**Morphology, Histology, and Fine Structure**

**Antennal Sensilla of Tamarixia radiata (Hymenoptera: Eulophidae), a Parasitoid of Diaphorina citri (Hemiptera: Psyllidae)**

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**ABSTRACT** Tamarixia radiata (Waterston) (Hymenoptera: Eulophidae) is an effective idiobiont ectoparasitoid of immature Diaphorina citri Kuwayama (Hemiptera: Psyllidae) (Étienne et al. 2001, McFarland and Hoy 2001). This parasitoid has demonstrated convincing potential as a classical biological control agent of D. citri (Aubert and Quilici 1984, Étienne et al. 2001). D. citri is an economic citrus pest occurring in tropical Asia and in the New World (Halbert and Manjunath 2004). This psyllid vectors three species of the nonculturable bacterium Candidatus Liberibacter, responsible for huanglongbing (greening disease) in citrus (Halbert and Manjunath 2001). Greening invades the tree phloem, causing fruit drop, missapen bitter and unmarketable fruit, and sometimes results in tree death (Halbert and Manjunath 2004, Bové 2006). This vector species has spread rapidly throughout the state of Florida since its detection in 1998 (Tsai et al. 2000, Halbert et al. 2003). T. radiata revived the citrus industry in Reunion Island after its introduction from India in 1978 (Étienne et al. 2001). Also, T. radiata became successfully established after its release in Guadeloupe Island, resulting in substantial decline of D. citri’s populations within 1 yr of release (Aubert and Quilici 1984, Étienne et al. 2001). T. radiata was released in Florida in 1999 and has also established throughout the major citrus-growing regions of the state (Hoy and Nguyen 2001). A single female T. radiata can deposit up to 300 eggs over her lifetime (Pluke et al. 2008). Despite T. radiata’s reported efficacy as a classical biological control agent of D. citri, little is known about its biology. To date, investigations on T. radiata have focused on its distribution, parasitization rates, and developmental biology (McFarland and Hoy 2001, Étienne et al. 2001, Michaud 2002, Pluke et al. 2008). To our knowledge, information on the roles of mate-, host- or host habitat-related chemicals for mate or host location is unavailable for this parasitoid species.

The reproductive success of parasitoids is determined by their ability to effectively locate mates, hosts, and to avoid natural enemies and unsuitable environmental conditions (Dicke and Grostal 2001). Semiochemicals are involved in mate (Wesoloh 1976, Quicke 1997) and host (Vinson 1991) location by parasitoids (Lewis et al. 1982). Perception of mate- or host-related semiochemicals occurs on specialized sensilla on the antennae of parasitoids (Vinson et al. 1986, Isidoro et al. 1996). The antennal sensilla of hymenopteran parasitoids have been characterized.
using electron microscopic techniques in numerous studies ( Olson and Andow 1993, Isidoro et al. 1996, Amornsak et al. 1998, Onagbola and Fadamiro 2008). Some authors have reported considerable sexual dimorphism in structure and types of antennal sensilla, whereas others have reported little or no distinct sexual differences. For example, Navasero and Elzen (1991) and Onagbola and Fadamiro (2008) reported sexual differences in the antennal morphology of Microplitis crocipes (Cresson) (Hymenoptera: Braconidae) and Pteromalus cerealellae (Ashmead) (Hymenoptera: Pteromalidae) respectively, whereas Petersson et al. (2001) reported little or no sexual differences in the antennal structure of Rhopalicus tutela (Walker) (Hymenoptera: Pteromalidae). The antennal morphology of T. radiata including abundance and distribution of sensilla has not been investigated previously. To provide required background information that will facilitate future identification of mate- or host-related semiochemicals for T. radiata, we characterized the types, abundance, and distribution of sensilla on its antennae by using standard scanning (Onagbola and Fadamiro 2008) and transmission (Onagbola et al. 2008) electron microscopic techniques. Characterizing the possible functions of T. radiata’s antennal sensilla is an important preceding step to achieving our goal of developing an effective attractant for monitoring establishment of this beneficial insect and recruiting its population into citrus groves for improved biological control of D. citri.

