55, 19.x.1978 (ANIC).

Paratype: Victoria. 1 parasitised adult female: Cardinia Reservoir Park, Duffys Lookout Picnic area, 37°57′57′S, 145°23′20′E, under bark of unidentified eucalypt, NB Hardy & PJ Gullan, 13.ii.2005 (ANIC).

Description. Adult female: Body outline almost circular, length 2.1–3.86 (3.86 for holotype) mm, greatest width 1.7–3.52 (3.52 for holotype) mm. Eyes *ca*. 20 µm wide. Antennae (Fig. 17a) 6-segmented; length 75–92 µm; with 2 or 3 hair-like setae on segment I, 1 or 2 hair-like setae on segment II, 0 or 1 setae on segment III, 2 hair-like setae on segment IV, 1 fleshy seta on segment V, and *ca*. 4 hair-like + 3 fleshy setae on segment VI. Frontal lobes (Fig. 17i) broad and flat, posteromedial of antennae, appearing as 2 areas of convoluted cuticle, *ca*. 75 µm wide. Tentorial box 192–257 µm long, 170–270 µm wide. Labium *ca*. 175 µm long, 110–159 µm wide. Spiracles 62–95 µm long, 25–40 µm wide across atrium. Holotype with legs reduced to hemispherical lobes, composed of fragmented, ring-like segments; hind legs (Fig. 17e) (118, 105 µm wide, *ca*. 100 µm long) much larger than fore (50, 46 µm wide*) or mid legs (55, 50 µm wide); paratype with legs not as reduced, segments clearly differentiated; fore legs *ca*. 40 µm long; mid legs *ca*. 55 µm long; hind legs (Fig. 17e) *ca*. 110 µm long, hind tibia + tarsus globose, *ca*. as long as inner margin of hind trochanter; claw 9 µm long; tarsal digitules truncate, 10–14 µm long; claw digitules *ca*. 5 µm long; translucent pores 1–3 µm in diameter, total of 60–100 on both surfaces of each hind leg. Anal ring (Fig. 17d) 25–30 µm wide, open posteroventrally, slightly invaginated into dorsal surface, bearing 6 setae, *ca*. 10 µm in length. Caudal setae 17–35 µm long.

Dorsum. Derm membranous. Dorsal setae (Fig. 17c) *ca*. 5 µm long. Macrotubular ducts (Fig. 17b) *ca*. 10 µm long, orifice with distinct rim 4 µm in diameter; found along margin and in transverse row across each body segment. Quinquelocular disc pores (Fig. 17f) 6 µm in diameter, distributed around posterior margin.

Venter. Setae similar to those on dorsum, 10–14 µm long. Macrotubular ducts similar to those on dorsum; in transverse row across each of abdominal segments IV–VIII and throughout margin and submargin. Quinquelocular disc pores dense around vulva, clustered around each spiracle and mouthparts. *Leg length could not be measured because of the orientation of the fore and mid legs.

Etymology. The species name comes from the Latin word for 'stumps', referring to the stumpy legs of this species.

Notes. *Fragorbis stipites* is not likely to be confused with any other species of *Fragorbis*. The extremely reduced legs and slightly invaginated, U-shaped anal ring are unmistakable. The type locality, Crystal Brook Park at Cardinia Reservoir, is now part of Cardinia Reservoir Park and is known now as Crystal Brook Picnic Area. The paratype female was collected at the adjacent Duffys Lookout Picnic Area.

Fragorbis superfacies sp. n. (Fig. 18)

Types. Victoria. Holotype adult female, Lower Plenty, on bark of *E. goniocalyx*, JW Beardsley, V-44, 11.ix.1971 (ANIC); holotype female is on the same slide as 2 paratype females and is the circled middle specimen.

Paratypes: Victoria, 15 adult females, same data as holotype (5 slides in BPBM, 1 slide with 2 paratype females + holotype in

ANIC); 3 adult females (2 slides), same data as holotype except V-74, 23.ix.1971 (BPBM).

