

## ***Agrostaleyrodes arcanus*, a New Genus and Species of Whitefly (Homoptera: Aleyrodidae) from Taiwan**

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**Chiun-Cheng Ko, Liang-Yih Chou and Wen-Jer Wu (2001)** *Agrostaleyrodes arcanus*, a new genus and species of whitefly (Homoptera: Aleyrodidae) from Taiwan. *Zoological Studies* 40(2): 177-186. The adult male, female, immature stages, and egg of a new genus and species of whitefly, *Agrostaleyrodes arcanus* Ko gen. et sp. nov. are described from Taiwan, where the species is widely distributed on *Miscanthus sinensis* (Gramineae). Scanning electron micrographs and figures are included with descriptions of immature stages and adults.

**Key words:** Insecta, Aleyrodidae, Taxonomy, Taiwan.

This paper describes the immature stages and adults of a peculiar new genus and species of Aleyrodidae that is widely distributed in Taiwan but is unknown elsewhere. The species appears to have restricted host associations; it has been recorded feeding only on graminaceous hosts, especially on *Miscanthus sinensis* (Gramineae). A detailed study of the structural features of the puparium indicated that the species under study does not fit the concept of any known genus of Aleyrodidae. Hence, a new genus, *Agrostaleyrodes*, has been proposed to accommodate this new species.

### **MATERIALS AND METHODS**

Grass blades containing eggs and late instar nymphs of the new species were collected in the field, and a colony was established in the laboratory. Emergent parasitoids were removed. Specimens for scanning electron microscopy were removed from host plants and washed in 95% ethanol with ultrasonic mini cleaner at 50-60 Hz for 2 min, then dehydrated in 95%, and finishing with 100% ethanol.

Specimens were next critical-point dried using CO<sub>2</sub> as a transfer fluid, mounted on stubs, sputter-coated with a gold-palladium alloy, and examined with a scanning electron microscope (Hitachi S-800) in the Advanced Instrument Center, National Taiwan University. Descriptions and terminology of external and interior morphological structures are based on Bink-Moenen (1983), Martin (1985), Gill (1990), and Guimarães (1996). Measurements were made of 5 specimens of each stadium and morph. In the text, the following abbreviations are used for the depositories of material: (ANIC) Australian National Insect Collection, CSIRO Entomology, Canberra, ACT, Australia; (CDFA) California Department of Food and Agriculture, Sacramento, CA, USA; (BNHM) Natural History Museum, London, UK; (NMNS) National Museum of Natural Science, Taichung, Taiwan; (NTU) National Taiwan University, Taipei, Taiwan; (SIE) Shanghai Institute of Entomology, Shanghai, China; (TARI) Taiwan Agricultural Research Institute, Taichung, Taiwan; and (USNM) United States Department of Agriculture, Beltsville, MD, USA (Sternorrhyncha collections of the United States National Museum of Natural History, Wash-

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\*\*This paper is dedicated to the memory of Professor Liang-Yih Chou.

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***Agrostaleyrodes* Ko, gen. nov.**

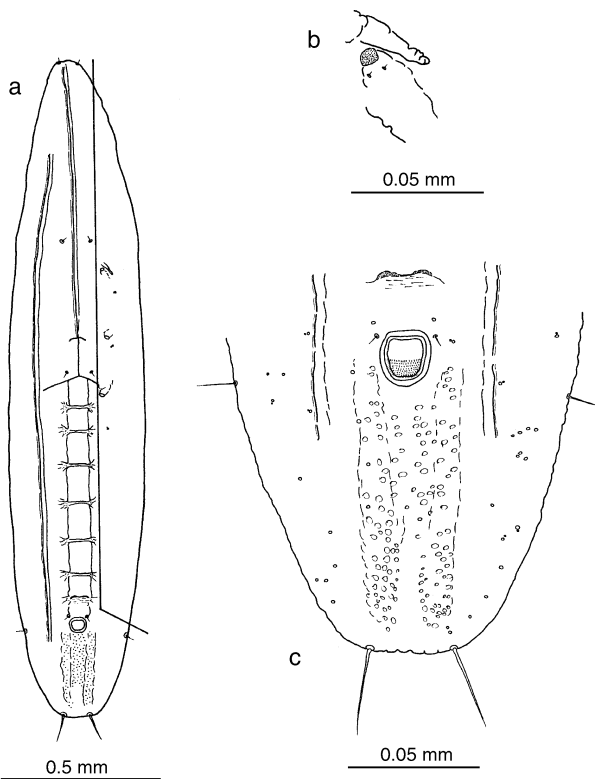
*Type species: Agrostaleyrodes arcanus* Ko, sp. nov.

**Diagnosis:** Puparium medium in size, narrowly elongate. Margin irregularly crenulate. Secretions usually present as a narrow rim of marginal wax. Submargin not separated from dorsal disc by a fold or suture. Transverse molting suture terminating in dorsal disc. Abdominal segments not or only slightly reduced. Paired cephalic, hindthoracic, and 8th abdominal setae present; 1st abdominal setae absent. Raised longitudinal ridges present on dorsum. Abdomen with a series of prominent submedian depressions. Tracheal openings not differentiated from margin. Thoracic and caudal tracheal folds not discernible. Vasiform orifice subcordate. Operculum trapezoidal, filling most of orifice. Lingula not exposed, covered with minute spinules, lingular setae not prominent. Antennae short, base situated mesal to forethoracic leg. Antennae of both sexes subequal in length. Forethoracic leg with 2 basal microsetae, midthoracic leg with 1 basal microseta, and hindthoracic leg with 2 basal microsetae. Adhe-