Materials and Methods

**Insect Culture.** Newly expanded ‘Hamlin’ orange [Citrus sinensis (L.)] leaf flush infested with D. citri was collected from mature trees in an unsprayed grove in Polk Co., FL. The flush was maintained in 40- by 40- by 40-cm Plexiglas cages at 26 ± 1°C, 60 ± 5% RH, and a photoperiod of 14:10 (L:D) h. Collected psyllid nymphs were observed daily for adult emergence. Emerging parasitoids were segregated by sex and reared under the above-mentioned conditions in similar cages containing third-instar D. citri nymphs that were obtained from a greenhouse culture described in Wenninger et al. (2008). The D. citri culture was maintained on sour orange [Citrus aurantium (L.)] and Hamlin orange (C. sinensis) seedlings at 27 ± 1°C, 63 ± 2% RH, and a photoperiod of 14:10 (L:D) h. A wasp specimen was sent to Florida Department of Agriculture and Consumer Services (Division of Plant Industry), Gainesville, FL, and identified as Tamarixia radiata (Hymenoptera: Eulophidae) (sample E2008-4416-1).

**Scanning Electron Microscopy (SEM).** Newly emerged adult T. radiata of each sex were obtained from our laboratory-reared culture and anesthetized by freezing at −20°C for ≈5 min. Insects were decapitated with a surgical quality steel dissecting knife (Fisher Scientific, Waltham, MA), and their antennae were excised with fine forceps under 40× magnification using a Wild MC3 stereomicroscope (Leica, Heerbrugg, Switzerland). The excised antennae were kept in 70% alcohol for ≈24 h and subjected to a graded alcohol dehydration series by using methods similar to those described by Onagbola and Fadamiro (2008) and Onagbola et al. (2008). Thereafter, the excised antennae were dried in a LADD critical point dryer (LADD Research Industries, Burlington, VT) and were carefully mounted on aluminum stubs with double-sided copper sticky tape. The antennae were sputter coated with gold/palladium (40:60) in a LADD SC-502 high-resolution sputter coater (LADD Research Industries) and then examined in a Jeol JSM-5400 SEM operated at 10, 15, or 20 kV under ambient laboratory conditions. The sizes of adult male and female T. radiata, each flagellar antennomere, and its adhering sensilla were determined under the SEM. Measurements were taken from at least 20 individuals of each sex.

**Transmission Electron Microscopy (TEM).** TEM was conducted using methods similar to those described previously by Onagbola et al. (2008). T. radiata specimens of each sex were anesthetized and decapitated under a stereomicroscope as described above. The isolated parasitoid heads were placed in 3% glutaraldehyde in 0.1 M cacodylate buffer at 6°C for ≈24 h. Subsequently, the specimens were rinsed in the buffer solution and postfixed in 1% osmium tetroxide for ≈2 h. Specimens were later infiltrated in 50, 70, and 100% Spurr’s resin for ≈24, 12, and 12 h, respectively, and embedded in pure Spurr’s plastic. Specimens were polymerized at 60°C for ≈72 h thereafter. Ultrathin sections of the wasps’ antennae were cut with a diamond knife on an ultramicrotome (model RMC, LKB-Huxley Cambridge, United Kingdom) and placed on Gilder grids #200 (Ted Pella Inc., Redding, CA), which were previously coated with 0.5% Formvar (Electron Microscopy Sciences, Fort Washington, PA) solution. Sections were first stained in 2% uranyl acetate for ≈15 min. The grids with the affixed ultrathin sections were then submerged in a drop of lead citrate for ≈5 min to regulate the electron density for clearer viewing under the TEM. Sections were rinsed with 2% sodium hydroxide solution followed by excess distilled water before examination under a Morgagni #268 transmission electron microscope (JEOL Electron Optics, Eindhoven, The Netherlands) at 60 kV.

**Calculations and Statistical Analyses.** The antennal sensilla on the dorsal and ventral surfaces of male and female T. radiata were identified, counted, and measured according to methods described earlier by Onagbola and Fadamiro (2008) and Onagbola et al. (2008). The mean ± SE number of sensillar types per male and female antennomere was determined and the differences between the total number of individual sensillar types on male and female antennae were compared using chi-square analyses. At least 10 T. radiata were investigated per sex and at least 20 sensilla of each type and location were examined to calculate average size.
**Results**

**Gross Antennal Morphology.** Scanning electron photomicrographs of adult male (Fig. 1A) and female (Fig. 1B) *T. radiata* and of their respective antennae are presented in Fig. 1. Adult males (0.92 ± 0.002 mm) (mean ± SE) were slightly smaller (body length, measured from the frons to the tip of the abdomen) than females (1.04 ± 0.003 mm) (n = 20 per sex). The geniculate antennae of male (Fig. 1C) and female (Fig. 1D) *T. radiata* are of the conventional type having a long scapula-shaped scape, S; the barrel-shaped pedicel, P and the long thread-like flagellum, F.

