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Singhiella melanolepis, a new species of whitefly (Hemiptera: Aleyrodidae) from Taiwan with remarks on the genus *Singhiella* Sampson

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Abstract

The adult male, female and puparium of *Singhiella melanolepis* sp. nov. are described from *Melanolepis multiglandulosa* (Euphorbiaceae), together with scanning electron micrographs and figures. Comparisons are made between the puparium of this species and that of *Singhiella elaeagni* (Takahashi 1935), and remarks are provided on the genus *Singhiella* Sampson. After consideration of the diversity in adult structure among the species of *Singhiella*, it is suggested that this genus may be defined unsatisfactorily, and that more importance should be placed on adult morphology in whitefly taxonomy.

Key words. Hemiptera, Aleyrodidae, *Singhiella*, adults, new species

Introduction

The whitefly genus *Singhiella* was described by Sampson (1943) for *Trialeurodes bicolor* Singh. Prior to the year 2000 this genus was represented by only five species (Qureshi & Qayyam 1969; Mound & Halsey 1978; Qureshi 1979; Chou & Yan 1988; Martin 1999). However, as a result of a cladistic analysis of a large subset of species of *Dialeurodes sensu lato*, Jensen (1999, 2001) indicated that the whitefly species formerly accommodated in *Dialeurodes* in U.S.A. could be divided into three genera. Appropriate existing generic names were assigned to these groups, based on the placement of the type species of *Dialeurodes* Cockerell, *Massilieurodes* Goux and *Singhiella* Sampson. Species were assigned to each of these genera based on their placement in the cladograms and the original descriptions. As defined by Sampson (1943) and redefined by Qureshi (1979), Martin (1999) and Jensen (2001), *Singhiella* now comprises 29 described species (Table 1). A new species of this genus from Taiwan is described here that has been found only on *Melanolepis multiglandulosa* (Euphorbiaceae). A detailed study of the structural features of the puparium and adults of this species indicate that its inclusion in *Singhiella* Sampson as currently understood is appropriate. Moreover, a comparison is made of the characteristic features of the pupal case of the new species with those of the closely related species, *S. elaeagni* (Takahashi). Furthermore, remarks are provided on the genus *Singhiella* Sampson.

Material and methods

Puparia of the new species were collected in the field, and a colony was established in the laboratory. Specimens for scanning electron microscopy were removed from the host plants and washed in 95% ethanol with an ultrasonic mini-cleaner at 50–60 Hz for 2 min, dehydrated in 95% ethanol, and finished in 100% ethanol. Specimens were then critical-point-dried using CO_2 as a transfer fluid, mounted on stubs, sputter-coated with a gold-palladium alloy, and examined with a scanning electron microscope (JEOL JSM-5600, Japan) in the

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Department of Entomology, National Taiwan University, Taiwan. Descriptions and terminology of the external and internal morphological structures are based on those of Bink-Moenen (1983), Martin (1985), Gill (1990), Guimarães (1996) and Jensen (2001). Measurements were made of 5 specimens of each stadium.

TABLE 1. The fauna of whitefly genus *Singhiella* of the world*.

	Species	Author	Depositories	Country	Citation
1.	*S. bassiae*	(David & Subramaniam 1976)	ZSI	India	Jensen 2001
2.	*S. bicolor*	(Singh 1931)	BMNH	India	Jensen 2001
3.	*S. brideliae*	(Jesudasan & David 1991)	IDAV	India	Jensen 2001
4.	*S. cambodiensis*	(Takahashi 1942b)	?	Cambodia	Jensen 2001
5.	*S. cardamomi*	(David & Subramaniam 1976)	IDAV	India	Jensen 2001
6.	*S. chinensis*	(Takahashi 1941)	?	Hong Kong	Jensen 2001
7.	*S. chitinosa*	(Takahashi 1937)	TARI	Taiwan	Jensen 2001
8.	*S. citrifolii*	(Morgan 1893)	BMNH	USA	Jensen 2001
9.	*S. crenulata*	Qureshi & Qayyam 1969	?	Pakistan	Qureshi & Qayyam 1969
10.	*S. delamarei*	(Cohic 1968)	?	Congo	Jensen 2001
11.	*S. denticulata*	Qureshi 1979	?	Pakistan	Qureshi 1979
12.	*S. dioscoreae*	(Takahashi 1934)	TARI	Taiwan	Jensen 2001
13.	*S. dipterocarpi*	(Takahashi 1942b)	TARI	Thailand	Jensen 2001
14.	*S. elaeagni*	(Takahashi 1935)	TARI	Taiwan	Jensen 2001
15.	*S. elbaensis*	(Priesner & Hosny 1934)	BMNH	Egypt	Jensen 2001
16.	*S. ficifolii*	(Takahashi 1942b)	TARI	Thailand	Jensen 2001
17.	*S. kuraruensis*	(Takahashi 1933)	TARI	Taiwan	Jensen 2001
18.	*S. longisetae*	Chou & Yan 1988	EMNAFU	China	Chou & Yan 1988
19.	*S. malabaricus*	(Jesudasan & David 1991)	IDAV	India	Jensen 2001
20.	*S. mekoensis*	(Takahashi 1942b)	TARI	Thailand	Jensen 2001
21.	*S. melanolepis* **sp. nov.**	Chen & Ko	NTU	Taiwan	-
22.	*S. pallida*	(Singh 1931)	ZSI	India	Jensen 2001
23.	*S. piperis*	(Takahashi 1934)	TARI	Taiwan	Jensen 2001
24.	*S. premnae*	Martin 1999	ANIC	Australia	Martin 1999
25.	*S. serdangensis*	(Singh 1931)	?	Malaya	Jensen 2001
26.	*S. subrotunda*	(Takahashi 1935)	TARI	Taiwan	Jensen 2001
27.	*S. sutepensis*	(Takahashi 1942a)	TARI	Thailand	Jensen 2001
28.	*S. tetrastigmae*	(Takahashi 1934)	TARI	Taiwan	Jensen 2001
29.	*S. vanieriae*	(Takahashi 1935)	TARI	Taiwan	Jensen 2001

***** In some website or papers, *Singhiella tricolor* (Singh 1931) was described as type species of genus *Singhiella*. After the affirmance from the original papers and Gregory Evans (USDA/APHIS/PPQ c/o Systematic Entomology Laboratory), *Singhiella tricolor* (Singh) does not exist, and the name *Singhiella tricolor* was an error.

