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Abstract. *Aleurolobus confusus* David and Subramaniam and *Bemisia lespedezae* (Danzig) occurring on *Stephanandra incisa* (Thunb.) and *Lespedeza bicolor* Turcz. are newly documented in the Korean fauna of whiteflies (Hemiptera: Aleyrodidae). Characteristics of these species are briefly redescribed and illustrative photographs and information on their distribution and hosts are provided. A dichotomous key to whiteflies of Korea is given for correct species identification. In addition, the current status of *Bemisia takahashii* (Danzig) in Korea is discussed based on the results of a survey of the whiteflies of Korea and related papers.

Key words. *Aleurolobus confusus*, *Bemisia lespedezae*, whiteflies

Introduction

The genus of *Aleurolobus* (Hemiptera: Aleyrodidae) was described by Quaintance and Baker (1914) and currently contains 90 species known worldwide (Martin and Mound 2007; Evans 2008). Most of these species were described from Asia (80%) with 69% from the Oriental and 11% from Eastern Palearctic region. The remaining species were described from the Afrotropical (15.6%), Western Palearctic (3.3%) and Nearctic (1.1%) regions (Regu and David 1993; Dubey and Sundararaj 2006; David and David 2007). The puparium (4th instar nymph) of almost all of the species (96%) of the genus is black. In Korea, three *Aleurolobus* species which have black puparia have been reported (Suh and Evans 2012). However, an *Aleurolobus* species having a white puparium was collected on *Stephanandra incisa* (Thunb.) (Rosaceae) during the survey conducted in 2006 which was deposited in the Collection of Animal and Plant Quarantine Agency (QIA). In 2014, this specimen and image were sent to Raymond Gill (California Department of Food and Agriculture, USA) and Anil Kumar Dubey (Indian Agricultural Research Institute, India) respectively, where it was determined as *Aleurolobus confusus* David and Subramaniam.

Morphological and molecular studies of the genus *Bemisia* Quaintance and Baker, particularly on the global pest *Bemisia tabaci* (Gennadius), have been conducted worldwide (Dinsdale et al. 2010; De Barro et al. 2011; Gill 2012). This genus currently includes 54 species known worldwide (Martin and Mound 2007; Evans 2008; David and Dubey 2009). In Korea, seven *Bemisia* species (13%) have been reported; of these, one species, *Bemisia tabaci*, has been documented as an exotic species which has had an economic impact in Korea, affecting plants cultivated in greenhouses. Specimens of a species of *Bemisia* occurring on *Lespedeza bicolor* Turcz. and *Lespedeza maximowiczii* Schneid (Fabaceae) were collected in Korea, however, the specific assignment of this species has remained unsettled. In 2012, the author visited the Systematic Entomology Laboratory (SEL), USA to identify these specimens, where it was verified as *Bemisia lespedezae* (Danzig) by Gregory A. Evans (USDA/Animal and Plant Health Inspection Service, USA).

As the result of the Korean Aleyrodidae survey project, *Aleurolobus confusus* David and Subramaniam and *Bemisia lespedezae* (Danzig) represent the first records of the occurrence of these species in Korea. Both of these species were collected on leaves of their host plants and they have restricted host range. No economic damage to their host plants was observed during the survey.

The purpose of this paper is to update the list of the whitefly species that occur in Korea (Tab. 1), provide an identification key to species of whitefly in Korea along with photos, diagnoses for the two species newly documented in Korea and information on their plant hosts and distribution. In addition,

the current status of *Bemisia takahashii* (Danzig) is reviewed based on the results of a survey of the whiteflies of Korea and papers related to these species.

Materials and Methods

David and Subramaniam (1976) and Danzig (1966) provided descriptions for two whitefly species that are newly reported in Korean whitefly fauna. Also Evans' catalog of the whiteflies of the world (2008) provided a comprehensive summary of information on the nomenclature, hosts and distribution of whiteflies of the world. Herein I provide a brief diagnosis and photographs of major characters of two species and also an updated dichotomous key to the whitefly known to occur in Korea, based on morphological characters of the puparium (also known as the fourth instar nymph) collected on leaves of their plant hosts. Abbreviations of collecting regions are as follows (Fig. 1): Gyeonggido (GG), Gangwondo (GW), Chungcheongbukdo (CB), Chungcheongnamdo (CN), Gyengsangbukdo (GB), Gyengsangnamdo (GN), Jeollabukdo (JB), Jeollanamdo (JN) and Jejudo (JJ).

