Gymnandrosoma aurantianum

Scientific Name
Gymnandrosoma aurantianum Lima, 1927

Synonyms:
Ecdytolopha aurantianum (Lima, 1927)
Ecdytolopha torticornis Powell et al., 1995

Common Name(s)
Citrus fruit borer, orange fruit borer, macadamia nut borer

Type of Pest
Moth, fruit and nut borer

Taxonomic Position
Class: Insecta, **Order:** Lepidoptera, **Family:** Tortricidae

Reason for Inclusion
CAPS Target: Tropical Hosts Survey Manual-2015 - 2018

Figure 1. Female *Gymnandrosoma aurantianum* moth (Todd M. Gilligan and Marc E. Epstein, CSU, Bugwood.org).

Figure 2. Male *Gymnandrosoma aurantianum* moth (Todd M. Gilligan and Marc E. Epstein, CSU, Bugwood.org).

Pest Description
Eggs: Newly laid eggs are 1.1 to 1.3 mm (between $^{1}/_{32}$ and $^{1}/_{16}$ in) in length, pale white, flattened, and circular or ovoid in shape (Blanco-Metzler, 1994). Eggs darken to a reddish brown as development occurs (Blanco-Metzler, 1994).

Larvae: The body is creamy white and the head is brown (Gómez Orellana et al., 2008). The last instar larvae are approximately 16 -19 mm (approx. $^{5}/_{8}$ to $^{3}/_{4}$ in) in length (Adamski and Brown, 2001). A setal map may be used to identify larvae (Adamski and Brown, 2001).

Pupae: The pupae are 9-12 mm (approx. $^{3}/_{8}$ to $^{1}/_{2}$ in) in long and 2.5-3 mm (<$^{1}/_{8}$ in) wide. There is tapering at both the anterior and posterior end of the pupae (Adamski and Brown, 2001). Pupae can be found in the soil (Cabrera-Asencio et al., 2012).

Adults: Moths are brown and grey in color with a wingspan of about 11-18 mm (approx. $^{7}/_{16}$ to <$^{3}/_{4}$ in) (Bento et al., 2001; Pereira, 2008; White and Tuck, 1993) (Figs. 1 and 2). Males of this species have a flattened, notch-like basal portion of the antennae and a hairpencil on the hind tibia (Adamski and Brown, 2001). Flagellomeres six through ten are compressed in males, forming a shallow notchlike depression. In males, the cucullar ridge points ventrally and the sacculus ridge points distally. The vesica has a long row

or more than 130 long deciduous cornuti. In females, the ductus bursae forms a short, sclerotized ring from ostium (Adamski and Brown, 2001).

Biology and Ecology

In Costa Rica, *G. aurantianum* is active all months of the year (Adamski and Brown, 2001). *Gymnandrosoma aurantianum* has a short lifecycle and up to ten generations a year have been recorded in Costa Rica (Blanco-Metzler, 1994). In laboratory conditions, adult moths lived 16 days (Blanco-Metzler, 1994).

In Brazil, most moths mate on the third and fourth nights after emergence (Bento et al., 2001). There are two peaks of moth activity over a 24 hour period; one during dawn and one during dusk (Bento et al., 2001). Moths rest on leaves in the lower and middle crowns of the citrus trees during the hot, dry daytime (Bento et al., 2001). In the evenings, most moths move up to the upper crowns of the tree. A large portion of mating activity occurs between 7:00 and 8:00 pm and nearly all mating occurs within 5:00 to 9:00 pm. After several hours of activity, there is another resting period during the nighttime until dawn. At dawn, another period of activity occurs (Bento et al., 2001).

In citrus, eggs are laid on the fruit. Mature fruit are preferred, however, green fruits will be attacked when the moth's population is high (Parra et al., 2004). Hatched larvae burrow into and feed upon the fruit pulp (Adamski and Brown, 2001; White, 1999). They may also feed on the seeds (White, 1999). To pupate, the larvae exit the fruit and make a cocoon of silk, frass, and soil in the soil (Blanco-Metzler, 1994). Some will also pupate in the fruit.