Specimen depositories

ANIC Australian National Insect Collection, CSIRO Entomology, Canberra, Australia
BMNH The Natural History Museum, London, UK
EMNAFU Entomological Museum, Northwestern A & F University, Shaanxi, China
IDAV Personal Collection of B. V. David, India

NTU	National Taiwan University, Taipei, Taiwan
TARI	Taiwan Agricultural Research Institute, Taichung, Taiwan
USNM	United States Department of Agriculture, Beltsville, MD, USA (Sternorrhyncha collections of the United States National Museum of Natural History, Washington DC)
ZSI	Zoological Survey of India, Kolkata, India

Generic diagnosis

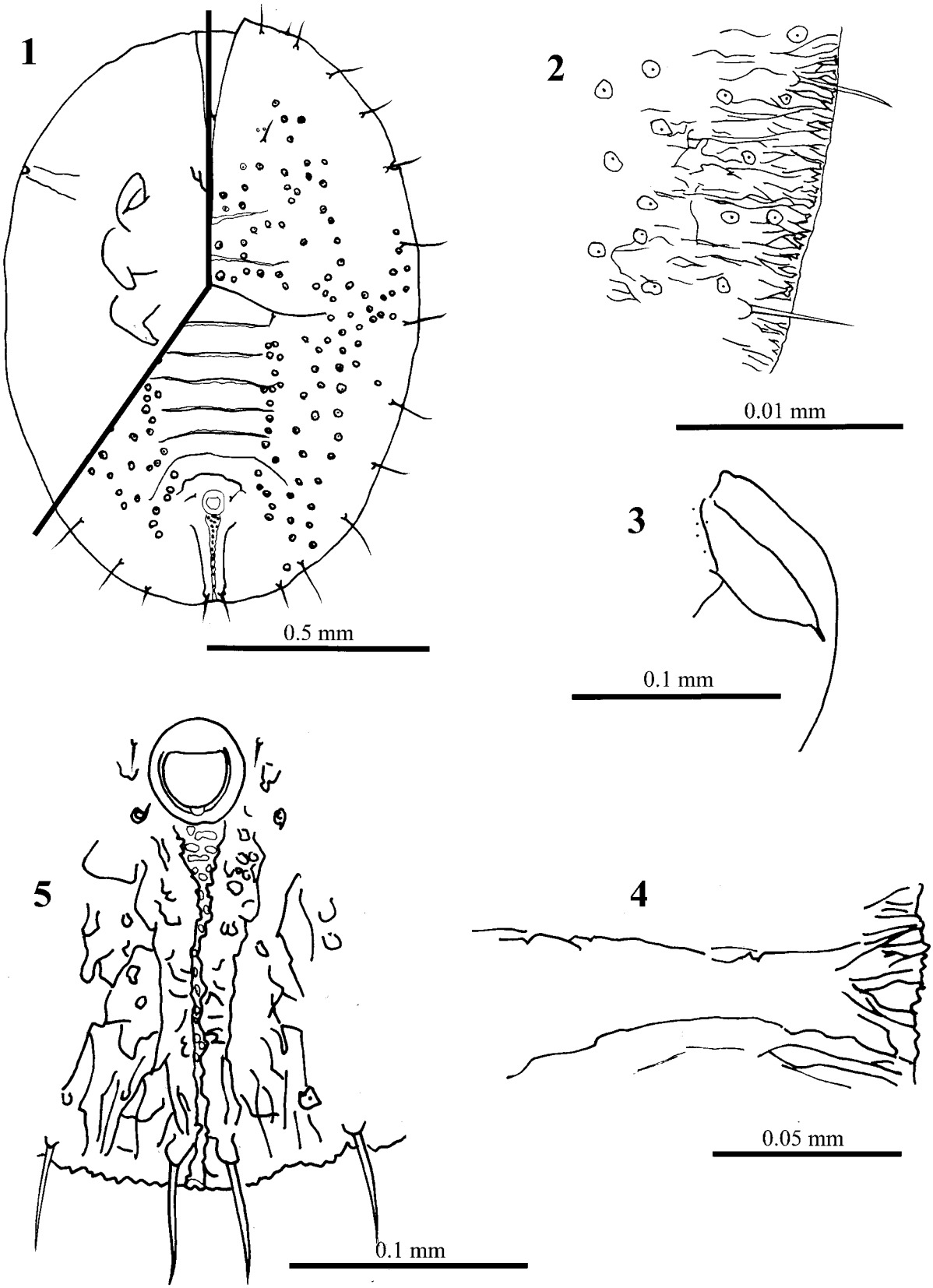
As originally defined by Sampson (1943), species of the genus *Singhiella* possess the following character states: Pupal case usually large in size, elliptical in shape. Margin with one row of teeth and submarginal area not separated from dorsal disc, with a row of significant setae. Thoracic tracheal folds and pores usually present; caudal fold distinct. Dorsum covered with circular, raised papilla-like pores. Vasiform orifice and operculum subsemicircular, lingula usually exposed.

Jensen (2001), in redefining *Singhiella* to include several species from the *Dialeurodes*-group, indicated the following combination of character states: Some or all dorsal pores situated on round papillae (which may be very shallow); outer edges of legs without ornamentation; front and middle legs not contiguous; usually with three or more pairs of dorsal pores on abdominal segment I; often with minute basal spinules on antennae.

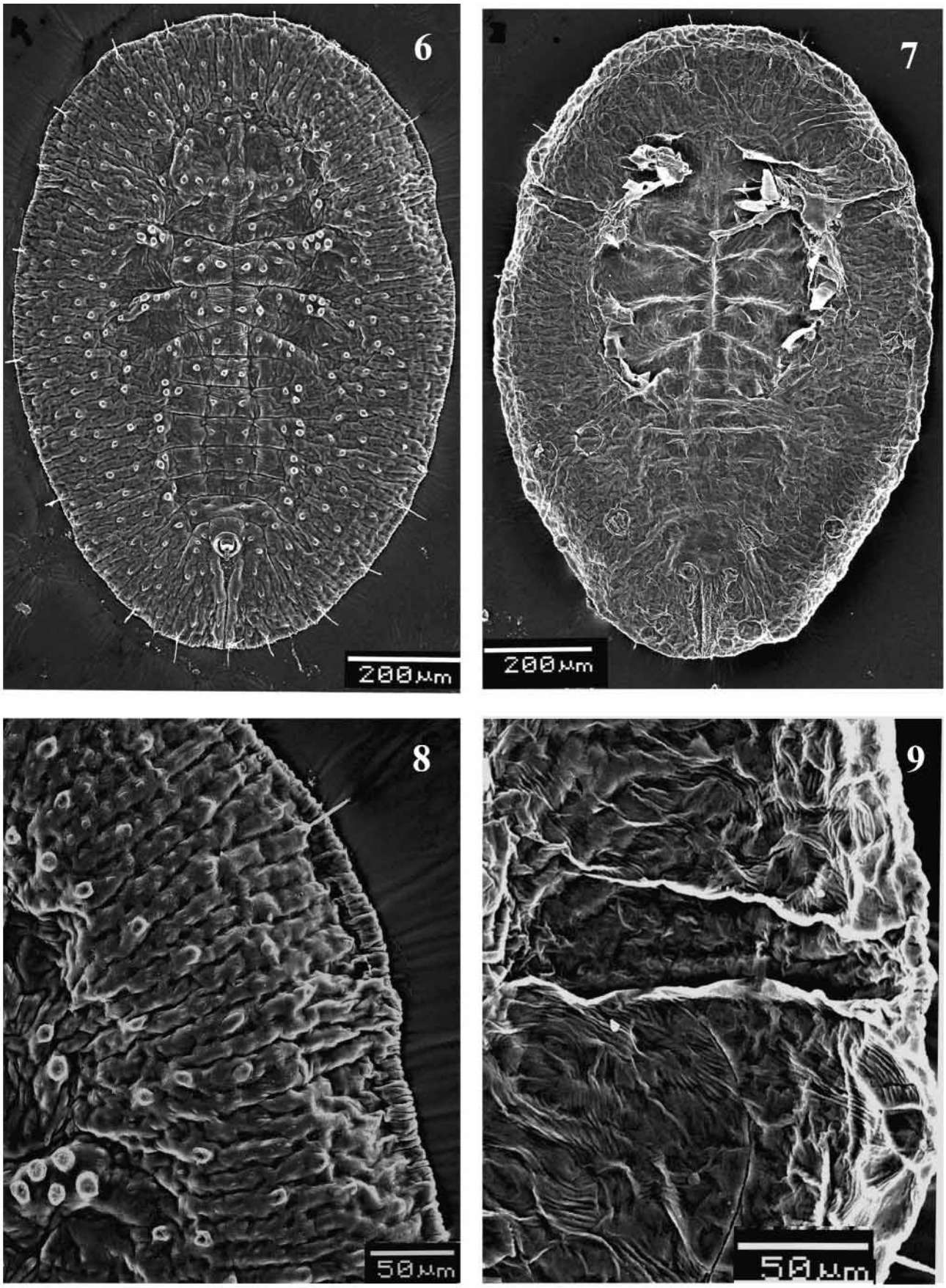
Singhiella melanolepis **Chen & Ko sp. nov. (Figs 1–36)**