![Fig. 1. Scanning electron photomicrographs of adult male (A) and female (B) *T. radiata* and gross morphology of male (C) and female (D) antennae. The antenna of male or female *T. radiata* subdivides into a ball-like radicula, R; at the base of the long scapula-shaped scape, S; the barrel-shaped pedicel, P and the long thread-like flagellum, F.](https://academic.oup.com/aesa/article-abstract/102/3/523/8649)

The AST-1 are 32–45 μm long and 1.2 μm thick (basal diameter), depending on their location.

The AST-2 are short and peg-like with bent shafts that taper to a very fine tip (Fig. 2, AST-1). The shafts of these sensilla have fluted surfaces and are inserted into cuticular sockets (Fig. 2). As observed under the TEM, the walls of the AST-1 are thick and grooved (Fig. 3, AST-1). They occur only on the scape and pedicel of males and on the scape, pedicel and proximal (first two funicular antennomeres) portion of the female antennal flagellum. The AST-1 are 32–45 μm long and 1.2 μm thick (basal diameter), depending on their location.

The AST-2 are short and peg-like with bent shafts that taper to a very fine tip (Fig. 2, AST-2). They are characterized by smooth shaft surfaces and are inserted into cuticular pits. The AST-2 are 40–60 μm long and 1.2 μm thick. Transverse sections of both the AST-1 and the AST-2 revealed nonporous walls (Fig. 3, AST-1, AST-2).
The multiporous placoid sensilla (MPS) on males and females are elongate, plate-like, and are highly conspicuous with numerous wall pores on their sausage-shaped shafts (Fig. 2, MPS). The cuticular wall of the MPS seemed to be nonporous in the TEM photomicrographs (Fig. 3, MPS) given their highly compacted arrangement as revealed by SEM (Fig. 2). The MPS align parallel along the antennal longitudinal axis and are distributed between rows of the multiporous sensilla trichoidea (MST) on each antennal flagellomere of both sexes except for the male’s second claval flagellomeres. The MPS arise from the antennal cuticular surface forming an elevated ridge, which protrudes slightly above the antennal surface. In contrast to the MST described above, the MPS are numerically (but not statistically: $\chi^2 = 3.6$, df = 1, $P = 0.058$) more abundant on the antennae of females than males (Table 1). They are $\approx 100 \, \mu m$ long in males and between $\approx 45$ and $50 \, \mu m$ in length in females and are $\approx 6 \, \mu m$ thick in both sexes. The density of pores on the surface of MPS was $\approx 20–25$ pores per $\mu m^2$ (Fig. 2, MPS).

Fig. 2. Scanning electron photomicrographs of the various sensilla on the antennae of male and female T. radiata. The figure shows the type I aporous sensilla trichoidea with a grooved shaft surface (AST-1, with asterisks); type II aporous sensilla trichoidea, AST-2; the multiporous placoid sensilla with numerous wall pores, MPS (also magnified to show the presence of wall pores); multiporous sensilla trichoidea, MST; and the basiconic capitate peg sensilla with a grooved bulbous tip, BCPS.
The MST are the most conspicuous and the most abundant sensillar type on the antennae of both male and female *T. radiata* (Fig. 1, M, F; Table 1). They are long and tapering, slightly bulbous at the base and have gradually curved shafts. They arise directly from the antennal cuticular surface and are distributed only on the funicular and claval flagellomeres of the antennae of both sexes. Their shaft surfaces are smooth (Fig. 2, MST) with wall pores (Fig. 3, MST). The MST are more numerous and ≈4 times larger on the antennae of males (Fig. 1M) than females (Fig. 1F). The MST on the antennae of females are ≈71–76 μm long and ≈3.5 μm thick.

The basiconic capitate peg sensilla (BCPS) are short and peg-like with a distinguished, grooved, bulb-like head on a distinct stalk (Fig. 2, BCPS). They are set in shallow cuticular depressions on the distal ends (around the interflagellomere membrane) of both the
male and female antennal flagellum. Transverse sectioning of the BCPS revealed no evidence of wall pores suggesting a nonolfactory function (Fig. 3, BCPS).