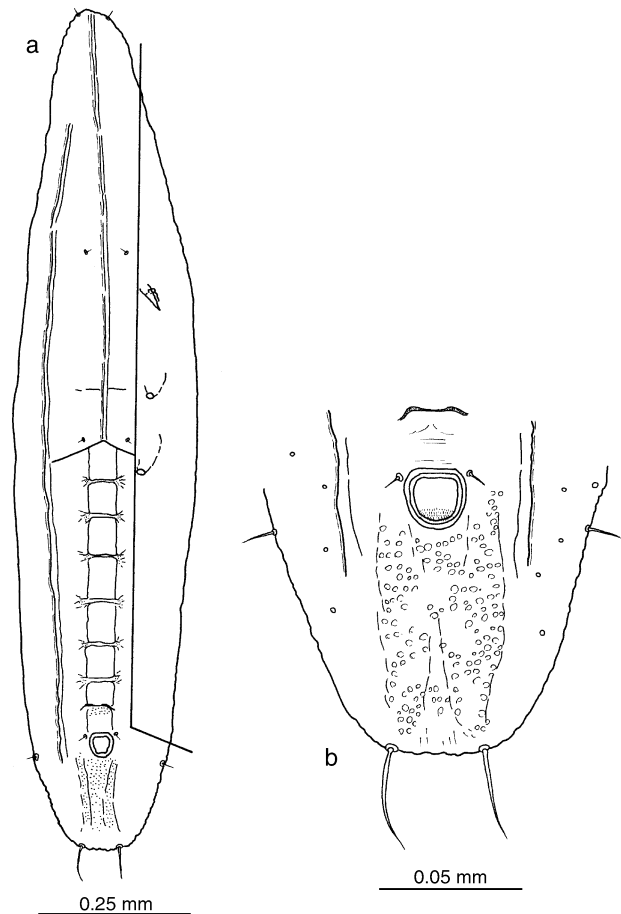
sive sacs not discernible. Ventral abdominal setae present. Four pairs of spiracles well developed, two situated near front and middle legs, one just on 2nd abdominal segment, and 1 just lateral to vasiform orifice. Caudal fold ornamented with tubercles.

**Etymology:** The generic name *Agrost-* is derived from the Latin word for grass; the gender is masculine.

**Discussion:** The elongate shape of the puparium is not particularly unusual; it is probably an adaptation to the narrow shape of the leaf of the host plant; the condition is also found in some species of genera such as *Aleurocybotus* Quaintance and Baker, *Aleurolonga* Mound, *Dialeurolonga* Dozier, and *Vasdavidius* Russell. Survival of the nymphal stages requires stylet penetration of the smallest veins in host plant leaves. An elaborate series of behavioral acts must be performed for the insect to achieve this goal. The new genus appears to be most closely allied to members of the tribe Dialeurodini; however, there is no visible pore or



**Fig. 1.** *Agrostaleyrodes arcanus* Ko, n. sp., 4th instar, ♀ (a) dorsal view; (b) antenna and foreleg; (c) posterior area.



**Fig. 2.** *Agrostaleyrodes arcanus* Ko, n. sp., 4th instar, ♂ (a) dorsal view; (b) posterior area.

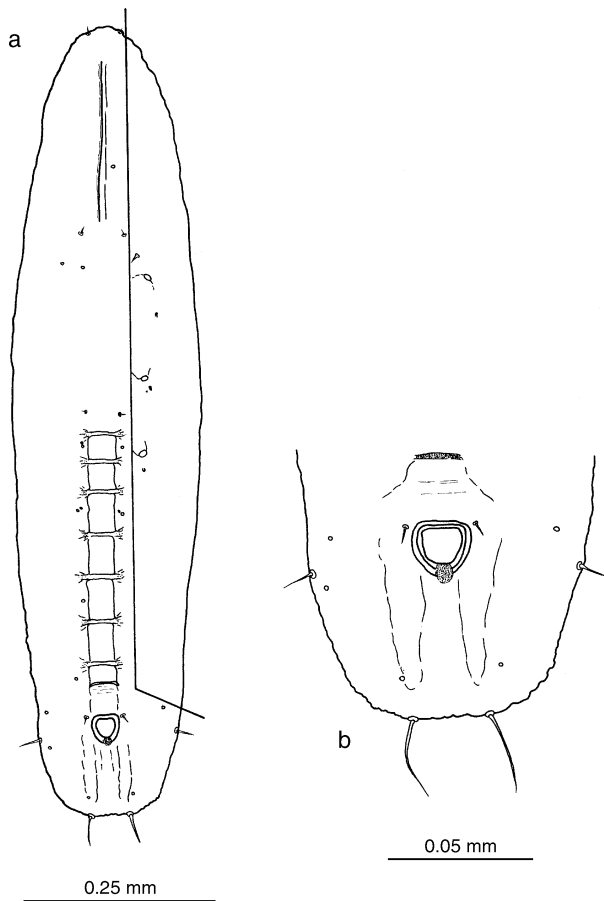
comb at the marginal opening of the tracheal fold. Puparia of the new genus differ from those of *Dialeurodes* Cockerell by the lack of any tracheal openings which are differentiated from the margin. The most distinctive characters that support the generic status of *Agrostaleyrodes* are the presence of a pair of hindthoracic setae, raised longitudinal ridges present on the dorsum, and the cuticle seeming as though it was being viewed through a translucent film in the puparia of both sexes. For these reasons a new genus is defined herein to contain this single species.

***Agrostaleyrodes arcanus* Ko, sp. nov.**

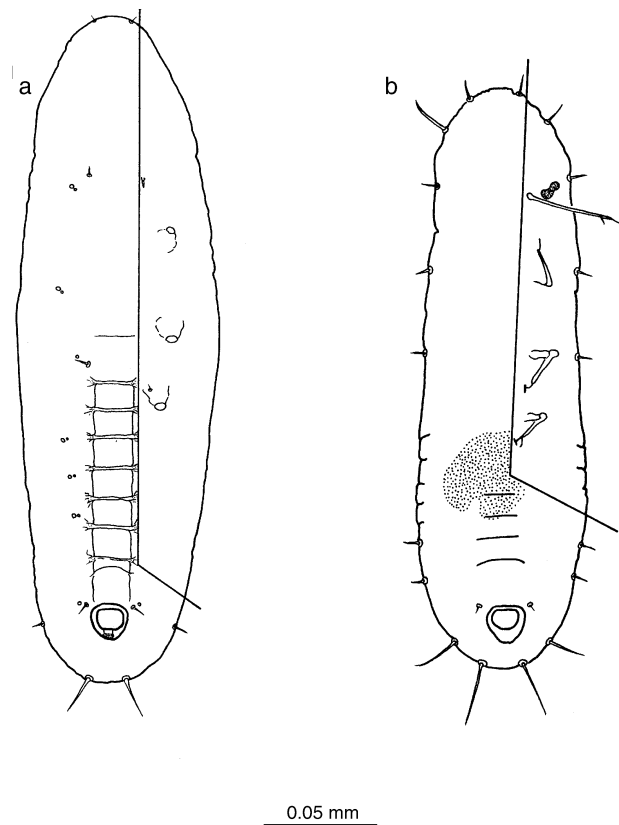
**Pupal case** (Figs. 1-2, 8-14): Color pale yellow in life. Colorless when cleared and slide-mounted. Puparium medium in size, very narrow, elongate sides nearly parallel, ♀ 2.08-2.18 mm long, 0.45-0.53 mm wide, 4.28× maximal width; ♂ 1.45-1.55 mm long, 0.31-0.35 mm wide, 4.58× width, widest at

about 1st abdominal segment. Margin irregularly crenulate. Thoracic and caudal tracheal pore areas undifferentiated from rest of margin. Eyespots not evident. Cephalic setae needle-like, 10-20 µm long, far removed anteriorly from mouthparts. A pair of well-developed caudal setae needle-like, each 0.90-1.01 mm long, extending posteriorly from caudal margin. Anterior marginal setae needle-like, 15-20 µm long; a pair of posterior marginal setae needle-like, each 30-50 µm long, present on caudo-lateral margin. Wax secretions not prominent, usually present as a narrow rim of marginal fringe, produced by submarginal pores.