PUPARIUM (Figs 1–11). Found in groups on the undersurface of leaves. Pale to yellowish, but generally colourless when slide-mounted. Most pupae without, or with only a little, waxy secretion. Pupal case average 1.35 mm long, 1.05 mm wide, elongate to ovoid, broadest at first abdominal segment. Margin more or less smooth, or with faint crenulations marked by short radiating ridges, about 24 ridges per 100 μm. Ends of thoracic and caudal tracheal folds not evident and marked by short smooth areas in margin (Fig. 2). ***Dorsum***. More-or-less flat, with raised rachis or other ridges, usually on cephalothorax and dorsal disc, abdominal tergites I–VII without median tubercle but subdorsal tubercles on cephalothorax and on each side of tergites III–VI. Sculpturing of fine papillae and inscriptions, in subdorsal areas arranged in less radiating rows of papillae; sculpturing sometimes highly reduced. Longitudinal moulting suture more or less straight, reaching margin. Transverse moulting suture reaching a point just above or slightly beyond lateral margins of hind legs; ends of suture with distinct raised areas or clusters of papillae, slightly posterior relative to middle of suture. Eighth abdominal segment subequal to seventh in length. Disc pores and associated porettes scattered over dorsum; each pore/porette pair not close together, pores uniformly mounted on tubercles or papillae but porette not. ***Setae***. Marginal setae pointed, on anterior and posterior margins, anterior pair 0.02 mm long, posterior pair 0.045 mm long. Twelve pairs of submarginal setae (Figs 2, 8) of nearly uniform length, 0.05 mm; sixth submarginal setae usually in line with other submarginal setae and not inset medially to nearly above middle leg; twelfth pair of submarginal setae not inset on caudal ridges. Cephalic setae 0.025 mm long, distinctly forward of mouthparts. First abdominal setae present. Eighth abdominal setae laterad of vasiform orifice, more or less in line with anterior margin. Caudal setae slightly anterior to margin, 0.5 mm long. ***Vasiform orifice*** (Figs 5, 10). More or less trapezoidal to almost circular, 0.06 mm long and 0.055 mm wide, middle of posterior margin not broken, often with loose tile-like structures in notched area; inner margin often with faint ridges radiating into orifice; operculum equal in size to vasiform orifice and similar in shape, nearly filling orifice, usually without posterior part distinctly narrowed; lingula exposed, without setae, almost included, except a small part of posterior end exposed outside. ***Caudal furrow*** (Figs 5, 10). With a larger tile-like structure, 0.225 mm long, less wide than vasiform orifice anteriorly, abruptly narrowed posteriorly, reaching margin; furrow lined with large granules in more or less transverse rows on wide part, more scattered on narrow part. Caudal ridges

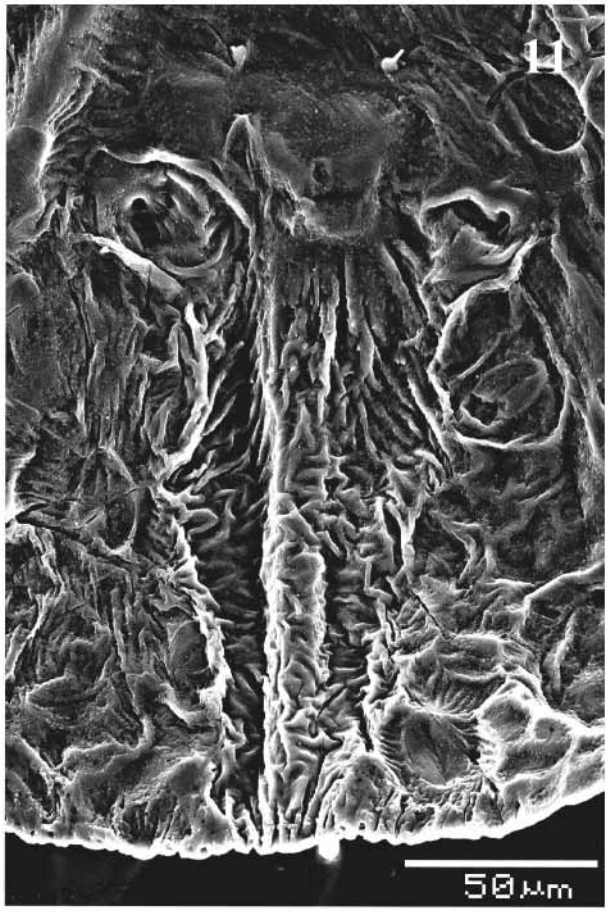
apparently slightly raised above adjacent derm, especially posteriorly. Area lateral to vasiform orifice and caudal furrow without spinules.



FIGURES 1–5. *Singhiella melanolepis* **sp. nov.**, puparium. 1, dorsal and ventral view; 2, margin; 3, antenna; 4, thoracic tracheal fold; 5, vasiform orifice and caudal furrow.



FIGURES 6–9. Photomicrographs, *Singhiella melanolepis* **sp. nov.** 6, dorsal view; 7, ventral view; 8, dorsal view of thoracic tracheal pore; 9, thoracic tracheal fold.



FIGURES 10–11. Photomicrographs, *Singhiella melanolepis* **sp. nov.** 10, vasiform orifice and caudal furrow; 11, caudal fold.

Ventral surface (Figs 4, 7, 9, 11). Thoracic and caudal tracheal folds usually distinguishable but entirely smooth; caudal fold with a few short rows of minute spinules extending about half way to margin from vasiform orifice. Ventral setae finely pointed, posterior pair just anterior to vasiform orifice. One small, fine seta mesad of each leg, normally 2 minute setae on or near basal curve of each leg, often difficult to see. Legs curved laterally, front and middle legs on each side closely apprised; posterolateral margin of front legs and lateral margins of middle and hind legs without spinules. Antenna located just mesad of front leg, 0.07 mm, terminal process 7.5 µm, lacking spinules at base, with a minute seta basally. Rostrum short, conical. Four pairs of spiracles present, 2 near posterior part of front and middle legs, one just beyond hind legs on anterior abdomen and one just laterad of vasiform orifice.