All of the specimens for this paper were processed and mounted in Canada Balsam on microscope slides and are deposited in the Collection of Plant Quarantine Technology Center (PQTC), QIA. Terminology for the morphological structures used in an identification key follows that of Martin (1987) and Gill (1990). Photographs were taken using an AxioCam MRc5 camera through ZEISS Axio Imager M2 Microscope. An asterisk(*) is used to indicate a new host and distribution record.

Results and Discussion

Description

Aleurolobus confusus David and Subramaniam, 1976 (Fig. 2A-C)

Aleurolobus confusus David and Subramaniam, 1976: 160. Type data: India, on *Murraya koenigii*.

Diagnosis. Puparium white, flat and oval. Puparial margin with sparse waxy secretion (David and Subramaniam 1976). Dorsal submarginal region separated from the rest of the dorsum by a longitudinal suture. Thoracic and caudal tracheal combs present. Three pairs of dorsal setae present - a pair on the cephalic region, first abdominal segment and eighth abdominal segment. Seven pairs of large setae along the submarginal suture usually present (however, specimens examined absent). Vasiform orifice surrounded by a trilobed figure. Submarginal row of pores/porettes present. Thoracic and caudal tracheal folds distinct but without stipples.

Material examined. Korea. GG: Eobisan, 4 puparia on two slides, on *Stephanandra incisa* (Rosaceae) leaf, 7-vii-2006 (S.J. Suh).

Distribution. India, Sri Lanka (intercepted at USA port) and *Korea (Evans 2008).

Hosts. Rosaceae: **Stephanandra incisa*. Rutaceae: *Murraya koenigii*, *Murraya* sp. and *Citrus* sp. (Evans 2008).

Bemisia lespedezae (Danzig), 1966 (Fig. 2D-F)

Bemisiella lespedezae Danzig, 1966: 378. Type data: Russia, on *Lespedeza bicolor*.

[illegible]

Diagnosis. Puparium white, flat and oval. Dorsum with median abdominal tubercles, submedian abdominal depressions, and usually submarginal pores at base of marginal crenulations. Thoracic tracheal folds absent. Transverse suture curved, directed anteriorly, joined at the anterior end of body to form a closed figure; sides not always distinct. Caudal furrow more or less clearly defined with striations. Only found on *Lespedeza* plants.

Material examined. Korea. GW: Yeongok-myeon, Gangneung-si, 19 puparia on four slides, on *Lespedeza bicolor* (Fabaceae) leaf, 29-x-1998 (M.L. Lee). CN: Anmyeondo, 4 puparia on two slides, same host, 15-ix-2006 (S.J. Suh). GB: Seokguram, 2 puparia on one slide, on *Lespedeza maximowiczii* (Fabaceae) leaf, 10-x-2008 (S.J. Suh). GN: Geumjeongsan, 4 puparia on one slide, on *Lespedeza bicolor* (Fabaceae) leaf, 28-ix-2006 (S.J. Suh); Gadeokdo, 2 puparia on one slide, same host, 8-ix-2011 (S.J. Suh).

Hosts. Fabaceae: *Lespedeza bicolor* and **Lespedeza maximowiczii*.

Distribution. Russia (Maritime Territory) and *Korea.

Key to Whiteflies of Korea Based on the Puparium

1. Puparium black 2
- Puparium white 12

- 2(1). Dorsal disc with elongate spines with acute apices; submargin normally with 11 pairs of spines in a row, all similar in length ***Aleurocanthus spiniferus* (Quaintance)**
- Dorsal disc without elongate spines with acute apices; submargin without a series of spines . 3

- 3(2). Dorsal disc separated from submarginal region by a suture 4
- Dorsal disc not separated from submarginal region by a suture 9

- 4(3). Vasiform orifice surrounded by a trilobed figure 5
- Vasiform orifice not surrounded by a trilobed figure 7