**Dorsum:** Submarginal area with faint reticulated inscriptions; not separated from dorsal disc. Longitudinal molting suture conspicuously ridged, reaching margin, transverse molting suture terminating midway on dorsal disc, subtending an angle of ca. 100°. Cephalothoracic suture indistinct, promidthoracic and mesohindthoracic sutures short, turned slightly forward, reaching subdorsal area. Cephalothorax with prominent paired depressions. Paired longitudinal ridges present on dorsal disc, extending from cephalic region to beyond vasiform orifice. A



**Fig. 3.** *Agrostaleyrodes arcanus* Ko, n. sp., 3rd instar (a) dorsal view; (b) posterior area.



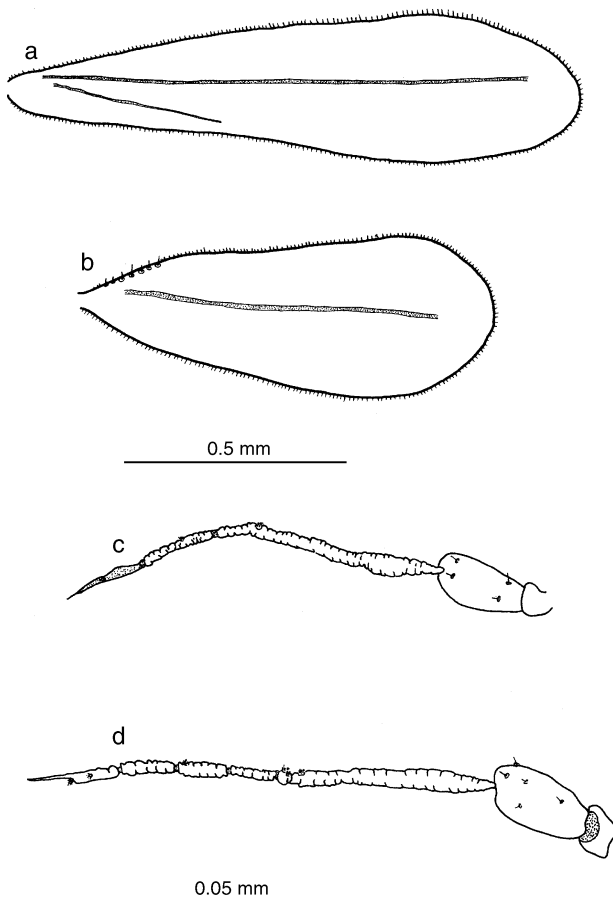
**Fig. 4.** *Agrostaleyrodes arcanus* Ko, n. sp. (a) 2nd instar, dorsal view; (b) 1st instar, dorsal view.

series of minute pores present along submarginal area. Minute pores sparsely scattered on dorsum. Hindthoracic setae needle-like, 20-25  $\mu\text{m}$  long. Abdominal segments distinct on median and submedian areas, each segment with a pair of submedian depressions, on each side of median area. First abdominal setae absent. Median part of 7th abdominal segment nearly as long as other abdominal segments. A pair of pockets present on median part of 7th abdominal segment. Eighth abdominal microsetae present, 25-35  $\mu\text{m}$  long, situated on anterolateral edge of vasiform orifice. Vasiform orifice subtriangular, 60-65  $\mu\text{m}$  long, 50-55  $\mu\text{m}$  wide, teeth or ribs posteriorly absent, without rim or median tubercle. Operculum trapezoidal, 50-55  $\mu\text{m}$  long, 40-45  $\mu\text{m}$  wide, filling about half of orifice, apical part parallel. Lingula short, about as long as vasiform orifice; apex with minute spinules, not exposed, lingular setae not discernible. Caudal furrow present, dorsal ornamentation an irregular tile pattern. Caudal ridges present, with sculpturing. Disc pores and

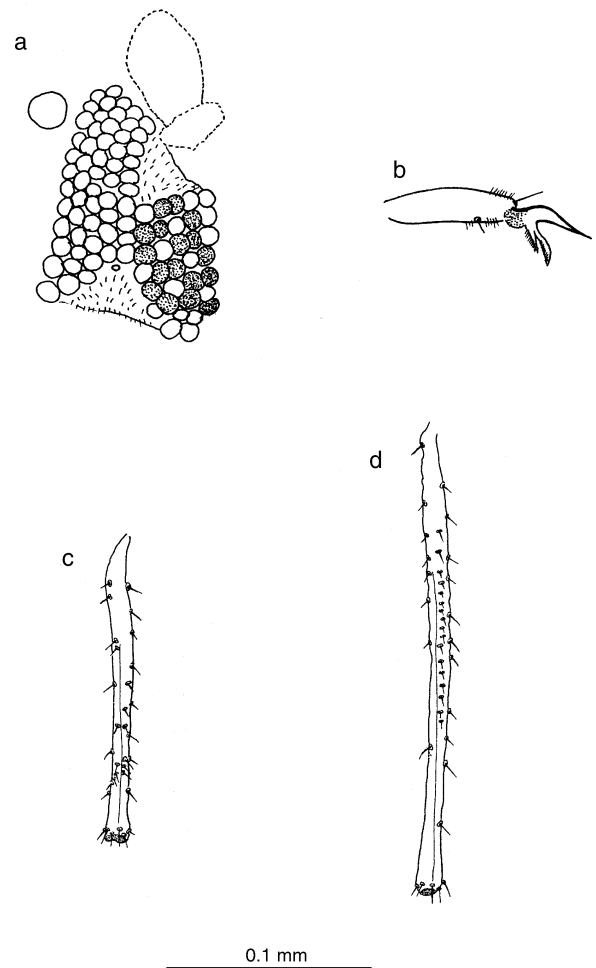
associated porettes scattered over dorsum; each pore/porette pair close together, rather difficult to see in some specimens.