ADULT MALE (Figs 12–18, 28, 32–34). Yellowish to brown when alive, with a light dusting of wax. Middle and distal end of forewing with four dusky spots. Yellowish when mounted, except extreme tip of rostrum and thorax brown. Average body length 1.5 mm (included claspers). Essentially entire body covered with minute setae. ***Head***. With scattered minute setae with short cylindrical bases. Width across eyes 0.3 mm. Rostral IV 0.125 mm measured along longest edge, with 15–20 setae. ***Antennae*** (Figs 12, 28). Inserted in median indentation of compound eyes; segment I less than half as long as II; segment II with several scattered setae of various sizes; segment III 0.125 mm, with 2 primary sensoria apically, one about its width basad of other, one bidirectional sensorial cone more basad 0.045 mm; segment IV 0.02 mm; V 0.045 mm, with one primary sensorium apically; VI 0.03 mm, with one bidirectional sensorial cone near middle, about as long as sensorial cone on segment III; VII 0.0325 mm, with one primary sensorium a little beyond middle of segment and one sensorial cone 0.015 mm in basal third of segment, apical spine 0.02 mm; apparent annulations of

antenna composed of very close-set setulae. ***Compound eyes*** (Figs 13, 32). Constricted laterally, dorsal and ventral parts connected by 2 facets; ventral facets about 50% larger than dorsal facets. Lateral ocelli abut dorsal margin of compound eyes, about twice as wide as dorsal eye facets. ***Thorax***. Sclerotized plates typical for aleyrodine adults. Wings with a patch of maculation in middle and near distal end. ***Legs***. Coxa 1, 0.145 mm; femur 1, 0.2 mm, femur 2, 0.2 mm, femur 3, 0.263 mm, including dorsal tooth-like projection at extreme apices, femur 3 with 3 strong subapical spines dorsally; tibia 1, 0.263 mm, with about 45 setae and no tibial brushes, tibia 2 (Fig. 14), 0.3 mm with 1 tibial brush with 2 setae and sometimes a third seta close but slightly basad, tibia 3 (Fig. 15), 0.385 mm with about 12 setae in tibial comb, without tibial brush, and with a distinct nonsetose area basad of apical spines; tarsal segment I with following lengths and setae (tarsi 1, 2, 3): 0.105 mm with 6–8 setae, 0.105 mm with 8–10 setae, 0.12 mm with 7–9 setae; tarsal segments II with following lengths and setae (tarsi 1, 2, 3): 0.0875 mm with 7–8 setae, 0.08 mm with 4 setae, 0.0875 mm with 4 or 5 setae; hind tarsal claw 0.0375 mm. ***Abdomen***. Ventral surface with 4 pairs of wax plates on segments II–V (Fig. 17), length/width of plate on segment II = 0.08 mm/0.12 mm, III = 0.0575 mm/0.13 mm, IV = 0.0575 mm/0.125 mm, V = 0.053 mm/0.10 mm. Each wax plate with 2 pairs of setae inward but 1 pair outward. ***Genital capsule*** (Fig. 18). 0.113 mm long and 0.165 mm wide. ***Vasiform orifice*** (Fig. 18). Oval, wider than long, lingula 0.002 mm; capsule with 5–6 pairs of dorsal setae, lateralmost setae distinctly thinner and shorter than more medial pairs, most medial pair thinner than thick middle pair. ***Clasper*** (Figs 18, 33–34). 0.1 mm, with five pairs of dorsal setae, and four and three pairs of setae present on inner and outer surfaces respectively, small rounded tooth on medial surface subapically. Aedeagus 0.1 mm, curved up apically and forked at end.

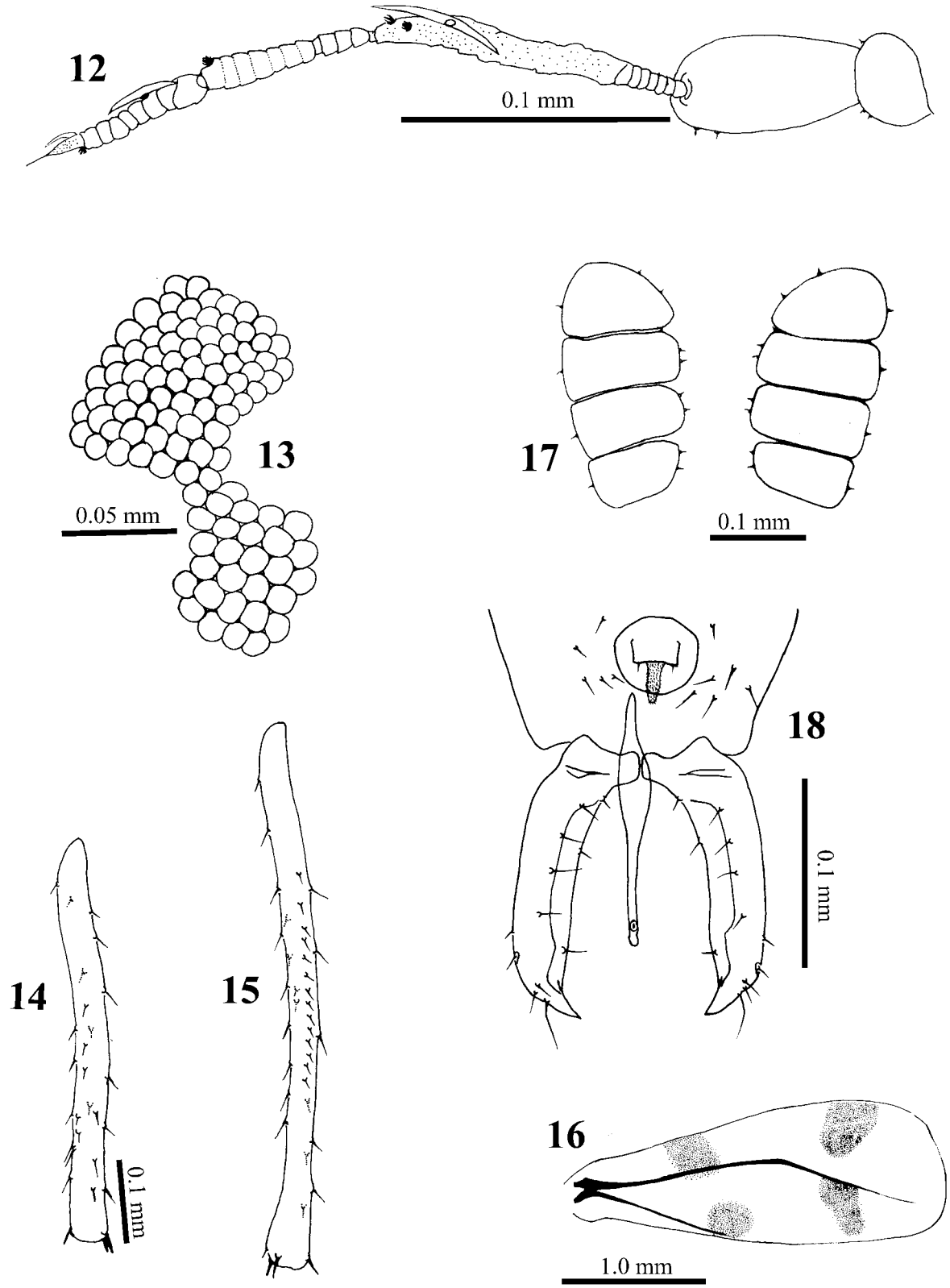
ADULT FEMALE (Figs 19–27, 29, 35–36). Colour as in male. Body length 2 mm. ***Head***. Width across eyes 0.4 mm. ***Antennae***. (Figs 19, 29). Inserted in median indentation of compound eyes; segment I less than half as long as II, segment II with several scattered setae of various sizes; III 0.138 mm, with 2 primary sensoria apically, one just distad of other and one bidirectional sensorial cone more basad 0.06 mm; IV 0.025 mm; V 0.043 mm, with one primary sensorium apically; VI 0.045 mm, with one bidirectional sensorial cone near middle, about as long as sensorial cone on segment III; VII 0.04 mm, with one primary sensorium a little beyond middle of segment and one sensorial cone 0.05 mm on basal third of segment, apical spine 0.015 mm. Rostral IV 0.135 mm measured along longest edge, with 15–20 setae. ***Compound eyes*** (Fig. 20). Constricted laterally, dorsal and ventral parts connected by 2 facets. ***Legs***. Coxa 1, 0.163 mm; femur 1, 0.25 mm, femur 2, 0.24 mm, femur 3, 0.30 mm with a strong subapical spine dorsally; tibia 1, 0.14 mm, tibia 2 (Fig. 21), 0.16 mm, tibia 3 (Fig. 22), 0.22 mm with about 16 setae in tibial comb and with a brush with 3 setae; tarsal segment I with following lengths and setae (tarsi 1, 2, 3): 0.11 mm with 10 setae and a strong subapical spur, 0.1 mm with 8–9 setae, 0.125 mm with 6 setae; tarsal segment II with following lengths and setae (tarsi 1, 2, 3): 0.10 mm with 7 or 8 setae, 0.09 mm with 7 setae, 0.10 mm with 4 setae; hind tarsal claws 0.025 mm, paronychium 0.04 mm. ***Abdomen***. Ventral surface with 2 pairs of wax plates (Fig. 24) on segments II and III, length/width of plate on segment II = 10.118 mm/0.175 mm, III = 0.113 mm/0.180 mm. Each wax plate with 2 inner but 1 outer pairs of setae. ***Vasiform orifice*** (Fig. 25). With lingula 0.03 mm. ***Genitalia*** (Figs 26–27, 35–36). With lateral ovipositor 0.095 mm, measured as shown in Fig. 26, with 4 setae; middle ovipositor 74–84 mm, with 2 setae. The cement gland slightly segmented (Fig. 27).

