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Descriptions of Adult Genitalia and Immatures of the Asian Planthopper *Ricania speculum* Recently Introduced to Italy (Hemiptera: Fulgoroidea: Ricaniidae)

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ABSTRACT The ricaniid planthopper *Ricania speculum* (Walker) (Hemiptera: Fulgoroidea) was recently introduced to Italy, apparently from southeast Asia. This species has the potential to become a significant agricultural pest as it feeds on over 60 species plants some of which are of economic importance. Here we describe and illustrate the adult male and female genitalia and the first through fifth instar nymphs.

KEY WORDS: planthoppers, Auchenorrhyncha, Ricaniidae, alien species

The planthopper Family Ricaniidae includes 415 extant species in 56 genera (Bourgoin 2016). Several species are considered pests of a number of economically important woody plants (Solis and Esguerra 1982; Wilson and O'Brien 1987; Bhumannavar 1990; Choi et al. 2011, 2012; Özgen et al. 2011; Ak et al. 2015; Rossi and Lucchi 2015) and the honeydew of one species was implicated as the source of poison honey (Cumber 1966, 1967). The majority of ricaniid species are found in eastern Asia, however, five species of *Ricania* have been introduced to countries in Europe and western Asia — *R. simulans* (Walker) and *R. hedenborgi* Stål to Turkey (Özgen et al. 2011, Ak 2015), *R. japonica* Melichar to Bulgaria and the Ukraine (Holzinger et al. 2003, Gjonov 2011), *R. limbata* Lallemand to France (Bourgoin 2016), and *Ricania speculum* (Walker) to Italy (Mazza et al. 2014) (Fig. 1).

R. speculum has been recorded from China, Indonesia, Japan, Korea, Philippines, Taiwan, and Vietnam (Bourgoin 2016). This species is broadly polyphagous having been recorded from over 60 mostly woody plants in 33 families (Mazza *et al.* 2014, Rossi and Lucchi 2015, Rossi *et al.* 2015). Females insert eggs into the woody twigs of their host plants on which the nymphs develop (Rossi and Lucchi 2015, Rossi *et al.* 2015). This species is bivoltine in China and overwinters as nymphs (Yu 2007); however, it is univoltine in Italy and South Korea and overwinters as eggs (Kang et al. 2013, Rossi *et al.* 2015).

The eggs and the egg-burster of *R. speculum* were described and illustrated by Rossi et al. (2015) and Lucchi and Rossi (2015) . Here we describe and illustrate the male and female adult genitalia and the five nymphal instars and provide a key for separating them.

Materials and Methods

Descriptions (by S.W.W.) are based on specimens reared in the laboratories of Pisa University. Egg clusters collected in April 2015 in the countryside of Arcola (La Spezia, Italy)

were left under room conditions (20 ± 2 °C) until the 1st instar nymphs eclosed. Single immatures were transferred in a modified Munger cell, with a leaf of orange tree (*Citrus sinensis*) on the bottom for their feeding, replaced twice a week. Daily the cells were checked for observing the moults. The immatures, when moulted, were collected and preserved in 70% alcohol. Adults were collected in September 2015 in a garden of Arcola.

Light microscopic pictures were made with a stereomicroscope Leica Z16 APO assembling photos with a Zerene Stacker program, according to the Staking technique (Zerene Systems LLC, http://zerenesystems.com). For Scanning Electron Microscopy (SEM), nymphs were immersed in 70% ethanol, dried at room temperature, directly gold coated in a Edwards S150B sputter unit and immediately observed and photographed through a Philips 515S SEM.

Terms used for morphological structures follow O'Brien and Wilson (1985), Bourgoin (1993), and Bartlett (2016). Measurements are given in mm as mean ± SD. Length was measured from the apex of the vertex to the apex of the abdomen; thoracic length, along the midline from the anterior margin of the pronotum to the posterior margin of the metanotum; and width, across the widest part of the body. Specimens are deposited in the S. W. Wilson Collection at the University of Central Missouri, Warrensburg, USA and in the Entomology collection at the DAFE (University of Pisa, Italy).

Details of the abdominal wax glands were described from scanning electron microscopic photographs of fifth instar nymphs.

Descriptions of Adult genitalia and Immature Stages. Descriptions of the adult and illustrations of the head, wings, and male and female genitalia were provided by Yang (1989) and the male genitalia by Yang and Chang (2000). The male and female genitalia are redescribed and illustrated here in greater detail (n = 3 males, 3 females).