In Macadamia nuts, eggs are laid individually on immature nuts that are 8 to 20 mm (approx. 5/16 to ¾ in) in diameter and on the tree within three meters of the ground (Blanco-Metzler, 1994). Usually one egg is laid, but sometimes multiple eggs may be laid per nut (Blanco-Metzler, 1994). Over their lifetime, females lay about 37 eggs (Blanco-Metzler, 1994). Eggs hatch in about 5 to 6 days (Blanco-Metzler, 1994). Larvae burrow into the husk and feed on the kernel. There is typically one larva per nut, but in densely populated scenarios, multiple larvae may be found per nut, usually of different instar stages (Blanco-Metzler, 1994). There are 4 to 5 larval instars (Blanco-Metzler, 1994; Pereira, 2008). When there are 4 instar stages, instar stages 1 through 3 are approximately 3 to 4 days each and instar stage 4 is 3 to 9 days (Blanco-Metzler, 1994). To pupate, the larvae exit the nut and lower themselves to the ground on a silk thread or crawl down the trees branches and trunk (Blanco-Metzler, 1994).

Damage

In oranges, infestation by larvae can cause the fruits to yellow and prematurely fall from the tree (Agricultural Department of Dominica, 1923; Fundecitrus, 2007). The entry hole becomes a brown, necrotic area on the fruit (White, 1999). As the larvae burrow through and feed on the pulp of the fruit, the fruit rots and decomposes (Anonymous, 1957). Frass can be seen coming out of the entry hole (Carvalho et al., 2015). Secondary infection from bacteria, fungi, and other insects can occur (White and Tuck, 1993).

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In macadamia nuts, larvae will burrow into the macadamia nuts and feed on the kernel. Frass will be seen emerging from the entry hole (Blanco-Metzler, 1994). Premature falling of the nuts may also occur due to larval feeding (Blanco Metzler et al., 2007). *G. aurantianum* larvae will also burrow into *Melicoccus bijugatus* (Spanish lime) by piercing an entry hole (Cabrera-Asencio et al., 2012) (Fig. 3). The larvae will eat the fruit pulp which changes the fruit's color and allows for accelerated decomposition of the fruit, rendering it unmarketable (Cabrera-Asencio et al., 2012).

Figure 3. Left: frass material expelled from the entry hole of the *G. aurantianum* larva in *Melicoccus bijugatus* (Spanish lime) fruit. Right: *G. aurantianum* larva found in the pulp of a *Melicoccus bijugatus* (Spanish lime) fruit (from Cabrera-Asencio et al

Pest Importance

In Brazil, *G. aurantiana* has become one of the most important pests in citrus as damage from *G. aurantiana* larvae can cause citrus to become unmarketable for both fresh consumption and processing (Carvalho et al., 2015). Infested areas in Brazil can experience yield losses of 5 to 50 percent (Revista Citricultor, 2016). Damages incurred to citrus by *G. aurantianum* in the State of São Paulo, Brazil were estimated at $50 million per year during the 1990's (Revista Citricultor, 2016).

Significant losses have been reported from other countries and in other crops, as well. A yield loss of ten percent or greater has been reported for oranges from Dominica in 1921 and 1922 (Agricultural Department of Dominica, 1923). In Costa Rica, 4.6 percent to 27.5 percent of macadamia nuts were damaged by *G. aurantianum*, depending on sample year (Blanco-Metzler, 1994). Differences in the number of damaged nuts also depended upon the cultivar of macadamia tree (Blanco-Metzler, 1994). In Puerto Rico in 2011, approximately 5 percent of Spanish lime fruits were damaged by *G. aurantianum* (Cabrera-Asencio et al., 2012).

An outbreak of *G. aurantianum* occurred during the growing season of 1992-1993 in Trinidad (White and Tuck, 1993). Losses of 2 to 40 percent were reported for this citrus growing season at a commercial citrus orchard in Trinidad (White, 1999).

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Known Hosts

Major hosts

Citrus sinensis (orange), *Citrus* spp., and *Macadamia integrifolia* (macadamia nut) (Adamski and Brown, 2001; Anonymous, 1957; Carvalho et al., 2015).