- 5(4). Thoracic tracheal pore present, tracheal comb distinctly protruding, formed by two fused teeth ***Aleurolobus vitis* Danzig**
- Thoracic tracheal pore absent; tracheal comb absent or less protruding, and not formed by fused teeth 6

- 6(5). Thoracic and caudal tracheal comb present, three thoracic and three caudal tracheal teeth; marginal crenulations not distinct, but 2 to 4 minute rounded lobes at the tip ***Aleurolobus marlatti* (Quaintance)**
- Thoracic and caudal tracheal comb absent; marginal crenulations distinctly bilobed at the tip . ***Aleurolobus itae* Takahashi**

- 7(4). With thoracic tracheal clefts at the margin of cephalothorax 8
- Without thoracic tracheal clefts at the margin of cephalothorax ***Aleuroclava montanus* (Takahashi)**

- 8(7). Abdomen with a very sclerotised median rhachis without lateral arms; thoracic tracheal clefts distinct with its fold represented by an oval or semi-circular-shaped area extending into the submarginal area ***Aleuroclava aucubae* (Kuwana)**
- Abdomen without a sclerotised median rhachis, usually with a slightly elevated median area with lateral arms; thoracic tracheal clefts distinct, but short, without a fold as above ***Aleuroclava euryae* (Kuwana)**

- 9(3). Vasiform orifice rounded about as long as wide 10

- Vasiform orifice triangular or heart-shaped longer than wide 11
- 10(9). Rhachis prominent, forming ridges, reaching the margin; without paler patches as below; dorsum with many, very short capitate setae and 13 pairs of short lanceolate setae arranged in a single row along the entire margin ***Rhachisphora styraci* (Takahashi)**
- Rhachis and ridges undeveloped; prominent paler areas at the ends of the transverse suture between the thorax and abdomen, with 2 pairs of pale patches on the cephalothorax; dorsum with 16 pairs of long fine setae, each arising from a very small-tubercle, arranged in a single row along the entire submargin ***Pentaleyrodes yasumatsui* Takahashi**
- 11(9). Vasiform orifice completely occupied by operculum; transverse moulting suture not forming a closed figure ***Dialeurolobus pulcher* Danzig**
- Vasiform orifice not completely occupied by operculum; transverse moulting suture joined at the anterior end of body to a form a closed figure ***Bemisia atraphaxius* (Danzig)**
- 12(1). Dorsal disc separated from submarginal region by a suture 13
- Dorsal disc not separated from submarginal region by a suture 14
- 13(12). Vasiform orifice surrounded by a trilobed figure ***Aleurolobus confusus* David and Subramaniam**
- Vasiform orifice not surrounded by a trilobed figure ... ***Aleuroclava magnoliae* (Takahashi)**
- 14(13). Dorsum with a pair of prominent, longitudinal cephalothoracic folds; puparial margin with two rows of teeth ***Crenidorsum ishigakiensis* (Takahashi)**
- Dorsum without a pair of prominent, longitudinal cephalothoracic folds; puparial margin smooth or with one row of teeth 15
- 15(14). Vasiform orifice rounded about as long as wide 16
- Vasiform orifice triangular or heart-shaped longer than wide 18
- 16(15). Ventral caudal and thoracic tracheal folds distinct, covered with spinules; dorsal thoracic and caudal tracheal openings at margin marked by invaginated pores, which are nearly smooth internally; first abdominal setae absent ***Dialeurodes citri* (Ashmead)**
- Ventral caudal and thoracic tracheal folds smooth without spinules; dorsal thoracic tracheal pores at margin distinct with internal teeth; first abdominal setae present 17
- 17(16). Caudal furrow very narrow, much expanded on the basal two-fifths; a pair of small simple setae present on the cephalothorax, first abdominal segment, and caudal area ***Massilieurodes euryae* (Takahashi)**
- Caudal furrow distinct, widened on the anterior part, narrowed towards the posterior margin; two pairs of long stout setae on the cephalothorax, first abdominal segment and caudal extremity with a pair of long stout setae ***Massilieurodes formosensis* (Takahashi)**
- 18(15). Vasiform orifice situated in a pit and divided into two parts 19
- Vasiform orifice not situated in a pit and not divided into two parts 22
- 19(18). Only found on *Rhododendron* 20
- Not found on *Rhododendron* 21
- 20(19). Marginal teeth prominent, rounded apically; 20 short and fine setae arranged in a row along the margin ***Pealius rhododendri* Takahashi**
- Marginal teeth undeveloped; without a series of setae along the margin ***Pealius azaleae* (Baker and Moles)**