### Abundance and Distribution of Antennal Sensilla

Only one type of sensillum was present on the radicula and scape of *T. radiata*’s antennae. The AST-1 (Fig. 2) is found on the scape and the AST-2 (Fig. 2) on the radicula. The pedicel of the antennae of both sexes bears the AST-1 on its entire cuticular surface and the AST-2 around the basal scape-pedicel elbow joint region. There are \( \approx 10 \) AST-2 and 20 AST-1 on the radicula and scape of the antennae of both sexes, respectively. There are \( \approx 10 \) and 16 AST-1 on the antennal pedicel of both males and females whereas, \( \approx 6 \) AST-2 are present on the antennal pedicel of both sexes (Table 1). The antennal flagellum of both males and females bears three and four sensillar types, respectively. The ring-like annulus, which constitutes the first flagellar antennomere, is devoid of sensilla in both sexes. The AST-1 is absent on the antennal funicle of males but present on that of females (\( n \approx 14 \)), whereas the antennal funicle of both sexes bear the MST, the MPS, and the BCPS (Table 1). There are \( \approx 43 \), eight, and 10 (male) and \( \approx 31, 12, \) and 12 (female) MST, MPS, and BCPS, respectively, on *T. radiata*’s antennal funicle. The club-shaped antennal clava also bears \( \approx 26, \) six, and two (male) and \( \approx 23, 14, \) and eight (female) MST, MPS, and BCPS, respectively. In general, the AST-1 are significantly more abundant (\( \chi^2 = 4.46, df = 1, P = 0.035 \)) on the antennae of females than males (Table 1). In contrast, the abundance of the AST-2 (\( \chi^2 = 0.00, df = 1, P = 1.000 \)), MST (\( \chi^2 = 1.83, df = 1, P = 0.176 \)), MPS (\( \chi^2 = 3.6, df = 1, P = 0.058 \)), and BCPS (\( \chi^2 = 2.0, df = 1, P = 0.157 \)) was not significantly different between males and females (Table 1).

### Discussion

The current investigation aimed to describe the morphology of the antennal sensilla of *T. radiata* to gain insight into the behavioral ecology of this parasitoid. In general, the morphology and distribution of sensilla are characteristic of parasitic wasps such as *Trichogramma nubilale* (Erle & Davis) (Hymenoptera: Trichogrammatidae) (Olson and Andow 1993), *R. tutela* (Pettersson et al. 2001), *Cotesia* spp. (Hymenoptera: Braconidae) (Bleeker et al. 2004), and *P. cerealellae* (Onagbola and Fadamiro 2008). The antenna of *T. radiata* is composed of a long, scapula-shaped scape with a basal radicula; a barrel-shaped pedicel; and a long flagellum that subdivides into a ring-like proximal annulus, a mesal funicle, and a club-shaped distal clava (Isidoro et al. 1996, Pettersson et al. 2001, Onagbola and Fadamiro 2008). Five types of sensilla, including the AST-1; the short, peg-like AST-2; the long MST; the plate-like MPS; and the short BCPS, were present on the antennae of both males and females.

Sexual dimorphism of antennal structures occurs commonly among parasitic wasp species (Navasero and Elzen 1991, Onagbola and Fadamiro 2008). Likewise, the antennae of male and female *T. radiata* exhibit considerable sexual dimorphism. The male antenna contains one more funicular flagellomere than that of the female. Also, the MST are nearly four times longer in males than females. However, the overall array and abundance of all antennal sensilla (except for the AST-1) are similar between the sexes as observed in other parasitic wasps such as *R. tutela* (Pettersson et al. 2001). The greater abundance of porous sensilla on male antennae than that of females suggests possible involvement of a female-produced sex pheromone in the behavioral ecology of *T. radiata*.

The AST-1 occurs on the scape and pedicel in both sexes of *T. radiata* but only on the antennal flagellum of females. In general, the AST-1 is more abundant on the antennae of females than males. Information on the presence and distribution of the AST-1 in eulophid wasps is scant (e.g., Barlin et al. 1981). The distribution of the AST-1 on *T. radiata*’s antennae is atypical compared with previous descriptions of parasitic wasp antennal morphology. Only one bare ring-like annulus is present on the flagellum of *T. radiata*’s antenna in contrast to two ring-like annuli with numerous AST reported for other parasitic wasps such as *Nasonia vitripennis* (Walker) (Hymenoptera: Pteromalidae) (Wibels et al. 1984) and *P. cerealellae* (Onagbola and Fadamiro 2008). However, sensilla similar to *T. radiata*’s AST-1 have been described on the antennae of