Minor hosts

Annona cherimola (cherimoya), *Annona squamosa* (sugar apple), *Averrhoa carambola* (star fruit), *Citrus paradisa* (grapefruit), *Cojoba arborea, Cupania vernalis, Eriobotrya japonica* (loquat), *Litchi chinensis* (litchi), *Melicoccus bijugatus* (Spanish lime), *Pithecellobium dulce* (Madras thorn), *Plukenetia volubilis* (sacha inchi), *Prunus persica* (peach), *Psidium guajava* (guava), *Punica grantum* (pomegranate), *Punica* spp., *Sapindus saponaria* (wingleaf soapberry), *Simarouba amara,*and *Theobroma cacao* (cacao tree) (Adamski and Brown, 2001; Bento et al., 2001; Brown et al., 2008; Cabrera-Asencio et al., 2012; White and Tuck, 1993).

Although banana is listed as a host in the literature, the original source material indicates that the specimens were actually reared from cacao. Banana as a host is likely an error that has been perpetuated from the original source (Adamski and Brown, 2001).

Pathogens or Associated Organisms Vectored

This species is not known to vector any pathogens or associated organisms. Secondary infection from bacteria, fungi, and other insects can occur (White and Tuck, 1993).

Known Distribution

Caribbean: Barbados, Cuba, Dominica, Dominican Republic, Puerto Rico, and Trinidad and Tobago; **Central America:** Belize, Costa Rica, El Salvador, Honduras, Nicaragua, Panama; **North America**: Mexico; **South America:** Argentina, Bolivia, Brazil, Colombia, Ecuador, French Guiana, Peru, Suriname, and Venezuela (Adamski and Brown, 2001; Agricultural Department of Dominica, 1923; Cabrera-Asencio et al., 2012; Escalante et al., 1981; Razowski, 1999; Razowski and Wojtusiak, 2013).

Pathway

Importation of fruit containing larvae in baggage is a likely pathway of introduction into the United States. In the last ten years, *Gymnanadrosoma aurantianum* has been intercepted 51 times at U.S. ports of entry (PestID, 2018). The large majority of these interceptions were of larvae found in fruits for consumption in baggage (PestID, 2018). Larvae were retrieved from a variety of fruits; these fruits were guava, cacao pods, *Inga edulis* pods (ice-cream-bean), peach, *Byrsonima crassifolia* (Nance fruit), pomegranate, *Mangifera indica* (mango), *Citrus tangerina* (tangerine), grapefruit, Spanish lime, *Phaseolus vulgaris* (green bean), and Madras thorn (PestID, 2018). Infested baggage was from Brazil, Colombia, Cuba, Dominican Republic, Ecuador, Jamaica, Mexico, Puerto Rico, and Venezuela. Some interceptions were in permit cargo, which were cacao pods from Ecuador, and Spanish lime from the Dominican Republic. These infested materials were destined to Arizona, California, the District of Colombia, Florida,

Georgia, Kansas, Kentucky, Massachusetts, Nevada, New Jersey, New York, North Carolina, Ohio, Pennsylvania, and Tennessee.