Description. Adult female: Body outline ovate; length 1.12–1.92 (1.90 for holotype) mm, greatest width 0.82–1.50 (1.45 for holotype) mm. Eyes *ca*. 15 μm wide. Antennae (Fig. 18a) 6-segmented, 60–67 μm long; 3 hair-like setae on segment I, 2 hair-like setae on segment II, 2 hair-like setae on segment III, 1 fleshy seta on segment IV, 1 hair-like seta + 1 fleshy seta on segment V, and *ca*. 6 hair-like setae + 3 fleshy setae on segment VI. Frontal lobes absent. Tentorial box 142–175 μm long, 125–142 μm wide, with anterior extensions *ca*. 70 μm long. Labium 62–75 μm long, 88–105 μm wide. Spiracles 42–60 μm long, 18–25 μm wide across atrium. Legs moderately reduced, tibia and tarsus partly fused; fore and mid legs: trochanter + femur 47–75 μm, tibia + tarsus 37–57 μm, claw 12–17 μm; hind legs (Fig. 18e): trochanter + femur 135–167 μm, tibia + tarsus 105–130 μm, claw 20–27 μm; fore coxa with 5 setae, mid coxa with 6 setae, hind coxa with 7 setae, trochanter with 4 setae, fore and mid femur each with 4 setae, hind femur with *ca*. 10 setae, fore and mid tibia each with 4 or 5 setae, hind tibia with 8 setae, tarsus with 3 or 4 setae; tarsal digitules on fore and mid legs each 20–30 μm long, those on hind legs 30–40 μm long; claw digitules on fore and mid legs each 12–17 μm long, those on hind legs 13–25 μm long; translucent pores minute or indiscernible, less than 1 μm in diameter, confined to dorsodistal portion of hind femora. Anal ring (Fig. 18d) composed of 2 conspicuous anterodorsal fragments, each with a pair of setae, and 2 smaller posteroventral fragments each with a single seta; ring setae 11–25 μm long, anal opening 37–48 μm wide. Pair of elongate caudal setae 27–33 μm long.

Dorsum. Derm membranous. Dorsal setae (Fig. 18c) *ca*. 10 μm long. Macrotubular ducts of 2 size classes: larger ducts (Fig. 18k) 15–17 μm long, oral rim *ca*. 10 μm in diameter; smaller ducts (Fig. 18j) 8–10 μm long, oral rim *ca*. 2.5 μm in diameter; both duct types evenly distributed over dorsum. Quinquelocular disc pores (Fig. 18f) 5 μm in diameter.

Venter. Ventral setae 10–15 μm long. Macrotubular ducts same as smaller ducts on dorsum; in a transverse row across each abdominal segment and scattered around margin. Quinquelocular disc pores distributed across each body segment.

Etymology. The species name comes from Latin term *superfacies*, meaning surface and referring to the feeding site on the outside of *Eucalyptus* bark. It is a noun in apposition.

Notes. *Fragorbis superfacies* most resembles *F. fructus* (see comments under *F. fructus*). In Beardsley's field notebook, he remarks that the adult females were found in bark crevices, producing cottony ovisacs, and that they were tended by ants. In the slide-mounted material several elongate glassy filaments, each arising from one of the larger macrotubular ducts, have been preserved. The longest of these filaments exceed 1/3 of the body length. These filaments were not detected in slide-mounted material of the other species of *Fragorbis*. This absence may not reflect a true difference in life, but may have resulted from the slide-mounting process (there are several specimens of *F. superfacies* in which glassy filaments have not been detected). It is also possible that the glassy filaments are unique to the larger macrotubular ducts of *F. superfacies*, which is the only species of *Fragorbis* to have 2 size classes of macrotubular duct, neither of which is similar in size to the macrotubular ducts of the other *Fragorbis* species (the smaller ducts of *F. superfacies* have an oral rim diameter close to half that found in other species of *Fragorbis*).

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