

Scientific Note

Parasitism of *Draeculacephala minerva* Ball, 1927 (Hemiptera: Cicadellidae) eggs by three species of Trichogrammatidae and Mymaridae (Hymenoptera) in California, U.S.A.

The green sharpshooter (GSS), *Draeculacephala minerva* Ball, 1927 (Hemiptera: Cicadellidae), is indigenous to California, U.S.A., and a known vector of *Xylella fastidiosa* Wells et al., 1987 (Proteobacteria: Xanthomonadales: Xanthomonadaceae), the causal agent of the incurable Pierce's disease of grapevine and other xylem-related diseases such as oleander and almond leaf scorch (Hill & Purcell 1997, Redak et al. 2004). GSS is multivoltine and capable of completing up to three generations per year in California (Purcell & Frazier 1985). Host plants for GSS are typically grass species (Freitag 1951), and females oviposit eggs side-by-side in masses just below the epidermal layer of the leaf surface. Egg masses may contain two to 18 eggs (Freitag 1951) and typically average around six (Boyd & Hoddle 2007). Egg dimensions have not been documented. However, it is likely that egg measurements are close to that of its similar-sized congener *Draeculacephala mollipes* (Say, 1830) (Napometh & Nishida 1972), where an egg, on average, measures 1.35 mm long by 0.25 mm wide (Gibson 1915). *Gonatocerus mexicanus* Perkins, 1912 (Hymenoptera: Mymaridae), *Aprostocetus (Ootetrastichus) beatus* (Perkins, 1906) (Hymenoptera: Eulophidae), *Oligosita caeruleocephala* (Fullaway, 1914), *Paracentrobia lutea* (Fullaway, 1914), and *P. auriscutellum* (Girault 1915) (Hymenoptera: Trichogrammatidae) were previously documented as egg parasitoids of *D. mollipes* (Girault 1915, Swezey 1916, Huber 1988, Triapitsyn & Shih 2014). *Gonatocerus mexicanus* is the only documented field-collected mymarid egg parasitoid of GSS (Huber 1988, Huber & Beardsley 2000, Triapitsyn et al. 2010, Triapitsyn & Shih 2014). Although *D. minerva* eggs were determined to be an acceptable physiological host to the mymarid egg parasitoid *Cosmocomoidea fasciata* (Girault, 1911), in laboratory tests they were not determined to be an ecologically acceptable host (Boyd & Hoddle 2007 [as *Gonatocerus fasciatus* Girault, 1911]). Other reported natural enemies of *D. minerva* include an egg-predator, *Cyrtorhinus lividipennis* Reuter, 1885 (Hemiptera: Miridae) (Denno & Perfect 2012) and a parasite, *Halictophagus acutus* Bohart, 1943 (Strepsiptera: Halictophagidae) (Kathirithamby 2005). Here we report on surveys for egg parasitoids of GSS in California.

Field Sites. Three sites in California were surveyed for GSS egg masses. The first was west of Temecula (Riverside Co.), in the Sandia Creek area with southern California grape (*Vitis girdiana* Munson; Vitaceae), nutsedge (*Cyperus* spp.; Cyperaceae), and dallisgrass (*Paspalum dilatatum* Poiret; Cyperaceae) being the dominant understory plants. Nutsedge and dallisgrass adjacent to the creek had the greatest visual counts of GSS adults, nymphs, and eggs. The second GSS site was in Coachella (Riverside Co.) and was in the understory of a date palm (*Phoenix dactylifera* Linnaeus; Arecaceae) plantation consisting primarily of rescuegrass (*Bromus catharticus* Vahl; Poaceae), annual rabbitsfoot grass (*Polypogon monspeliensis* (Linnaeus) Desfontaines; Poaceae), and bermudagrass (*Cynodon dactylon* (Linnaeus) Persoon; Poaceae) as the dominant vegetation. The third GSS site was in Fresno (Fresno Co.) at the California State University and was a cow pasture dominated by bermudagrass and dallisgrass.