Potential Distribution within the United States

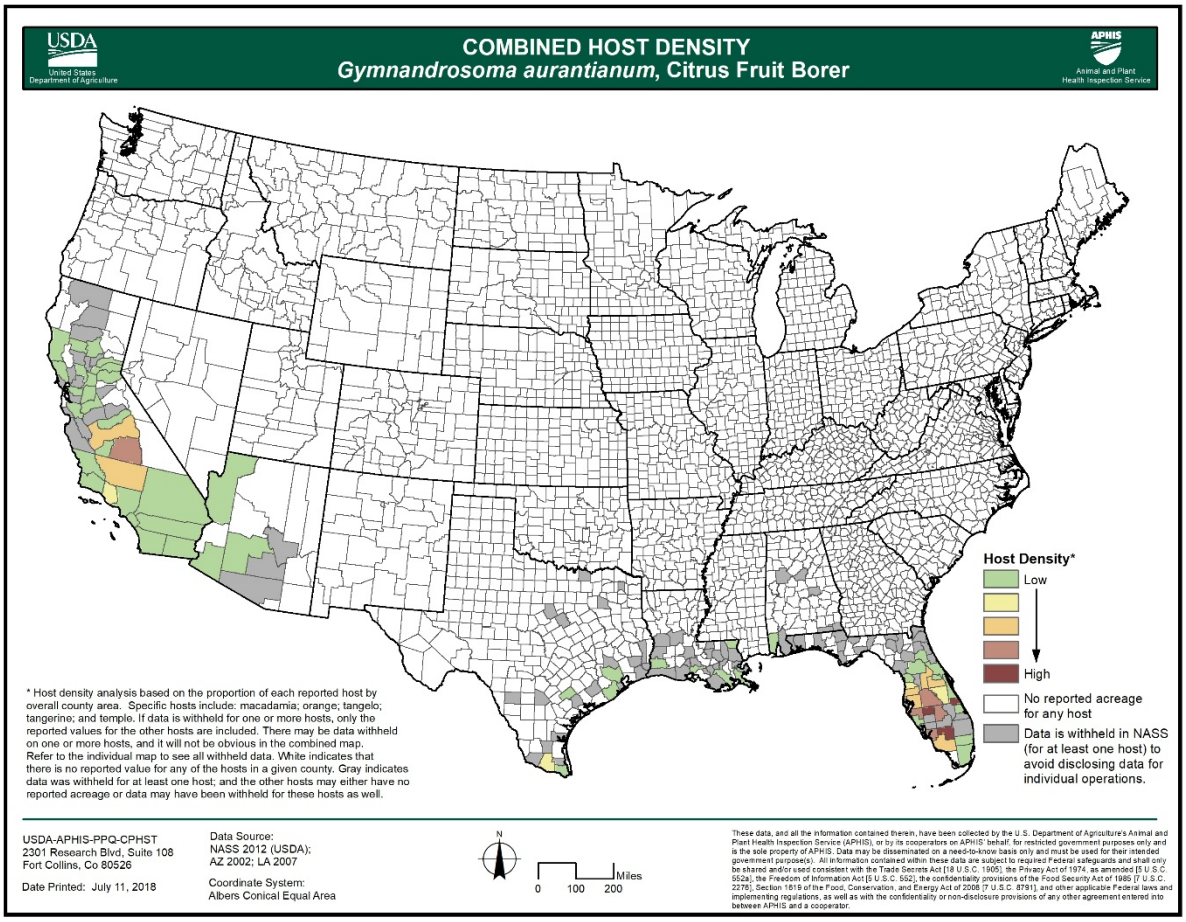

Figure 4. Combined Host Density Map for economically important hosts of *Gymnandrosoma aurantianum* within the continental United States. Values represent combined host acreage low to high (macadamia, orange, tangelo, tangerine and temple). Map courtesy of USDA-APHIS-PPQ-CPHST.

Currently, *G. aurantianum* is present in Puerto Rico (Cabrera-Asencio et al., 2012), but does not occur anywhere else in the United States. The moth is known to occur in Plant Hardiness Zones (PHZ) 9 through 13 (Magarey et al., 2008). In the United States, these PHZ encompass all of Hawaii, the U.S. Virgin Islands and Pacific Territories, nearly all of Florida, southern portions of South Carolina, Georgia, Alabama, Mississippi, Louisiana, Texas, Arizona, Nevada, very limited portions of New Mexico, a large portion of California, and western portions of Oregon and Washington. The moth could potentially establish in these areas where host plants are present.

A recent combined host density map for *Gymnandrosoma aurantianum* developed by USDA-APHIS-PPQ-CPHST (Fig. 4) identifies areas of high host acreage based on the combined acreage of macadamia, orange, tangelo, tangerine and temple. Agricultural host distribution maps are based on county level data. To combine host data for pest-

specific analyses, CPHST normalizes the data by dividing the total host present in a county by overall county area (acres of host in county/ total acres of county). This yields host by county area and allows CPHST to properly combine host distributions without the skewing effects of overall county size. For example, 500 acres of orange grown in one county can now be compared to 500 acres of orange grown in another county.