Material examined. Holotype puparium, TAIWAN, Chiao-chi, on *Melanolepis multiglandulosa* (Euphorbiaceae), 22-III-2006, C. H. Chen and Y. T. Shih (TW 2961) (NTU). **Paratypes:** 26 pupal cases, 7 males, 8 females, same data as for holotype (ANIC; BMNH; EMNAFU; IDAV; NTU; TARI; USNM; ZSI).

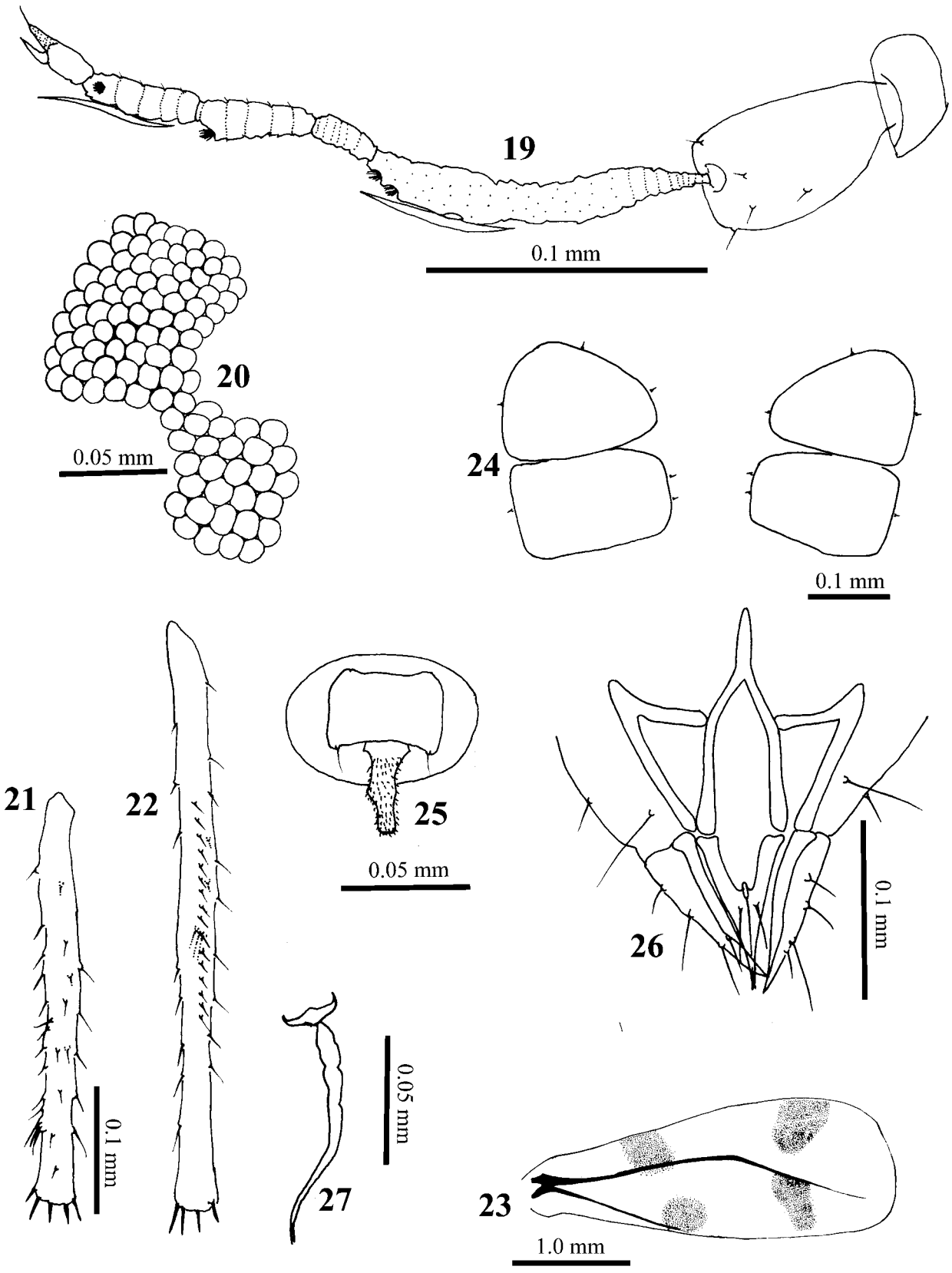
Etymology. The species name *melanolepis* is derived from the host plant genus.

Biology. This species has been collected only once, and is of no known economic importance. No ant attendance was observed, but mixed populations of *Aleurodicus dispersus* Russell were observed on the lower leaf surfaces. Based on the distribution of *Melanolepis multiglandulosa* (Euphorbiaceae), this whitefly species is likely to have a wider distribution. It is a perennial shrub widely distributed in the South Pacific Islands from Indonesia to eastern Polynesia, also in China, Taiwan, and Japan. It grows mainly in secondary places