- 21(19). Vasiform orifice shorter than caudal furrow; thoracic tracheal pore not clearly evident ***Pealius polygoni* Takahashi**
 — Vasiform orifice longer than caudal furrow; thoracic tracheal pore clearly evident ***Pealius rubi* Takahashi**
- 22(18). Submarginal row of papillae present **23**
 — Submarginal row of papillae absent **24**
- 23(22). Lateral margin with relatively broad crenulations, usually fewer than 13 in 100 μ m; eighth abdominal setae located anterior to widest part of operculum ***Trialeurodes vaporariorum* (Westwood)**
 — Lateral margin with relatively narrow crenulations, at least 22 in 100 μ m; eighth abdominal setae located posterior to widest part of operculum ***Trialeurodes packardii* (Morrill)**
- 24(22). Caudal furrow present **25**
 — Caudal furrow absent or more or less clearly defined with striation **27**
- 25(24). Thoracic tracheal folds absent ***Bemisia artemisiae* (Danzig)**
 — Thoracic tracheal folds present **26**
- 26(25). Vasiform orifice longer than length of caudal furrow; caudal setae always stout at least as long as length of vasiform orifice whose sides are almost straight ***Bemisia tabaci* (Gennadius)**
 — Vasiform orifice as long as, or shorter than length of caudal furrow; caudal setae usually stout shorter than length of vasiform orifice whose sides are usually distinctly concave ***Bemisia afer* (Priesner and Hosny)**
- 27(24). Abdominal segment VII very short, distinctly shorter than abdominal segments VI or VIII (measured along the dorsal midline); transverse suture joined at the anterior end of body to form a closed figure **28**
 — Abdominal segment VII similar in length to abdominal segments VI or VIII; transverse suture not forming a closed figure; abdomen usually with median tubercles on segments II-V or II-VI ***Aleyrodes lonicerae* Walker**
- 28(27). Vasiform orifice surrounded by a shallow trilobed figure; with some pigment on thoracic tracheal fold and around vasiform orifice ***Bemisia carpini* (Koch)**
 — Vasiform orifice not surrounded by a shallow trilobed figure; without pigment on characters above **29**
- 29(28). Thoracic tracheal folds present, short, with stipples; without submarginal pores at base of marginal crenulations. Found on various plants ***Bemisia takahashii* (Danzig)**
 — Thoracic tracheal folds and stipples absent; usually with submarginal pores at base of marginal crenulations. Only found on *Lespedeza* plants ***Bemisia lespedezae* (Danzig)**

Discussion

The updated list of the whiteflies known to occur in Korea, including *Aleurolobus confusus* David and Subramaniam and *Bemisia lespedezae* (Danzig) which are newly recorded in Korea, adds to our understanding of the Korean fauna of whiteflies and aids in the correct identification of species. This information is essential to assessing the economic impact that a given species poses and determining the appropriate management strategy and action that is to be taken against the pest. When dealing with pest issues concerning whiteflies, it is particularly important that a management strategy be implemented quickly due to their high reproductive capacity and ability of some species to transmit plant viruses.

The current status of *Bemisia takahashii* (Danzig), first described from Russia and *Bemisia shinanoensis* Kuwana reported to occur in Japan should be reviewed by analyzing information on their morphological affinities. A recent study by Gill (2012) suggested that *Bemisia takahashii* might be synonymous with *Bemisia shinanoensis*. Although I did not examine the type specimens of these species, based on their descriptions and illustrations, they appear to be very similar. The latter species differs mainly by the presence of a row of long setae on dorsal disc; whereas these setae are usually short in *Bemisia takahashii*. Such a distinction might be considered to be within the range of intraspecific variability of *Bemisia shinanoensis*, perhaps due to differences in their host plants or environmental conditions. Here I have treated them as separate species, however, the morphological variability that occurs in these species should be studied and discussed in more detail to determine they are whether or not conspecific.