Survey

Approved Method for Pest Surveillance*: The Approved Method is a trap and lure combination. The trap is the large plastic delta trap (Fig. 5). The lure is effective for 28 days (4 weeks).

IPHIS Survey Supply Ordering System product names:

Large Plastic Delta Trap Kits, Orange,
Large Plastic Delta Trap Kits, Red, or
Large Plastic Delta Trap Kits, White

Trap color is up to the State and does not affect trap efficacy for this species.

The Lure Product Name is "*Gymnandrosoma aurantianum* Lure."

Figure 5. Large plastic delta trap, orange. (Lee Spaulding, USDA-APHIS-PPQ).

IMPORTANT: Do not include lures for other target species in the trap when trapping for this target.

Trap spacing: When trapping for more than one species of moth, separate traps for different moth species by at least 20 meters (65 feet).

*For the most up-to-date methods for survey and identification, see Approved Methods on the CAPS Resource and Collaboration Site, at https://caps.ceris.purdue.edu/approved-methods.

Survey Site Selection:
This species can be surveyed in areas where host plant material is present, including citrus and macadamia groves. This species has also been recorded on other commercial crops like lychee, peach, guava, pomegranate, and cacao (Adamski and Brown, 2001). Hosts can be found in both agricultural and urban settings.

Trap placement:
Leal et al. (2001) suspended traps in host trees at 3 and 3 $^{1}/_{2}$ m (approx. 9 $^{7}/_{8}$ to 11 $^{1}/_{2}$ feet). In Brazil, Bento et al. (2001) found that the moths mate only in the upper crowns of orange trees, regardless of how tall the trees were (peaking an hour after dusk), which would be ideal placement for the traps, because during the day they mostly just rest on leaves on the lower and middle crown, not exhibiting mating behaviors.

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Time of year to survey:
This species can be found as long as appropriate host fruit is available. The short life cycle of this species (about 36 days) allows for multiple generations per year (Gilligan and Epstein, 2012).

Literature-Based Methods:
Trapping: The sex pheromones of *G. aurantianum* are (*E*)-8-dodecenyl acetate and (*E*)-8-dodecenol (Leal et al., 2001). A trapping system using these pheromones was commercially developed by CooperCitrus and implemented for grower use in the early 2000's in Brazil (Revista Citricultor, 2016). It is a four-walled trap with a pellet containing the pheromones. The traps are hung in citrus trees and placed 350 m (1148 feet) apart from one another (Fundecitrus, 2007). The number of males caught every seven days is to be monitored and traps should be changed every 30 days. A cost-benefit analysis was conducted to determine the effectiveness of this trapping program (Bento et al., 2016). An estimated $132.7 million to $1.32 billion U.S. Dollars from 2001 to 2013 were estimated to be saved due to the effectiveness of the trapping system in preventing losses from *G. aurantianum* (Bento et al., 2016).

Key Diagnostics/Identification

Approved Method for Pest Surveillance*:
Morphological: A taxonomic expert in the family Tortricidae is needed to confirm identification (Gilligan and Epstein, 2012).

Tortricids of Agricultural Importance (TortAI: http://idtools.org/id/leps/tortai/Gymnandrosoma_aurantianum.htm) provides a description of the adult and larva (Gilligan and Epstein, 2012). This species is also included in the TortAI Larval Key for port interceptions (http://idtools.org/id/leps/tortai/keys/TortAILarvae.html) (Gilligan and Epstein, 2012).

Descriptions of this species, including adult and last instar larva are found in Adamski and Brown (2001).

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Easily Confused Species

In general, this moth will require a taxonomic expert to identify it to the species level as dissection and examination of the genitalia will be required (Adamski and Brown, 2001; Cabrera-Asencio et al., 2012). For identification of larvae, a setal map will likely need to be used (Adamski and Brown, 2001).

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Draft Log

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