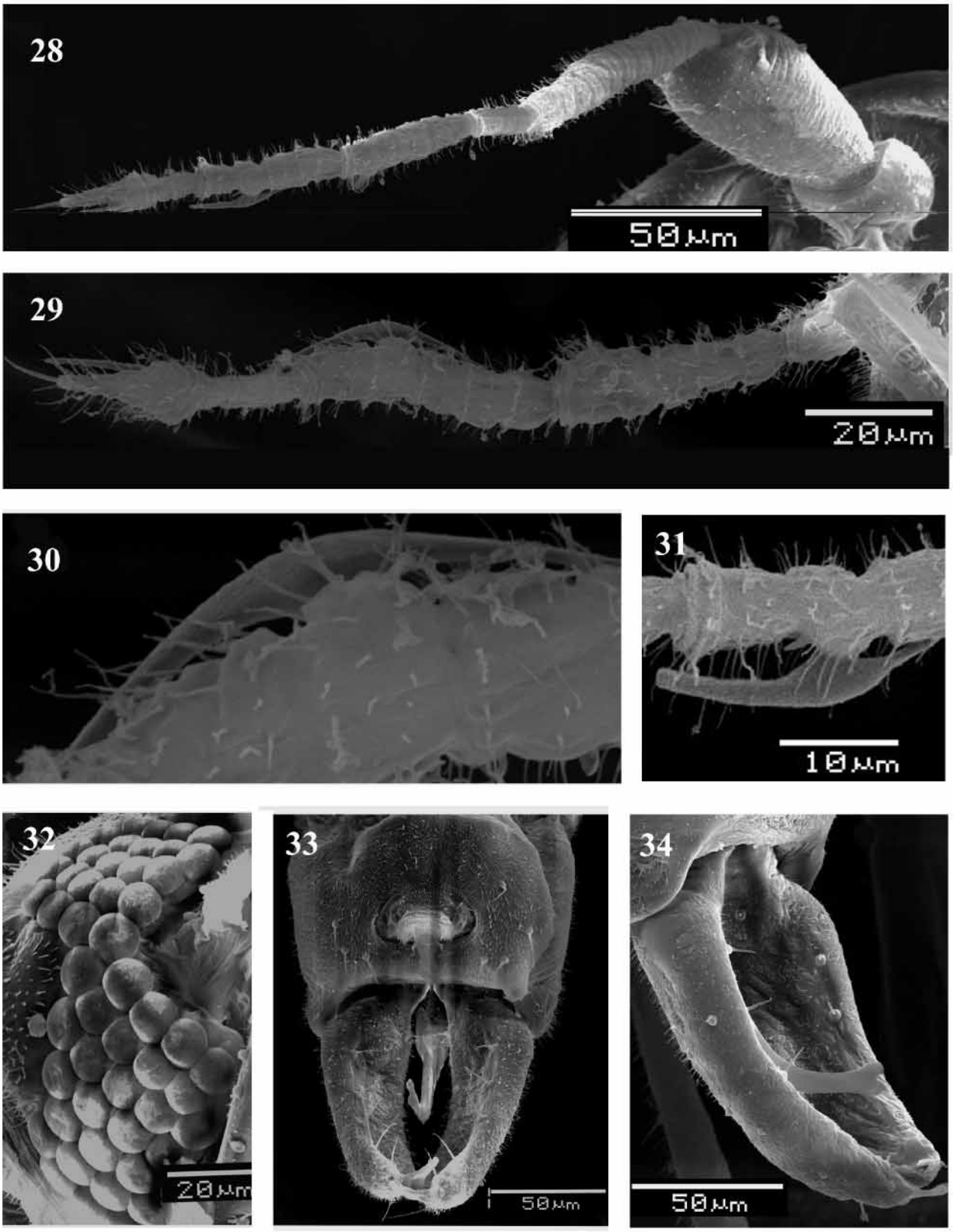
such as roadsides, regrowth thickets, depleted open secondary forest, forest edges in savannah, coconut plantations, old gardens, but also in primary forest, (*Barringtonia*) swamp forest, *Eucalyptus deglupta* dominated forest, monsoon (deciduous) forest, and among mangroves.



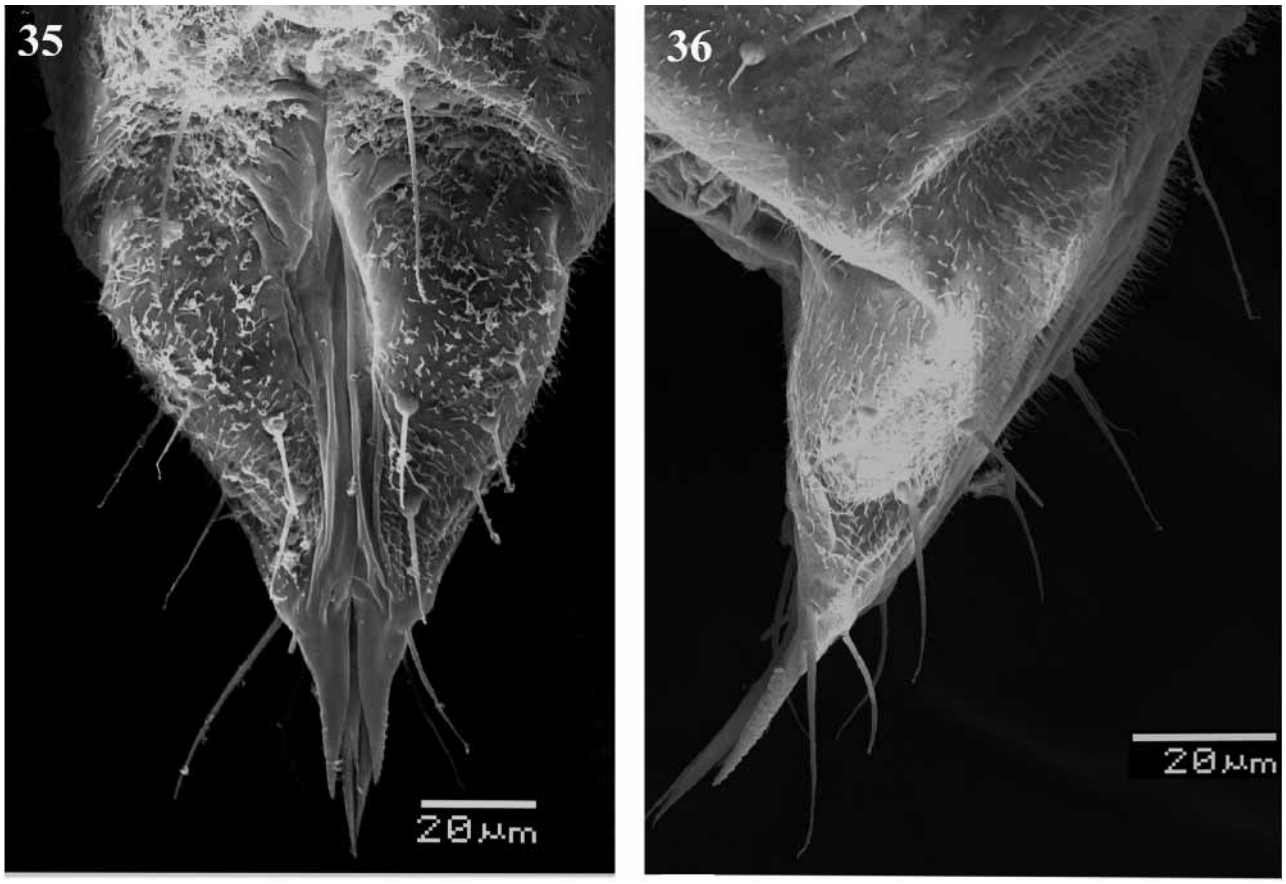
FIGURES 12–18. *Singhiella melanolepis* **sp. nov.**, male. 12, antenna; 13, compound eyes; 14, mesotibia; 15, metatibia; 16, fore wing; 17, abdominal wax plates; 18, vasiform orifice and genitalia.



FIGURES 19–27. *Singhiella melanolepis* **sp. nov.**, female. 19, antenna; 20, compound eyes; 21, mesotibia; 22, metatibia; 23, fore wing; 24, abdominal wax plates; 25, vasiform orifice; 26, genitalia; 27, cement gland.