Male genitalia (Figs. 2,3). Pygofer, in lateral view, longer than wide (height:width ratio = 5:4), slightly convex on posterodorsal aspect; in caudal view, with deep notch in middle of ventral aspect. Segment X (= anal flap), in lateral view, longer than wide (height:width ratio = 3:2), broadly convex on posteroventral aspect in distal half. Parameres, in lateral view, elongate (length:width ratio = 2:1), terminating in large, anterodorsally-directed curved hook. Aedeagus, in lateral view, consisting of symmetrical, sclerotized, dorsoposteriorly-curved phallobase with 3 elongate, curved spines on each side; apical spine widest at base, curving anteroventrally, middle spine shorter, more slender and paralleling apical spine, third spine very slender, originating on ventral aspect of phallobase and extending anteroventrally.

Female genitalia (Figs. 4,5). Pygofer, in lateral view, broadly convex, partially covered by lobe-like extension of segment 8. Anal flap, in lateral view, elongate (length:width ratio = 3:1). Gonapophyses 8 paired, in lateral view, broad at base, curved on ventral aspect, acute at apex, dorsal aspect with 8 blunt teeth; lateral gonapophyses 9 shaped as in Fig. 4A, in caudal view, with 3 rows of flat, broad, medially-directed overlapping teeth along caudal margin; median gonapophysis 9 elongate, very slender.

Fifth Instar (Figs. 6, 7, 8, 10E). Length 5.0 $\pm$ 1.09; thoracic length 2.5 $\pm$ 0.58; width 3.4 $\pm$ 0.54; n = 5.

Body robust, with hump-backed appearance (Fig. 6B); widest across mesothoracic wingpads; portions of thorax, abdomen, and membranous areas pale, thorax and lateral aspects of abdominal sclerites mottled brown to dark brown which obscures many of the numerous pits on the head, thorax, and abdomen. Abdominal wax pads bright rose.

Head, in dorsal view, rounded anteriorly, vertex broad, width ca. 8-10X length, apical transverse carina separates vertex from frons. Frons with length along midline ca. 0.7X width at widest point; lateral margins carinate (outer carinae) and broadly convex, each paralleled by a weak inner carina extending from near the anterior margin then fading near the clypeus, without median longitudinal carina; with numerous pits between inner and outer carinae on each side of head. Clypeus consisting of a subconical basal postclypeus and a subconical distal anteclypeus. Beak 3-segmented, extending to metacoxae; segment 1 obscured by anteclypeus, segment 2 slightly longer than length of 3. Eyes red. Antennae 3-segmented; scape ringlike, cylindrical; pedicel cylindrical; flagellum whiplike distally with bulbous base.

Thoracic nota divided by longitudinal mid-dorsal line into 3 pairs of sclerites. Each pronotal sclerite, in dorsal view, elongate, triangular, with ca. 17 pits; in lateral view, each sclerite elongate dorsoventrally with ventral aspect broadly rounded, carina extending from anterior aspect then curving ventrally to posterior aspect, with 7 additional pits. Mesonotal median length ca. 8-9X that of pronotum; each sclerite with partial longitudinal carina in median 1/3; cluster of 4-5 pits just lateral to carina; wingpad lobate, extending to apex of metanotal wingpad, with partial posterolaterally-directed thick carina in lateral 1/4, with 2 pits just lateral to carina. Metanotal median length ca. 0.6X that of mesonotum; wingpad broadly lobate and covered by mesonotal wingpad. Pro- and mesocoxae elongate, subquadrate, posteromedially-directed; in ventral view, metacoxae broad, fused to sternum. Metatrochanters cylindrical, each with a row of 11 interlocking, flattened teeth on the median aspect that constitute the "planthopper gears" (Burrows and Sutton 2013). Femora slightly flattened; profemora with 4-6 teeth on plantar aspect, mesofemora with 6-7 teeth on plantar aspect, metafemora longer without teeth. Pro- and mesotibiae slightly flattened, outer aspect concave; metatibiae laterally flattened,

with longitudinal row of 3 black-tipped lateral spines on shaft and transverse apical row of 6 black-tipped spines on plantar surface (Fig. 10E). Pro- and mesotarsi each with 2 tarsomeres; tarsomere l wedge-shaped, tarsomere 2 subcylindrical and curved. Metatarsi each with 3 tarsomeres; tarsomere 1 subcylindrical with transverse apical row of 8 black-tipped spines on plantar surface; tarsomere 2 only visible in plantar aspect, ca. 0.5Xlength of tarsomere 1, small, triangular, without spines; tarsomere 3 similar to terminal tarsomere of other legs. All legs with terminal pair of curved claws and a membranous, lobate, median pulvillus.