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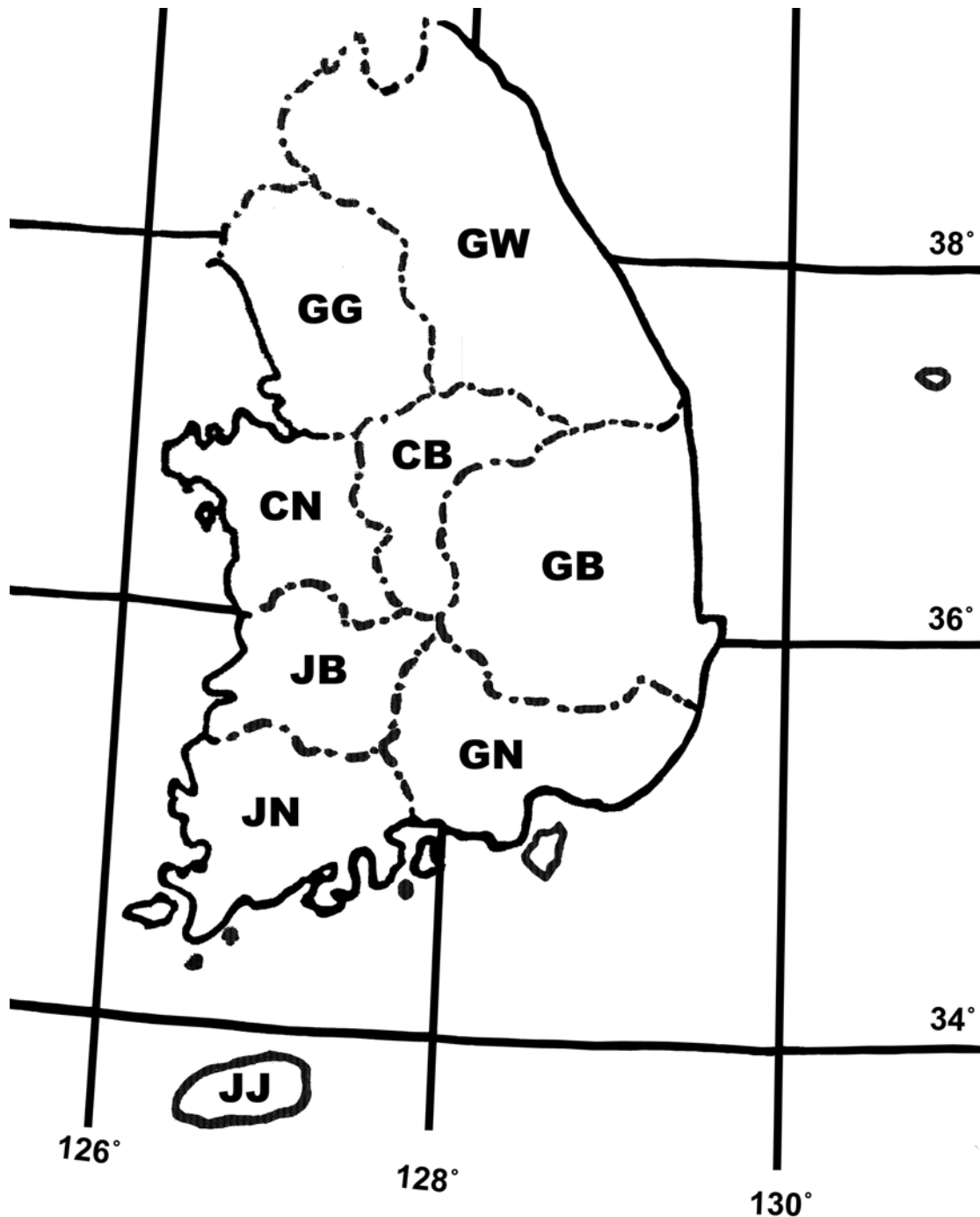


Figure 1. Regional map of Korea and abbreviations of regional names.