Egg Collection. Egg masses of GSS appear as small blisters of the epidermis that visually block the pattern of venation in grass leaves, making visual surveys for egg masses possible. For GSS egg collection, host plants were visually surveyed for egg masses at field sites, and grass leaves with eggs were collected on days they were located. A total of 47 GSS eggs from six egg masses in dallisgrass and 13 masses in nutsedge were collected from Temecula on 30 June 2005 and 21 June 2006. Two GSS egg masses in dallisgrass were collected from Fresno on 16 June 2006. Total egg counts were not determined for Fresno collections due to egg mass degradation. 319 eggs from 104 egg masses collectively from rescuegrass and rabbitsfoot grass were collected at the Coachella site on 27 March and 3 April 2006. Field collected leaves with egg masses were returned to the laboratory, trimmed no closer than 1 cm from the edge of each egg mass, placed in Petri dishes provisioned with moistened filter paper, and held at room temperature (~26 °C) and natural light for up to 45 d to allow for nymph and parasitoid emergence.

Parasitoids. The trichogrammatids *P. auriscutellum* and an undescribed *Paracentrobia* sp. near *auriscutellum*, and the mymarid *G. mexicanus* were reared from field collected GSS eggs. Since number of eggs per mass varied, field parasitism percentage of total eggs collected was calculated. Thirty-seven *G. mexicanus* were reared from GSS eggs collected in Temecula, the remaining 10 eggs were infested by an unknown fungus and no nymphs or parasitoids emerged. The *G. mexicanus* parasitism rate of eggs collected in Temecula was 78.7%. From GSS eggs collected in Coachella, 182 (124 ♀, 58 ♂) *G. mexicanus*, 28 *P. auriscutellum*, and 12 *P. sp. near auriscutellum* were reared. Overall female to male sex ratio of emerged *G. mexicanus* was approximately 7:3. Sex of emerged *Paracentrobia* spp. was not determined. For GSS eggs collected in Coachella, 69.3% of eggs were parasitized, and mean field parasitism of eggs was 57.0%, 5.9%, and 6.4% for *G. mexicanus*, *P. auriscutellum*, and *P. sp. near auriscutellum*, respectively. Egg masses did not appear to be parasitized by more than one species. Five *P. sp. near auriscutellum* were reared from Fresno. Parasitism rates were not calculated for Fresno due to egg mass degradation. Three female and two male *P. sp. near auriscutellum* (identified by J. E. George, formerly University of California, Riverside) were slide mounted and deposited in the University of California, Riverside, Entomology Research Museum (UCRC) (UCRC ENT 017547-017550 and UCRC ENT 017553). One male *P. auriscutellum* (identified by J. E. George) with the following label data was slide-mounted: Coachella, intersection of Airport Blvd. and Jackson St., collected 27.iii.2006, emerged 2.v.2006, E. A. Boyd, from *D. minerva* eggs on grasses in date garden floor (UCRC ENT 017551). *Gonatocerus mexicanus* specimens were identified by S. V. T. but not vouchered.

Parasitoid Confirmation. To confirm the association of emerged egg parasitoids reared from collected GSS egg masses, reciprocal host exposure tests were performed. Three emerged female parasitoids (1-d-old, mated, and fed honey-water) were exposed to < 2-d-old GSS colony-reared eggs on rescuegrass in Petri dishes provisioned with moistened filter paper and allowed ≥ 72 h to parasitize eggs. Petri dishes were held at 27.6 ± 0.4 °C and 16:8 L:D for 45 d for GSS nymph and parasitoid emergence. Egg masses were dissected after 45 d and examined for GSS embryos and parasitoids.

Paracentrobia auriscutellum, *P. sp. near auriscutellum*, and *G. mexicanus* successfully parasitized and emerged from GSS eggs and, thus, were confirmed to be parasitoids of this leafhopper. This is the first published confirmation of field collected egg parasitoids for GSS. Laboratory parasitism rates were 100% for all three parasitoid

species. *Paracentrobia* sp. near *auriscutellum* and *G. mexicanus* developed one offspring per egg, while *P. auriscutellum* developed two. This constitutes the **first confirmed host records** of *P. auriscutellum* and *P.* sp. near *auriscutellum* as GSS natural enemies from field surveys and reciprocal host tests in the laboratory. Additional confirmation tests with combinations of these parasitoids on GSS and other cicadelline and proconiine (Cicadellidae: Cicadellinae: Cicadellini and Proconiini) host eggs would be useful for determination of potential species overlap, competition, and host specificity.

As field parasitism rates of GSS are high for the mymarid species, it may be possible to mass-rear and augmentatively release *G. mexicanus* or to initiate conservation biological control practices to manage GSS populations where heavy infestations are known or where *X. fastidiosa* disease pressure is high and sympatric with GSS.

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