Abdomen 9 segmented, widest across segment 3; tergites 4-5 each with a row of 4 pits near lateral margine on each side. Segment 6 with 5 subtriangular, lateral waxpads bearing numerous minute pores and pits, which can be single, bi- or tripartited (Figs. 6D; 8C,D). Segments 7 and 8 each with 1 lateral, elongate, subtriangular caudal waxpad bearing numerous minute pores on each side whose diameter ranges from 8 to 17µm.

Each glandular unit consists of a central circular area surrounded by a cuticular ridge (Fig. 8D). On the 7^{th} segment 5 single pits are visible on each side whereas 4 bipartited pits surmounted by a single pit are present on the lateral margin of the 8^{th} segment (Figs.7; 8A,B)

Segment 9 surrounded by segment 8, subquadrate, encompassing anus, with one fingerlike translucent process on each side.

Fourth Instar (Figs. 9D, 10D). Length 1.8 $\pm$ 0.29; thoracic length 1.0 $\pm$ 0.08; width 1.6 $\pm$ 0.05; n = 3.

Vertex width ca. 6X length. Frons with length along midline ca. 0.75X width at widest point.

Each pronotal sclerite, in dorsal view, with ca. 12 pits; in lateral view, each sclerite with 5 additional pits. Mesonotal median length ca. 6X that of pronotum; wingpad lobate, extending ca. 2/3 distance to apex of metanotal wingpad. Metanotal median length ca. 0.5X that of mesonotum; wingpad short, not covered by mesonotal wingpad. Metatrochanters each with a row of 10 interlocking, flattened teeth. Metatarsomere 1 with transverse apical row of 6-7 black-tipped spines on plantar surface. Abdominal waxpads light rose to light brown.

Third Instar (Figs. 9C, 10C). Length 1.7 $\pm$ 0.23; thoracic length 0.8 $\pm$ 0.05; width 1.1 $\pm$ 0.00; n = 3.

Vertex width ca. 4X length. Frons with length along midline ca. 0.8X width at widest point.

Each pronotal sclerite, in dorsal view, with fewer, barely discernible pits. Mesonotal median length ca. 4X that of pronotum; wingpad not developed. Metanotal median length ca. 0.5X that of mesonotum. Metatrochanters each with a row of 8 interlocking, flattened teeth. Metatibiae with transverse apical row of 6 black-tipped spines on plantar surface. Metatarsi with 2 tarsomeres; metatarsomere 1 with transverse apical row of 6 black-tipped spines on plantar surface. Abdominal waxpads light brown.

Second Instar (Figs. 1, 9B, 10B). Length 1.5 $\pm$ 0.12; thoracic length 0.6 $\pm$ 0.03; width 0.8 $\pm$ 0.00; n = 3.

Vertex width ca. 3X length. Frons with length along midline subequal to width at widest point.

Mesonotal median length ca. 3X that of pronotum. Metanotal median length ca. 0.7X that of mesonotum. Metatrochanters each with a row of ca. 5 interlocking, flattened teeth.

Metatibiae with transverse apical row of 5 black-tipped spines on plantar surface.

Metatarsomere 1 with transverse apical row of 5 black-tipped spines on plantar surface.

First Instar (Figs. 9A, 10A). Length 0.9 ± 0.03; thoracic length 0.3 ± 0.04; width 0.4 ± 0.06; n = 3.

Vertex width ca. 1.5X length.

Mesonotal median length ca. 3X that of pronotum. Metanotal median length subequal to that of mesonotum. Metatrochanter teeth not discernible. Metatibiae with transverse apical row of 4 black-tipped spines on plantar surface. Metatarsomere 1 with transverse apical row of 4 black-tipped spines on plantar surface. Wax glands not subdivided.