*Venter*: Antennae of both sexes subequal in length, each 60-80  $\mu\text{m}$  long, situated mesally to fore leg. Spinules on base of antenna present. Legs smooth laterally. Mid leg basal microsetae not discernible, but hind leg with 2 basal microsetae. Adhesive sacs not visible. Thoracic and caudal tracheal folds not discernible. Ventral abdominal setae needle-like, 13-23  $\mu\text{m}$  long. Four pairs of spiracles well developed, two situated between fore and mid legs, one just beyond hind leg on anterior abdomen, and one just lateral to vasiform orifice. Caudal fold with no ventral ornamentation.

*Third instar* (Fig. 3): Color pale yellow in life. Outline elongate, slightly asymmetrical, 0.98-1.12 mm long, 0.24-0.31 mm wide, 3.80 $\times$  width. Margin,



**Fig. 5.** *Agrostaleyrodes arcanus* Ko, n. sp., adult (a) fore wing, ♀; (b) hind wing, ♀; (c) antenna, ♂; (d) antenna, ♀.



**Fig. 6.** *Agrostaleyrodes arcanus* Ko, n. sp., adult (a) compound eye (part), ♀; (b) hind tarsus and pretarsus; (c) midtibia, ♀; (d) hindtibia to show comb, ♀.

submargin, and dorsum similar to that of puparium. Longitudinal and transverse molting sutures absent. Vasiform orifice 55-60  $\mu\text{m}$  long, 45-50  $\mu\text{m}$  wide. Caudal furrow similar to that of puparium, but with ornamentation less distinct. Placements of setae similar to those on puparium. Anterior marginal setae 8-18  $\mu\text{m}$  long, posterior marginal seta 70-80  $\mu\text{m}$  long. Cephalic setae 15-20  $\mu\text{m}$  long. Hindthoracic setae 15-20  $\mu\text{m}$  long. Caudal setae 25-35  $\mu\text{m}$  long, situated on margin. Legs short, more or less conical, without ornamentation, evenly spaced. Otherwise taxonomically similar to puparium. Little distinguishes this stage from the puparium, apart from, of course, the lack of molting sutures, the smaller size, the typically triangular appearance of the legs, and the short antennae, each 15-20  $\mu\text{m}$  long, situated apart from the fore leg.

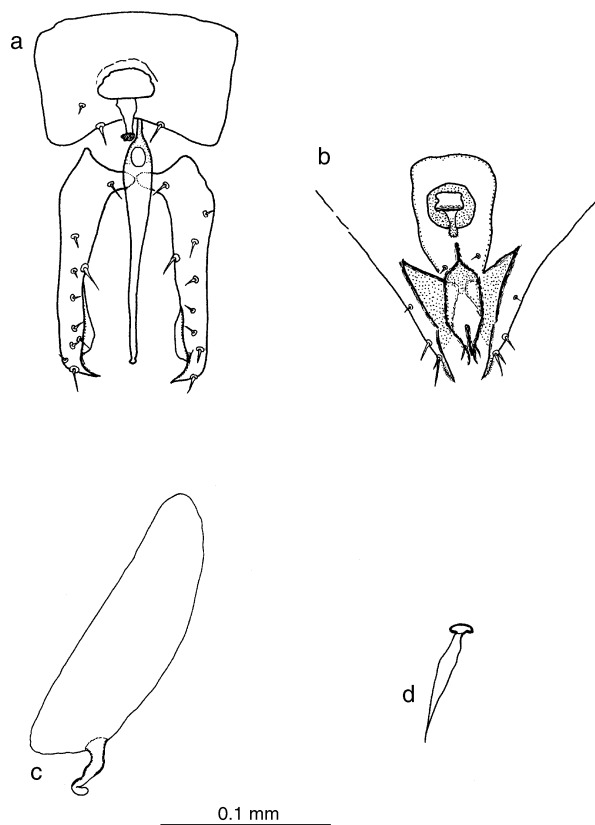
**Second instar** (Figs. 4a, 15-16): Color pale yellow in life. Outline elongate, 0.52-0.60 mm long, 0.13-0.16 mm wide, 3.54 $\times$  width. Margin, submargin, and dorsum essentially as in 3rd instar. Eyespots present. Vasiform orifice 35-40  $\mu\text{m}$  long, 35-40  $\mu\text{m}$  wide, lingula extending beyond operculum but included in orifice. Caudal furrow without significant ornamentation. Placements of setae similar to those of 3rd instar. Anterior marginal setae 8-13  $\mu\text{m}$  long, posterior marginal setae 40-48  $\mu\text{m}$  long; cephalic setae 13-15  $\mu\text{m}$  long, situated almost above antenna; hindthoracic setae 15-20  $\mu\text{m}$  long; 8th abdominal setae 13-15  $\mu\text{m}$  long, situated slightly anterior to position of vasiform orifice; caudal setae 10-13  $\mu\text{m}$  long, situated on margin. Legs short, more or less conical, without ornamentation. Antennae short, each 10-13  $\mu\text{m}$  long, more or less straight, thin, situated laterally to anterior edge of mouthparts, apart from fore leg. Thoracic and caudal folds not apparent. Otherwise taxonomically similar to 3rd instar.

**First instar** (Figs. 4b, 17-18): Color light green to yellow in life. Outline elongate, 0.35-0.38 mm long, 0.10-0.12 mm wide, 3.28 $\times$  width. Margin smooth, with no indication of tracheal areas. Eyespots present. Dorsal surface with intersegmental sutures reduced, only posterior 4-7 sutures on abdomen normally visible. Vasiform orifice roughly triangular, acutely curved posteriorly, 25-35  $\mu\text{m}$  long, 30-35  $\mu\text{m}$  wide, lingula not extending beyond operculum, included in orifice. Caudal furrow not developed. Relative lengths and arrangements of setae different from those of later instars. Anterior marginal setae 23-28  $\mu\text{m}$  long, posterior marginal setae 50-58  $\mu\text{m}$  long. Hindthoracic setae not prominent. Eighteen variably sized marginal setae present in a row around body, including caudal setae, 45-50  $\mu\text{m}$  long.

Eighth abdominal setae situated slightly anteriorly to vasiform orifice, 8-10  $\mu\text{m}$  long. Legs segmented, fore and mid legs set about twice as far apart as mid and hind legs. Antennae segmented, each with 70-85  $\mu\text{m}$  long, situated apart from forethoracic leg, inserted laterad of anterior edge of mouthparts. Thoracic and caudal folds not discernible.

**Egg** (Fig. 7c): Elliptical, elongate in shape, surface smooth, 0.23-0.26 mm long. Color changing from white to dark, scattered singly on lower leaf blades, usually covered with waxy powder. Distal end of the egg broadly acute, somewhat broader basal end with a pedicel. Pedicel short, 55-70  $\mu\text{m}$  long, holding the egg in an upright position.