FIGURES 28–34. Photomicrographs, *Singhiella melanolepis* **sp. nov.** 28, antenna of male; 29, antenna of female; 30, bidirectional sensorial cone on antennal segment III; 31, bidirectional sensorial cone on antennal segment VI; 32, compound eyes of male; 33, dorsal view of male genitalia; 34, lateral view of male genitalia.



FIGURES 35–36. Photomicrographs, *Singhiella melanolepis* **sp. nov.** 35, ventral view of female genitalia; 36, lateral view of female genitalia.

Comments and discussion. In Taiwan, nine species are currently included in *Singhiella*: *S. chitinosa* (Takahashi), *S. dioscoreae* (Takahashi), *S. elaeagni* (Takahashi), *S. kuraruensis* (Takahashi), *S. melanolepis* sp. nov., *S. piperis* (Takahashi), *S. subrotunda* (Takahashi), *S. tetrastigmae* (Takahashi) and *S. vanieriae* (Takahashi). *S. melanolepis* is similar to *S. elaeagni* but differs as follows:

1. All setae on the dorsal disc and all submarginal setae are capitate in *S. elaeagni* but spiny in *S. melanolepis*;

2. There are 14 pairs of submarginal setae (excluding caudal setae) in *S. elaeagni* but only 12 pairs in *S. melanolepis*;

3. Thoracic tracheal pores are distinct in *S. elaeagni*, with 2 or 3 small teeth, but there are no distinct pores in *S. melanolepis*;

4. The vasiform orifice of *S. elaeagni* is wider than long and the end of the caudal furrow is widely open, with 2 or 3 very short rounded teeth, but such characteristics are not present in *S. melanolepis*.

Following the redefinition of *Singhiella* by Jensen (2001), there are now 28 species in the genus. However, *Singhiella* is less clearly defined than *Dialeurodes* and *Massilieurodes*, with considerable variation in the puparia between species (see Table 2), including the opening of the thoracic tracheal pores, the number and shape of the submarginal setae, and the location of the most posterior pair of submarginal setae. Jensen (2001) described the adult characteristics of only one *Singhiella* species, *S. citrifolli*. In contrast, we have studied the adults of several species in this genus from Taiwan, and these show considerable variation in several characters. ***Antennal sensoria***: We compared the adults of five species of *Dialeurodes*, five species of *Massilieurodes* and five species of *Singhiella*. The antennal segments of the *Dialeurodes* species bore complex sensorial plaques (Fig. 37), whereas those of the *Massilieurode*s species bore simple sensorial cones (Fig. 38). However, in different *Singhiella* species two types of sensorial cones (bidirectional and simple sensorial

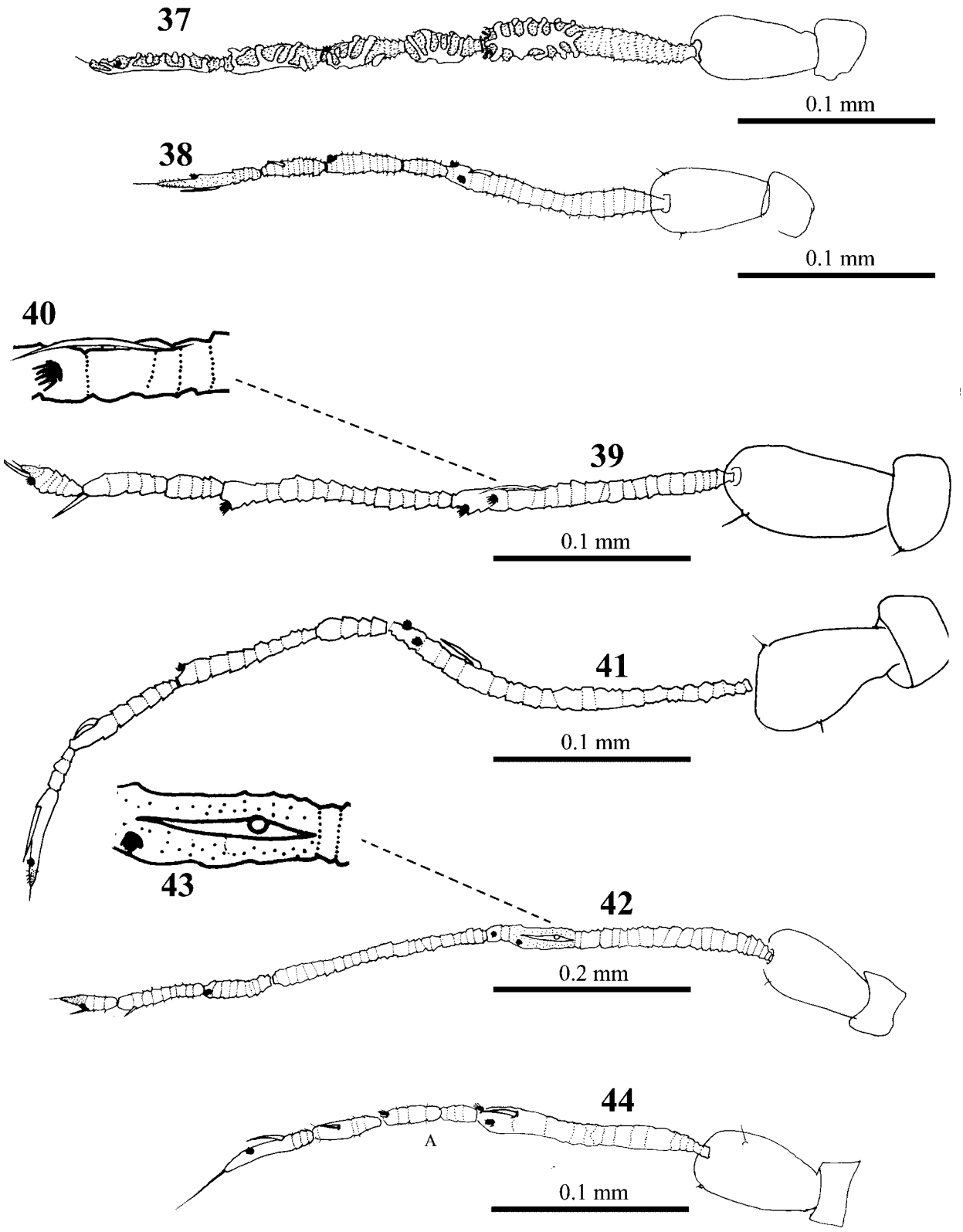
cones) were found on antennal segments III and VI (Figs 39–44). ***Compound eye pigmentation patterns***: In species of *Dialeurodes* and *Massilieurode*s, we could not find pigmentation in the lower facets of the compound eyes, but in *Singhiella* we found pigmentation in two species, *S. kuraruensis* (Fig. 45) and *S. piperis* (Fig. 46). ***Male genitalia***: In species of *Dialeurodes* and *Massilieurode*s, we did not observe any bifurcation in the aedeagus apex, but in *Singhiella* we found four types of aedeagus apex: *S. kuraruensis* (Fig. 47), *S. melanolepis* (Figs 33–34), *S. piperis* (Fig. 48), and *S. tetrastigmae* (Fig. 49). This variation might suggest that the genus *Singhiella* is currently unsatisfactorily defined.

Table 2. Characteristics of *Singhiella* species from Taiwan.