Key to the Nymphal Instars

1a. Mesonotum not lobate laterally (Figs. 9A-C); metatarsi with 2 tarsomeres (Figs. 10A-C) 2

1b. Mesonotum lobate laterally (Figs. 4A,B; 9D); metatarsi with 3 tarsomeres (Figs. 10D, E) 4

2a. Metatibia and metatarsomere 1 each with an apical row of 4 spines (Fig. 10A) .... First Instar

2b. Metatibia and metatarsomere 1 each with an apical row of 5 or 6 spines (Fig. 10B, C) 3

3a. Metatibia and metatarsomere 1 each with an apical row of 5 spines (Fig. 10B) .... Second Instar

3b. Metatibia and metatarsomere 1 each with an apical row of 6 spines (Fig. 10A) ..... Third Instar

4a. Mesonotal wingpads covering ca. 1/2 of metanotum laterally (Fig. 9D); metatarsomere 1 with an apical row of 6-7 spines (Fig. 10D) .....Fourth Instar

4b. Mesonotal wingpads completely covering metatnotum laterally (Fig. 6A, B); metatarsomere 1 with an apical row of 8 spines (Fig. 10E) .....Fifth Instar

Abdominal wax-plates in *R.speculum* nymphs are implicated in the secretion of enormous quantities of wax. Shortly after the hatching and after each moult, the body of juveniles appear completely covered by a great amount of whitish wax, arranged in a tail. The mass of wax progressively increases until the following moult happens. The waxy tail can be spread backward and forward like a parasol when disturbed (Hamilton, 2011).

The wax production is diffused in many fulgoromorphan species and the pattern of abdominal wax plates of immatures of Fulgoroidea has been reviewed in its ontogenetic and phylogenetic aspects (Emeljanov, 2009).

As in other Homopterans (Smith 1999, Lucchi and Mazzoni 2004), in Ricania, as well, wax is involved in protection against abiotic factors such as rain, UV radiation and high temperatures. In this species, the wax is likely to play a role in preventing juveniles from becoming contaminated with honeydew, continuously secreted by conspecific nymphs and adults, which would smear their cuticle with sticky droplets (Fig. 11A). Moreover, the habit of the nymphs to wag the caudal wax like a peacock and, at the same time, to entirely cover their body (Fig. 11B,C,D) suggests an important function of the wax in the defense from natural enemies.

Acknowledgments

We are grateful to Dr Riccardo Antonelli (DAFE, University of Pisa) for the pictures at light and SEM microscopes.

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Figure Legends

Fig. 1. *Ricania speculum.* A. Male (left) and female (right). B. Second instar nymph lateral view.

Fig. 2. *Ricania speculum*, male genitalia. A. Pygofer, segment X, aedeagus, and paramere, left lateral view. B. Aedeagus, ventral view. C. Aedeagus apex, dorsal view. D. Parameres, ventral view. Bar = 0.5 mm.

Fig. 3. *Ricania speculum*, male genitalia at SEM. A. Male ternimalia. Lateral view (200x). B. Parameres, ventral view (300x). C. Aedeagus. sublateral view (300x). D. Aedeagus. Subfrontal view (400x).

Fig. 4. *Ricania speculum*, female genitalia. A. Pygofer, segment X, gonapophyses of the 8th and 9th segments, left lateral view. B. Lateral gonapophyses of the the 9th abdominal segment (outer), gonopophyses of the 8th abdominal segment (middle), and median gonapophyses of the the 9th abdominal segment (central) segments, ventral view. Bar = 0.5 mm.

Fig. 5. *Ricania speculum*, female genitalia. A. Gonapophyses of the 9th segment, ventral view (100x) B. Gonapophyses of the 9th segment, lateral view. (100x) C. Gonapophyses of the 9th urite, frontal view. (100x). D. Detail of gonapophyses of the 8th and 9th abdominal segment, ventral view. (150x)

Fig. 6. *Ricania speculum*, fifth instar nymph. A. Habitus, dorsal view with legs. B. Habitus, lateral view. C. Head, frontal view. D. Abdomen, caudal view. Bars = 0.5 mm; A, B,and C, D.

Fig. 7. *Ricania speculum*, fifth instar nymph caudal view.

Fig. 8. *Ricania speculum* fifth instar nymph. SEM micrographs of wax glands and pits. A. Detail of a pair of pits located on the 8th segment. B. General view of segments 7-9. C. General view on the wax plates of the 6th segment. D. Detail of some glandular pores and pits.

Fig. 9. *Ricania speculum*, first - fourth instar nymphs, dorsal view. A. First instar. B. Second instar. C. Third instar. D. Fourth instar. Bars = 0.5 mm.

Fig. 10. *Ricania speculum*, first - fifth instar nymphs, apex of metathoracic leg, plantar view. A. First instar. B. Second instar. C. Third instar. D. Fourth instar. E. Fifth instar. Bars = 0.1 mm.

Fig. 11. *Ricania speculum*, Nymphs. A. 2nd instar nymph with drops of honeydew trapped in the wax. B. Fifth instar nymph in ventral view. C and D, respectively, Fifth instar nymph partially and completely covered by wax.