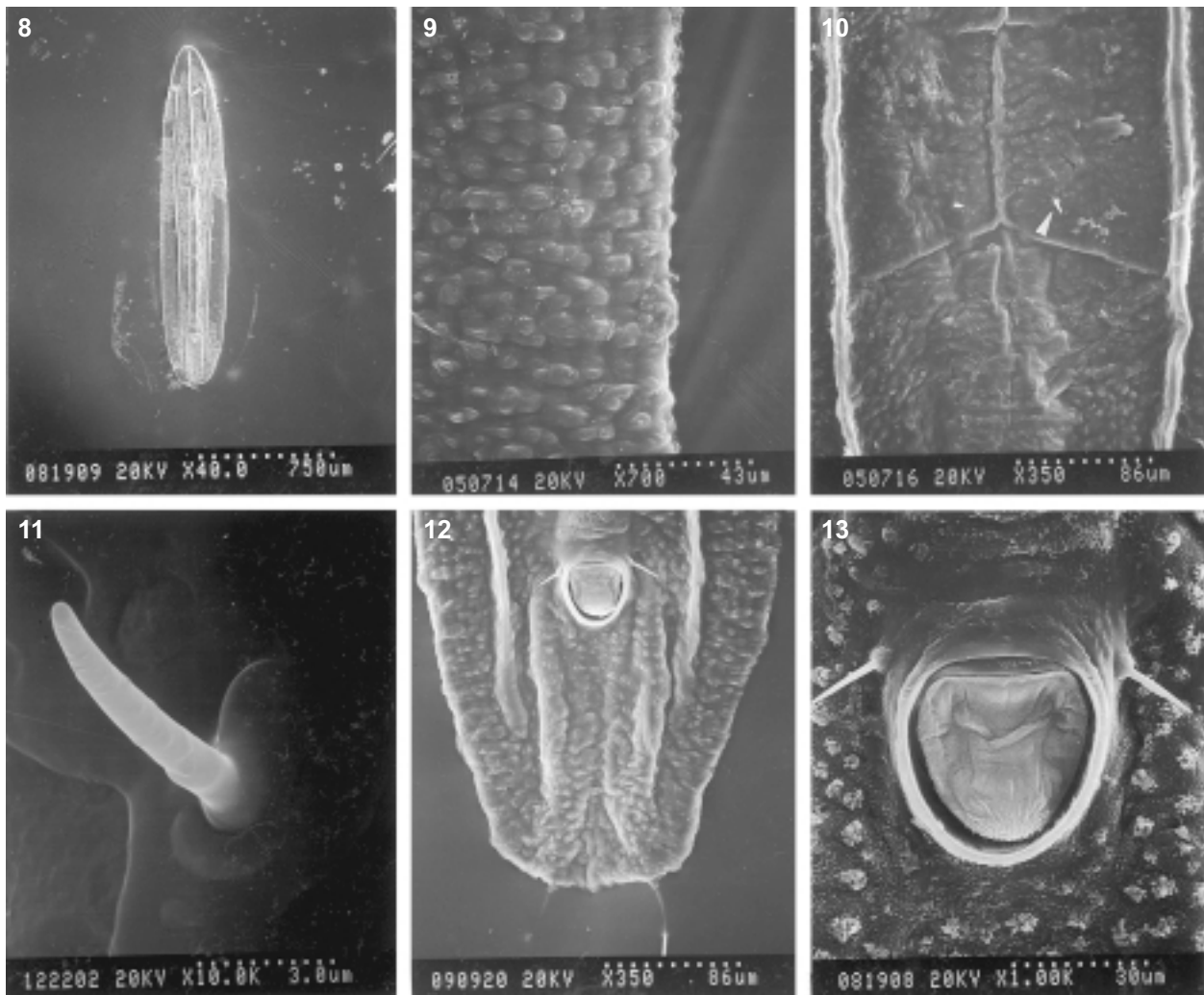
**Remarks:** The eggs are scattered irregularly on the leaf undersurface, probably due to the condition of the leaf surface. Poinar (1965) speculated that egg pedicels of *Aleurocybotus occiduus* Russell were inserted into the stomata because the epidermis of grasses and sedges contains large amounts of silica and lignin and would be difficult for the female ovipositor to penetrate. The pedicel is either inserted into a slit made by the ovipositor in the leaf surface or into a stomatal opening.



**Fig. 7.** *Agrostaleyrodes arcanus* Ko, n. sp., adult (a) terminalia of ♂; (b) terminalia of ♀; (c) egg; (d) cement gland.

**Adult** (Figs. 5-7, 19-30): Some adults emerged subsequent to collection of the puparia. Compound eyes dumbbell shaped, each centrally with pigmentation pattern in the lower eye shown in figure 6a. One pair of ocelli present, each ocellus located near the upper part of a compound eye. Antennae 7 segmented, each attached in a shallow depression just anteriorly to compound eye. First segment usually short, 25-35  $\mu\text{m}$  long, about as wide as long, and relatively thick. Second segment broader than 1st segment and longer, 60-75  $\mu\text{m}$  long. Third segment 130-190  $\mu\text{m}$  long; segments 4-7 subcylindrical and covered with numerous imbrications, 25-30, 30-40, 25-40, and 55-75  $\mu\text{m}$  long respectively. Fine hairs scattered, encircling the segments; 7th segment terminating in a bristle-like hair. Primary sensoria restricted to 3rd, 5th, and 7th antennal segments.

Two primary sensoria are present on the apical and subapical portions of 3rd segment and 1 on each of apex of 5th and subapical area of 7th segments. Sensorial cones positioned anteriorly on ventral surface of 3rd, 5th, and 7th antennal segments in male, but on 3rd and 7th antennal segments in female. Labium inserted at base of head, composed of 3 segments; near its proximal end, labium is bent strongly to the posterior and appears to be grooved along its entire length. At base this groove widens, but more distally becoming narrower (Fig. 19). Apex of labium bilobed, with 7 pairs of sensilla close together, on either side of labial groove (Fig. 20). Wing coloration patterns not prominent. Wing venation reduced primarily to costal-subcostal veins, radial vein prominent. Cubital vein faintly indicated. Borders of wings covered with a series of fine hairs,