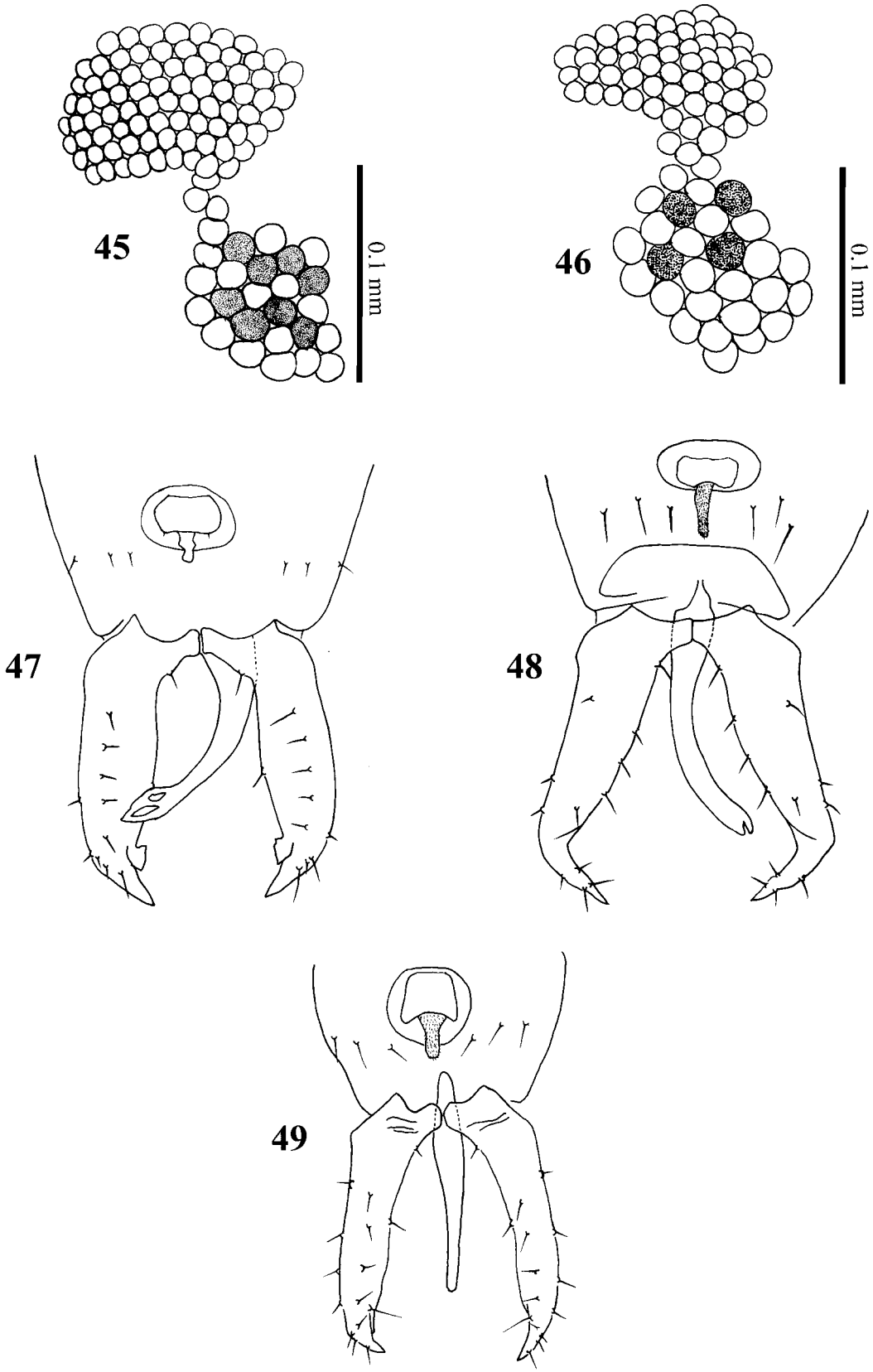
	Species	Colour	Thoracic tracheal pores	Tile-like structures	Pairs of s.m. setae (excluding caudal setae)	Tips of submarginal setae	Posteriormost s.m. setae
1.	*S. chitinosa*	dark	present	present	12	spiny	submargin
2.	*S. dioscoreae*	pale	present	present	15	capitate	caudal ridges
3.	*S. elaeagni*	pale	absent	present	14	capitate	submargin
4.	*S. kuraruensis*	brown	present	absent	12	capitate	submargin
5.	*S. melanolepis*	yellowish	present	present	12	spiny	submargin
6.	*S. piperis*	yellow to brown	present	present	10	spiny	submargin
7.	*S. subrotunda*	yellowish	absent	present but small	12	spiny	submargin
8.	*S. tetrastigmae*	yellowish	present	present	15	capitate	caudal ridges
9.	*S. vanieriae*	pale	present	present	12	capitate	submargin

The classification of whiteflies is based primarily on an immature stage, the puparium (Gill 1990), and adults are usually considered to be morphologically uniform (Bink-Moenen 1991). However, there are several examples of adult characters differing between species, and thus being useful for identification. David & Thenmozhi (1995) provided a comparison table of the clasper setation for four *Lipaleyrodes* species. Guimarães (1996) described lateral ovipositor and cement gland structure of seven species (*Aleurothrixus floccosus* (Maskell), *Aleyrodes proletella* Linnaeus, *Bemisia tabaci* (Gennadius), *Dialeurodes citri* (Ashmead), *Parabemisia myricae* (Kuwana), *Siphoninus phillyreae* (Haliday) and *Trialeurodes vaporariorum* (Westwood)) but omitted other useful adult morphological characters. Similarly, Calvert *et al*. (2001) described the length ratios of antennal segments and the position of antennal sensoria for five species belonging to *Bemisia, Rhachisphora* and *Aleurotrachelus*. Moreover, the generic definitions of *Dialeurodes* and *Massilieurodes* are well supported by the cladistic analysis of Jensen (2001), but *Singhiella* is much less well supported. Our observations on adult morphology, such as the antennal sensoria and male genitalia, support the genera *Dialeurodes* and *Massilieurodes*, but the diversity among the species assigned to *Singhiella* does not support the suggestion that they belong to the same genus.

After extensive study of whitefly specimens, we have found additional adult characters that could be used to define species. For example, the three related *Dialeurodes* species, *D. agalmae, D. citri* and *D. daphniphylli*, have very similar puparia but the adults differ in the numbers of antennal sensorial plaques, the numbers of ommatidia between upper and lower halves of the compound eyes, the shapes of abdominal wax plates, also the vasiform orifice, claspers, cement glands and lateral view of aedeagus, even the chaetotaxy of male and female genitalia and the chaetotaxy of mesotibia and metatibia. More importance needs to be placed on these adult character states in considering the systematic relationships between whitefly species than has been done hitherto, and adult morphological characteristics need to be taken into consideration in studies on whitefly taxonomy.



FIGURES 37–44. Antennae of adult whiteflies. 37, *Dialeurodes citri*, male; 38, *Massilieurodes formosensis*, male; 39–40, *Singhiella kuraruensis*, male; 41 *Singhiella piperis*, male; 42–43, *Singhiella subrotunda*, female; 44, *Singhiella tetrastigmae*, male.



FIGURES 45–49. Compound eyes and male genitalia of *Singhiella* spp. 45, *S. kuraruensis*; 46, *S. piperis*; 47, *S. kuraruensis*; 48, *S. piperis*; 49, *S. tetrastigmae*.

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