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**Table 1. Distribution and abundance of sensilla on the antennae of male and female *T. radiata***

| Sensillar type | Sex | Antennomere | Entire antenna |
|---------------|-----|-------------|---------------|
| AST-1         | Male| Radicula 20.2 ± 0.13 | 30.6 ± 0.16b |
|               |     | Scape 20.3 ± 0.15 | 50.1 ± 0.20a |
|               |     | Pedicel 16.2 ± 0.06 | 16.7 ± 0.11a |
|               |     | Annulus 13.6 ± 0.08 | 16.5 ± 0.12a |
|               | Female| Radicula 10.9 ± 0.07 | 12.0 ± 0.00a |
|               |     | Scape 10.7 ± 0.12 | 12.9 ± 0.00a |
|               |     | Pedicel 5.8 ± 0.42 | 20.0 ± 0.00a |
|               |     | Annulus 5.9 ± 0.32 | 18.3 ± 0.12a |
| MST           | Male| Radicula 43.1 ± 0.15 | 69.4 ± 0.17a |
|               |     | Scape 30.8 ± 0.18 | 54.1 ± 0.17a |
|               |     | Pedicel 6.0 ± 0.00 | 14.0 ± 0.00a |
|               | Female| Radicula 12.0 ± 0.00 | 26.0 ± 0.00a |
|               |     | Scape 10.0 ± 0.00 | 12.0 ± 0.00a |
|               |     | Pedicel 0.6 ± 0.00 | 8.0 ± 0.00a |

Mean ± SE number of sensilla on various antennomeres (flagellum: annulus, funicle, and clava) of the antennae of both sexes of *T. radiata*. Within each sensillar type, means followed by different letters indicate significant differences between males and females (\( P < 0.05 \); chi-square test).

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*Fadamiro 2008). However, sensilla similar to *R. cerealellae* (Onagbola and Fadamiro 2008) reported for other parasitic wasps such as *P. cerealellae* (Onagbola and Fadamiro 2008). The antennae of *T. radiata* in eulophid parasitic wasps are scant (e.g., Barlin et al. 1981). The distribution of the AST-1 on *T. radiata*’s antennae is atypical compared with previous descriptions of parasitic wasp antennal morphology. Only one bare ring-like annulus is present on the flagellum of *T. radiata*’s antenna in contrast to two ring-like annuli with numerous AST reported for other parasitic wasps such as *Nasonia vitripennis* (Walker) (Hymenoptera: Pteromalidae) (Wibels et al. 1984) and *P. cerealellae* (Onagbola and Fadamiro 2008). However, sensilla similar to *T. radiata*’s AST-1 have been described on the antennae of
other parasitic wasps species. For example, the “aporous sensilla trichoida” on the antennae of *T. nubilale* (Olson and Andow 1993) and *Microplitis pallidipes* Szepligeti (*Hymenoptera: Braconidae*) (Gao et al. 2007) are similar to the AST-1 described in this study. The “tactile mechanosensory bristles” on the antennae of *R. tutela* (Walker) (Pettersson et al. 2001) and the aporous type II sensilla trichoida on the antenna of *P. cerealellae* (Onagbola and Fadamiro 2008) are also similar to the AST-1 on *T. radiata*’s antennae. Numerous authors have suggested that sensilla characterized by morphology similar to *T. radiata*’s AST-1 are mechanosensors (Olson and Andow 1993, Pettersson et al. 2001, Onagbola and Fadamiro 2008). Mechanosensory sensilla detect acoustic/vibrational signals generated by hosts during feeding (Shade et al. 1990) or by some hemipteran hosts during courtship calling behaviors (Tishechkin 2005). Numerous authors have suggested mate finding by acoustic communication among Psyllidea (Tishechkin 1989, 2005; Percy et al. 2006). The minimal sexual dimorphism in the antennal sensilla of *D. citri* (Onagbola et al. 2008) is congruent with the hypothesis that *D. citri* use nonolfactory cues for mate finding. Vibrational signaling as a means of communication between the sexes was recently confirmed for *D. citri* (Wenninger et al. 2009). It is therefore possible that the AST-1 functions in host finding by detecting *D. citri*’s vibrational signals (Wenninger et al. 2009). Although adult *D. citri* are not parasitized, they typically occur among feeding nymphs; thus, adult presence would forecast availability of oviposition sites. Furthermore, the greater abundance of the AST-1 on female antennae corroborates their probable female-specific function of locating psyllid nymphs for egg laying.