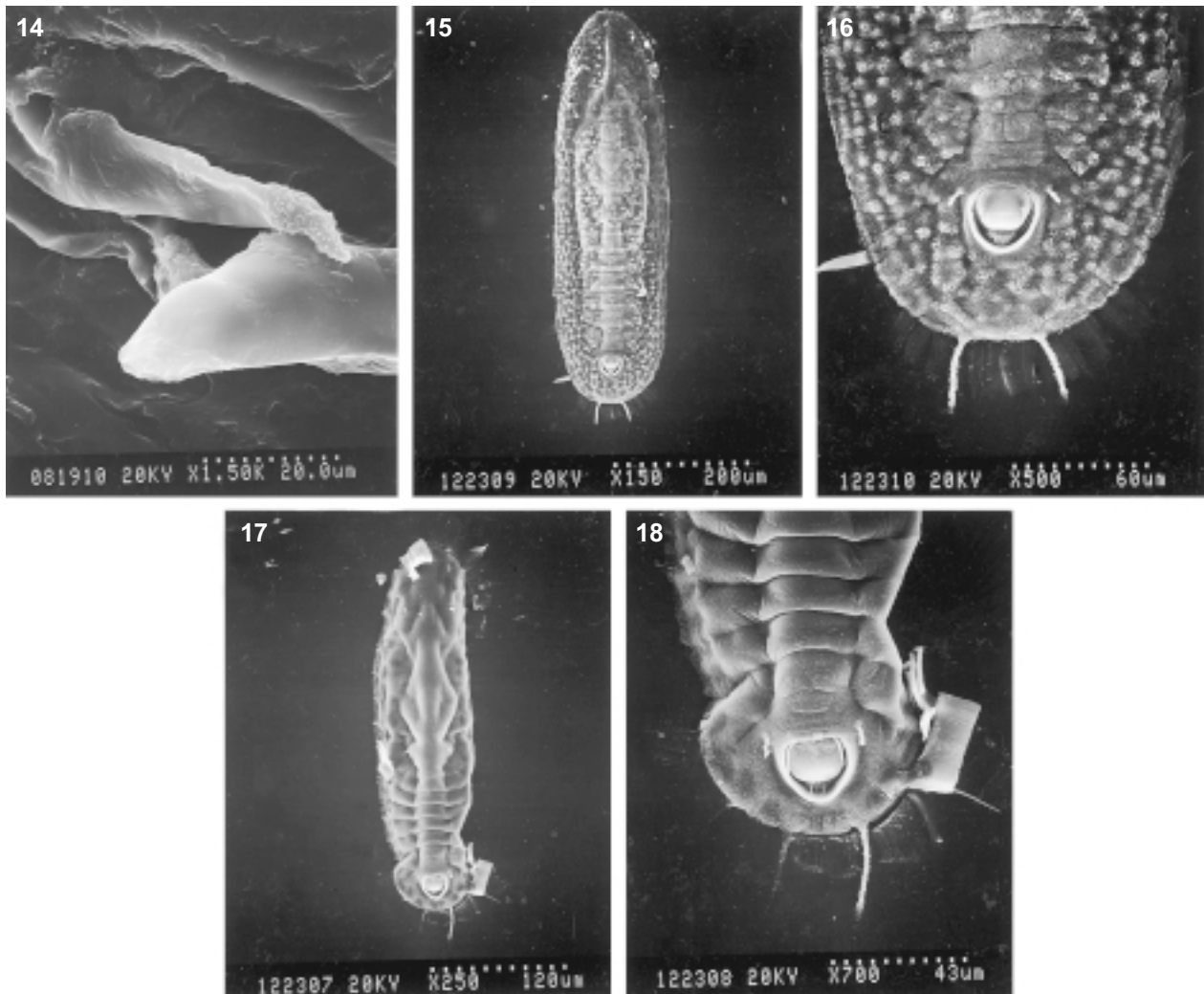


**Figs. 8-13.** *Agrostaleyrodes arcanus* Ko, n. sp., 4th instar, ♀ (8) dorsal view; (9) marginal area; (10) hindthoracic seta; (11) enlargement of hindthoracic seta; (12) posterior area; (13) vasiform orifice.

subequal in length and very minute, each about 0.005 mm long. Hind wing with a row of 7 strongly curved hairs, each with 30-35  $\mu\text{m}$  long on proximal portion of costal margin (Fig. 5). Four ventral abdominal wax plates (II-V) in males and 2 ventral abdominal wax plates (II-III) in females, plates nearly identical. Discoidal wax pores absent. Two groups of mesotibial brushes, each group with 2 to 3 setae, occurring on mesotibia, setae 15-20  $\mu\text{m}$  long (Figs. 6c, 24). A row of usually 15 metatibial combs present in a long straight line along distal, dorsal surface of metatibia, 13-15  $\mu\text{m}$  long (Fig. 25). Tarsal paronychium thickened, clothed with spinules (microsetae) on plantar surface, blade-like, 25-30  $\mu\text{m}$  long (Figs. 6b, 26). Vasiform orifice located on dorsum of 9th abdominal segment of males, 40-55  $\mu\text{m}$  long; in female, located on 8th abdominal seg-

ment, 60-70  $\mu\text{m}$  long. Male clasper curved at distal end and armed with a number of spines, 150-170  $\mu\text{m}$  long. Aedeagus not bifurcate, elongate, 160-175  $\mu\text{m}$  long, subcylindrical, tapering on distal part and swollen at base (Figs. 7a, 27-28). Female central gonapophysis with 1 pair of setae, four pairs on each lateral gonapophysis; caudal portion not strongly curved, with small teeth. Lingula clothed with spinules, setae absent (Figs. 7b, 29-30). Female cement gland, situated between central gonapophysis and internal reproductive organs, not sinuous, 100-120  $\mu\text{m}$  long, without a transverse constriction, caudal region tapering to efferent duct (Fig. 7d).

*Remarks:* Walker and Gordh (1989) revealed that 6 pest species of whiteflies possess 7 pairs of sensilla symmetrically positioned on either side of the labial groove. Adults frequently rub or tap the