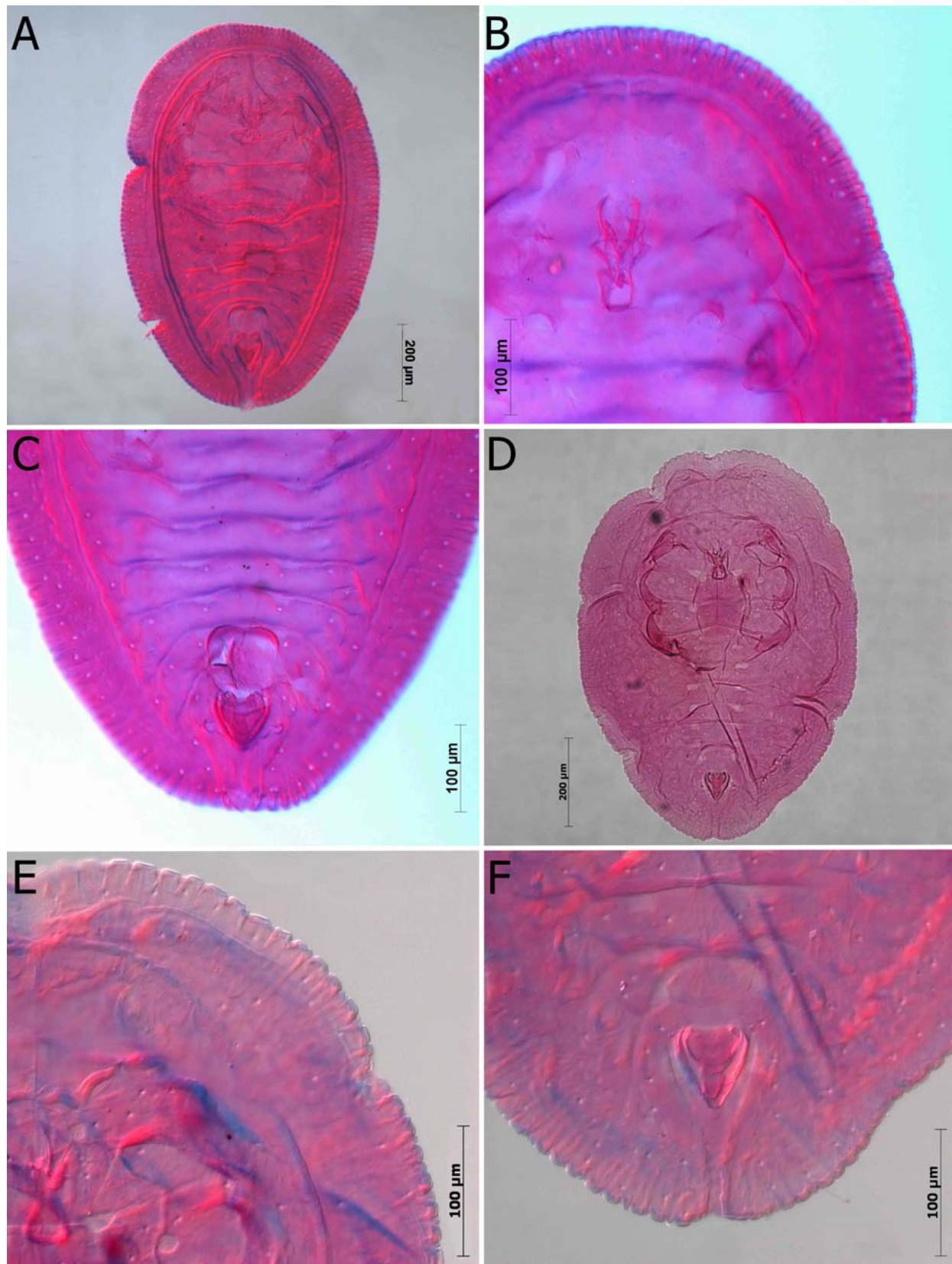


Figure 2. A-C: *Aleurolobus confusus* David and Subramaniam, A-C; A. puparium, B. tracheal margin, C. vasiform orifice. D-F: *Bemisia lespedezae* (Danzig), D. puparium, E. tracheal margin, F. vasiform orifice.