The AST-2 are present on the radicula and around the base of the pedicel (at the scape-pedicel joint) on the antennae of both sexes of *T. radiata*. The AST-2 on *T. radiata*’s antennae are similar in location and in structural morphology to the trichoid sensilla on the antennae of *Trichogramma australicum* Girault (Amornsak et al. 1998) and *P. cerealellae* (Onagbola and Fadamiro 2008). The AST-2 were present in similar abundance on the antennae of male and female *T. radiata*. This suggests that the AST-2 are unlikely to have a sex-specific role in the behavior of *T. radiata*. Combined SEM and TEM investigations revealed aperous walls on the AST-2, suggesting a nonolfactory function of these sensilla. However, the location (between two cuticular surfaces) and the finger-like structure of the AST-2 suggest a possible function as proprioceptors for detection of cuticular flexion during antennal movement as has been reported for other insect species like *P. cerealellae* (Onagbola and Fadamiro 2008).

MPS are often the most conspicuous sensilla on the antennae of insect parasitoids (Barlin and Vinson 1981, Amornsak et al. 1998, Pettersson et al. 2001, Bleeker et al. 2004, Onagbola and Fadamiro 2008). Male and female *T. radiata* possess sausage-shaped MPS on their antennae. The type of MPS observed on *T. radiata* occurs commonly on antennae of hyme-
et al. 1981. Olson and Andow 1993, Onagbola and Fadamiro 2008: however, the terminology regarding this structure has been inconsistent among various investigations to date. For example, Barlin et al. (1981) described sensilla similar to the BCPS as “multiporous peg sensilla” on the antennae of the eulophid parasitoid Tetrastichus hagenovii (Ratzburg). Bleeker et al. (2004) and Gao et al. (2007) described similar structures as “coeloconic sensilla” on the antennae of Coctesiinae spp and M. pallidipes, respectively. The “pit organs” described by Wcislo (1995) are also morphologically similar to BCPS on antennae of T. radiata. BCPS have been reported to function in odor perception (Steinbrecht 1987, Ryan 2002). However, our TEM investigation of this sensillar type revealed aporous walls, suggesting a nonolfactory role as has been observed previously in other species (Wibel et al. 1984, Wcislo 1995, Onagbola and Fadamiro 2008). The specific function of BCPS is difficult to infer given their similar distribution and abundance on males and females of parasitic wasp species (Onagbola and Fadamiro 2008). Based on their location and morphology on T. radiata, we suggest that these sensilla may be involved in the detection of hygro- and thermosensory cues as has been reported for similar sensilla in other parasitoid species (Wcislo 1995, Pettersson et al. 2001, Onagbola and Fadamiro 2008).

In summary we have characterized five antennal sensilla on the antennae of male and female T. radiata. Observation of their transverse sections by using TEM confirmed the presence of two aporous (likely mechanosensor and proprioreceptor functions), two porous (likely odor detector function), and one possible hygro- or thermosensory detector on T. radiata’s antennae. The antennae of both sexes exhibit considerable sexual dimorphism. Male antennae are much longer (relative to body length) and possess more multiporous sensilla trichoid. Semiochemicals are known to play a significant role in parasitoid communication and female-produced sex pheromones have been implicated in mate finding (Weseloh 1976, Quicke 1997). Female-produced sex pheromones are typically long-range male attractants in parasitoid species (Eller et al. 1984, Quicke 1997, Jewett and Carpenter 1999) and mediate subsequent close-range courtship behaviors (Yoshida 1978). Male T. radiata have likely evolved larger and more numerous olfactory MST for perception of a female-produced pheromone. In contrast, the antennae of female T. radiata possess more MPS and AST-1. The MPS and AST-1 likely serve in detection of host-related olfactory cues in both sexes. Vibrational communication has been recently reported to occur between male and female D. citri (Wenninger et al. 2009). Therefore, the mechanosensory AST-1 likely function for detection of psyllid-generated vibrational signals for host finding by females. Characterizing the morphology and the distribution of the various sensilla on the antennae of male and female T. radiata will facilitate subsequent electrophysiological investigations of T. radiata’s olfactory sensilla. This will enhance our ongoing investigations of the chemical ecology of this parasitoid species with aim of identifying specific attractants for monitoring wasp establishment and for recruiting wasps into commercial orchards for enhanced biological control.

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