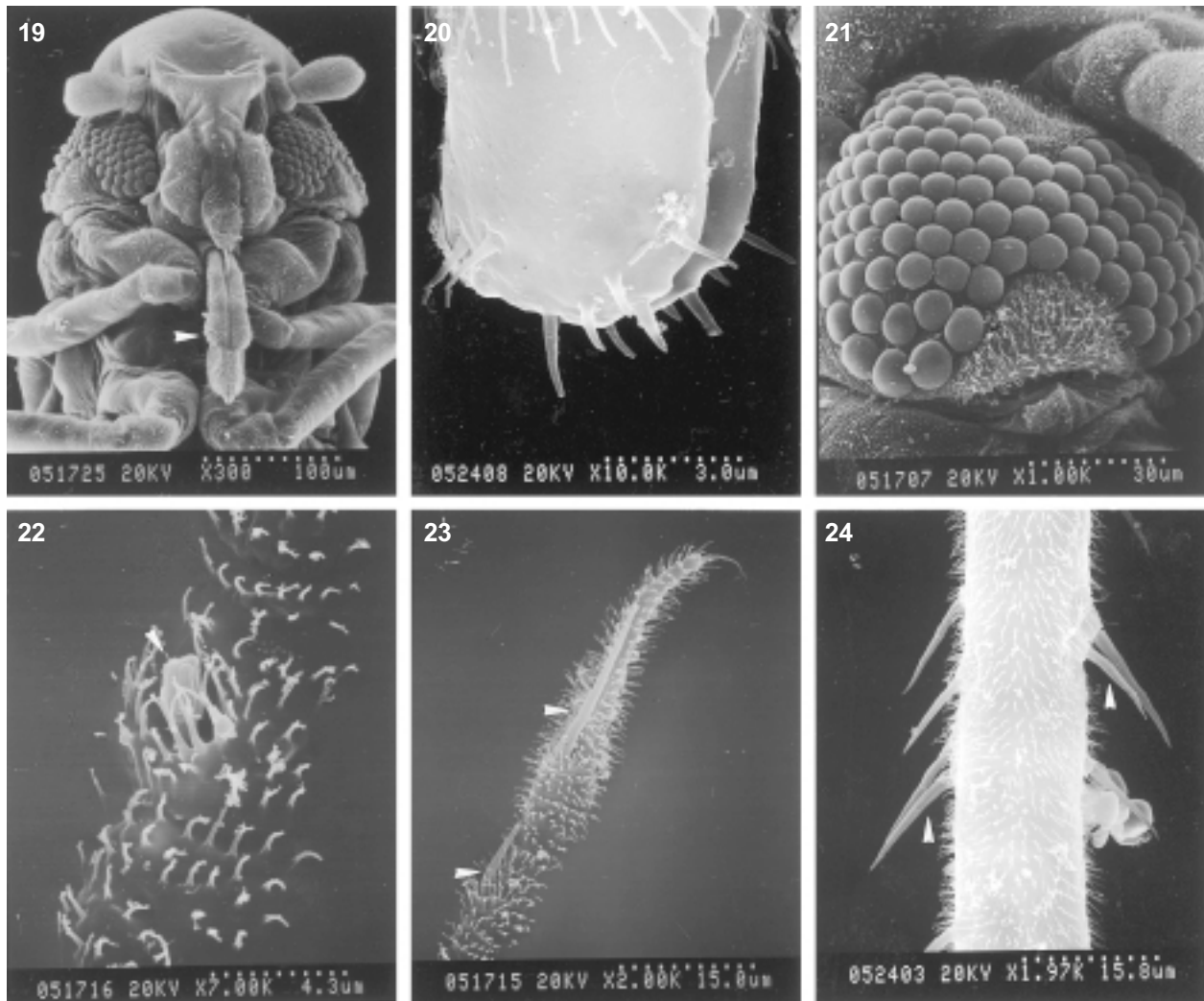
**Figs. 14-18.** *Agrostaleyrodes arcanus* Ko, n. sp. (14) antenna and foreleg, 4th instar, ♀; (15) dorsal view, 2nd instar; (16) posterior area, 2nd instar; (17) dorsal view, 1st instar; (18) posterior area, 1st instar.

apex of their labium on the plant surface prior to insertion of the stylets into plant tissue. This behavior suggests that whiteflies may use the apex of the labium to acquire sensory information about a potential host, but does not indicate whether the sensilla are mechanosensory or chemosensory in nature. Guimarães (1996) examined the cement gland of the female adult based on 7 important pest species. This secretory organ, which produces a substance that aids fixation of the egg on the plant tissue, might be sufficient for the recognition of some species if the adults of most genera were known.

*Holotype pupal case*: ♀, **Taiwan**, Taipei City, 7.viii.1998, on *Miscanthus sinensis*, (C. C. Ko) (on slide, NTU).

*Paratypes*: **Taiwan**, Keelung City, 36 pupal cases, 28.vi.1990, on *Miscanthus* sp., (C. C. Ko)

(ANIC; CDFA; NTU); 3 pupal cases, 25.vi.1994, on *M. sinensis*, (K. C. Chou) (NTU); Taipei City, 3 pupal cases, 9.viii.1994, on *M. sinensis*, (K. C. Chou) (NTU); 50 pupal cases, 9.viii.1997, on *M. sinensis*, (C. C. Ko) (NMNS; NTU; SIE; TARI; USNM); 272 pupal cases, 7.viii.1998, on *M. sinensis*, (C. C. Ko) (NTU); 4 pupal cases, 28.vii.1999, on *Saccharum officinarum*, (C. C. Ko) (NTU); 26 pupal cases, 28.vii.1999, on *M. sinensis*, (C. C. Ko) (NTU); Taipei Co., Shihing, 13 pupal cases, 29.i.1994, on *Miscanthus* sp., (K. C. Chou) (NTU); 6 pupal cases, 28.x.1994, on *M. sinensis*, (K. C. Chou); Wulai, 5 pupal cases, 13.viii.1990, on *Miscanthus* sp., (C. C. Ko) (BMNH; NTU); Hsinchu Co., Taoshan, 1 pupal case, 19.ix.1998, on *M. sinensis*, (Y. P. Lin) (NTU); Taitung Co., Chihpen, 1 pupal case, 25.ii.1990, on *Miscanthus* sp., (C. C. Ko) (NTU); Lanhsu, 1 pupal case, 7.v.



**Figs. 19-24.** *Agrostaleyrodes arcanus* Ko, n. sp., adult (19) ventral view showing labium; (20) sensilla on labium; (21) compound eye; (22) primary sensoria on antennal segment V; (23) sensorial cones on antennal segments IV and VII; (24) mesotibial brushes.

1996, on *Miscanthus* sp., (K. C. Chou) (NTU); Ilan Co., Tungao, 9 pupal cases, 16.ii.1990, on *Miscanthus* sp., (C. C. Ko) (NTU); Fushan, 19 pupal cases, 27.xi.1995, on *Miscanthus* sp., (C. C. Ko) (NTU).

**Host plants:** Gramineae: *Miscanthus sinensis* Andersson, *Miscanthus* sp., *Saccharum officinarum* Linnaeus.

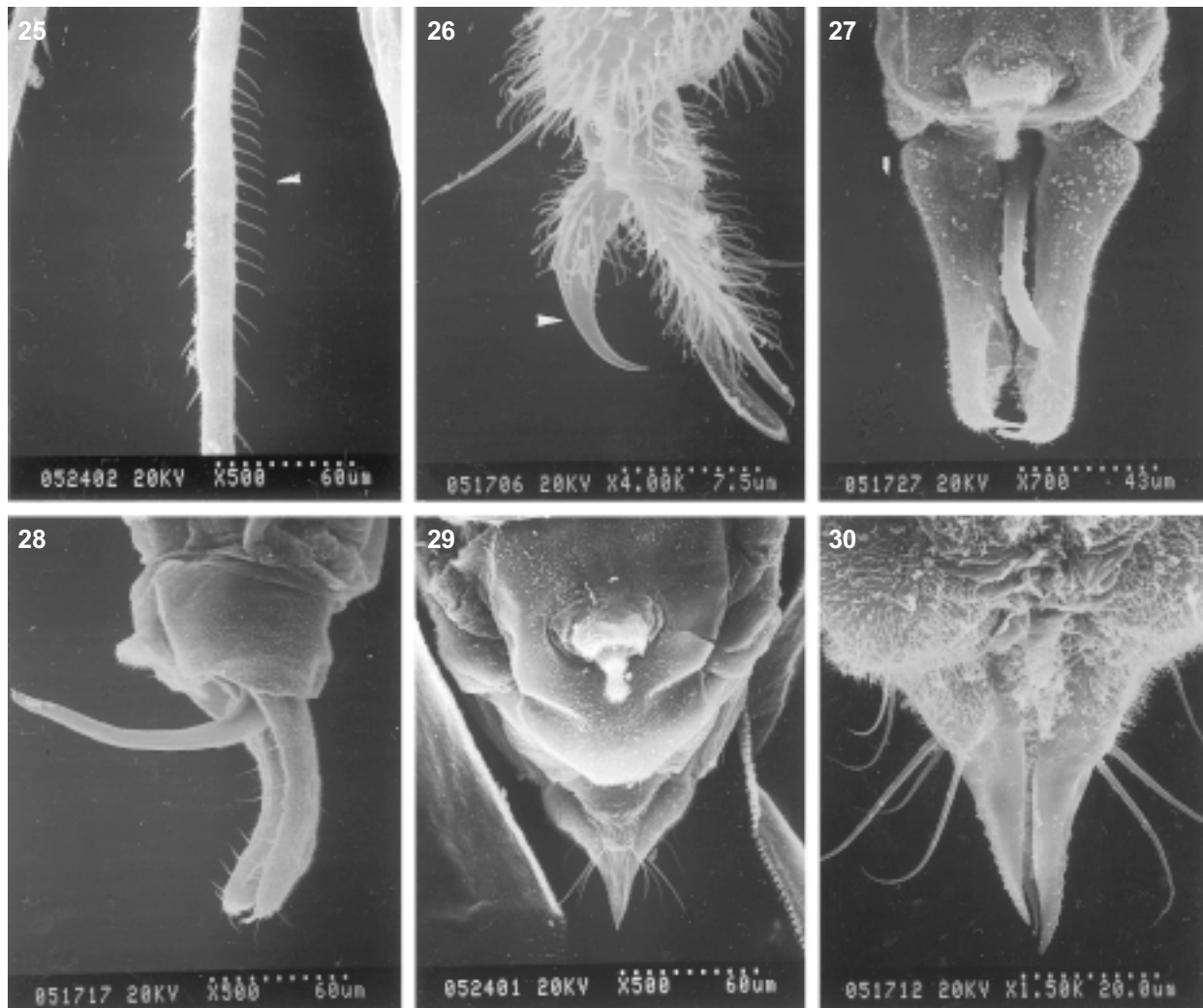
**Distribution:** Taiwan (Chihpen (知本), Fushan (福山), Keelung (基隆市), Lanshu (蘭嶼), Shihting (石碇), Taipei (臺北市), Taoshan (桃山), Tungao (東澳), Wulai (烏來)).

**Etymology:** The specific name *arcanus* is from the Latin word for secret, silent, mysterious; the gender is masculine.

**Biology:** This species is apparently restricted to members of the Gramineae, and is of no economic importance. No ant attendance was observed. The

pale yellow immature stages were invisible to the naked eye. The puparia were sparsely and singly scattered on the lower surface of each grass blade. They are cryptic in life and become more visible a few days before the emergence of the adult. Dorsal wax is probably present as thin transparent sheets only. The adult was found from June to Sept. only, and holds the wings in a tectiform position when at rest. The endoparasitoids *Encarsia transvena* (Timberlake) and *Eretmocerus* sp. (Hymenoptera, Aphelinidae) were reared. *Neomaskellia bergii* (Signoret), *Vasdavidius concursus* (Ko), and *V. miscanthus* (Ko) were sometimes found together, intermingled with *A. arcanus*, on the lower surface of the same colony of a host plant.

**Discussion:** *Agrostaleyrodes arcanus* is quite unlike any other previously described whitefly. Mar-



**Figs. 25-30.** *Agrostaleyrodes arcanus* Ko, n. sp., adult (25) metatibial comb; (26) tarsal claws showing paronychium; (27) dorsal view of terminal segments, ♂; (28) aedeagus and claspers, ♂; (29) dorsal view of terminal segments, ♀; (30) ovipositor and gonapophyses.

tin (1999) collected something similar on *Acacia* sp. in Western Australia, and has filed the slides under "undetermined genus, sp.1., aff. *Dialeurodes*". What it shares with the Australian material is the strange lack of visible detail, but can be distinguished by the absence of the 1st abdominal setae, the non-prominent thoracic tracheal fold, and the presence of a pair of hindthoracic setae. *Miscanthus* Andersson, of which 20 species have been identified worldwide, is found mainly in Asia and on Pacific islands. In Chinese mainland, eight species and 1 variety have been recorded mostly in the central and southern parts of the country. Six species and 1 variety have been found in Japan and 2 species and 1 variety in Okinawa. In Taiwan, five species and 2 varieties have been documented (Chou and Ueng 1992). Hence, this whitefly species may have a wider distribution than present records indicate. Such geographical and host limitations doubtless will be somewhat modified by additional collecting.

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## 臺灣產粉蝨科昆蟲一新屬及一新種(同翅目: 粉蝨科)

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本文描述臺灣產粉蝨科昆蟲一新屬及新種，神秘禾粉蝨 *Agrostaleyrodes arcanus* Ko gen. et sp. nov.。文中並附卵、各齡幼蟲期、成蟲之繪圖及掃描電子顯微照片。

**關鍵詞：** 昆蟲綱，粉蝨科，分類，臺灣。

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