Stenoma catenifer

Scientific Name
Stenoma catenifer
Walsingham, 1912

Synonyms:
None

Common Name(s)
Avocado seed moth, avocado borer, avocado moth, avocado seed worm

Type of Pest
Moth, borer

Figure 1. *Stenoma catenifer* adult. Image taken in Guatemala (Mark Hoddle, Department of Entomology, University of California Riverside).

Taxonomic Position
Class: Insecta, **Order:** Lepidoptera, **Family:** Elachistidae
(Also placed in Stenomidae, Oecophoridae and most recently in Depressariidae (S. Passoa, personal communication, 2015)).

Reason for Inclusion
Additional Pests of Concern 2013

Pest Description

Eggs: "Light green when first laid, oval, 0.6 by 0.4 mm with corium transparent at first then cream colored" (USDA, 1980). The texture of the chorion is "reticulate with longitudinal grooves resembling irregular hexagons" (USDA, 1980).

Larvae: "Fully grown larval length 20 – 25 mm [about 2 cm]. Body creamy white when newly emerged, becoming light rose by the 3rd instar. The dorsal side becomes violet and the ventral side, greenish [turquoise] blue by the 5th instar. Head light brown, turning black by the 5th instar with blackish eyespots and mandibles. Thoracic shield light brown with darker brown anterior edge.

Body light fuscous with blackish brown tubercles, prolegs with complete circle of alternating long and

Figure 2. *Stenoma catenifer* eggs on an avocado branch. Image taken in Guatemala (Mark Hoddle, Department of Entomology, University of California Riverside).

short crochets, abdominal segment 8 with spiracle high up on dorsum, anal shield dark brown" (USDA, 1980).

Gilligan and Passoa (2014) diagnosed *S. catenifer* in their key to intercepted lepidopteran larvae as having a large prespiracular shield extending below the spiracle on the prothorax; the SV group bisetose on A1; A1-8 with SD1 and SD2 on the same pinaculum; A3-6 with the crochets in a biordinal to weakly triordinal complete circle; A8 with L3 above L1 and L2 and A9 with the the D1 and D2 setae on same pinaculum.

Figures 3 & 4. Fifth instar larva of *Stenoma catenifer*. The dorsal side has a violet coloration (left), while the ventral side has a blue-turquoise coloration (right). Both images taken in Guatemala (Mark Hoddle, Department of Entomology, University of California Riverside).

Pupae: "Pupae are loosely attached with fine weak silk strands to a substrate but can be easily dislodged with gentle prodding. Young pupae are a striking turquoise blue in color and within 4 – 8 hrs of initial pupation this color becomes reddish-brown as pupae mature and sclerotize [melanize]" (Hoddle, 2013). Like other members of the subfamily Stenomatinae, the pupa has ridges on the scape of the antennal and lateral condyles on some abdominal segments (S. Passoa, personal communication, 2015). Lateral condyles were illustrated in Berenbaum and Passoa (1999).

Adults: "Moths are light tan color, and wings are marked with numerous black spots (Hoddle unpublished data, 2007)" (reviewed in Hoddle, 2013). The most characteristic marking on the forewings is a series of small black dots that may or may not form a "C" shaped row at the distal end of the forewings (S. Passoa, personal communication, 2016; J. Brambila, personal communication, 2016). "Adult females are about 15 mm in length (tip of head to tip of wings) when in the resting position with wings folded across the dorsum. Wing span for females with forewings fully spread is around 28–30 mm in breadth. Males tend to be slightly smaller (2–3 mm shorter) than females and are similarly colored (Hoddle unpublished data, 2007)" (reviewed in Hoddle, 2013).

A detailed description of the adult and life stages with drawings can be found in Cervantes Peredo et al. (1999).

Biology and Ecology

Adults are active at night; during the day they can be found resting in dried leaf duff, weeds, and other litter in host orchards (Landry and Roque-Albelo, 2003; Hoddle et al., 2013). Flight during the day is extremely limited. When disturbed, moths fly less than 3

m (~9 ft 10 in), before seeking refuge in leaf litter (Hoddle and Hoddle, 2008b). A day after mating, females will either oviposit eggs on the fruit crevices (Wysoki et al., 2002) or the branch to which the fruit pedicel is attached (Hoddle and Hoddle, 2008a). Females lay from 180 to 240 eggs. Eggs are mainly deposited in small crevices on the fruit surface, but they may also be laid individually on stems or other nearby places (USDA, 1980). Females do not discriminate between fruit of different sizes (Cervantes Peredo et al., 1999). This species prefers to oviposit and attack fruits that are found in the upper half of the trees; damage is mainly found on the lower half of the fruits (Hohmann et al., 2003).

Figures 5 & 6. *Stenoma catenifer* damage showing whitish exudates and holes in the side of the fruit. Image 5 taken in Guatemala; image 6 taken in the Galápagos Islands (Mark Hoddle, Department of Entomology, University of California Riverside).

Larvae hatch in about five to six days and tunnel into the fruit pulp where they feed on the seed (USDA, 1980). The seed can be devoured in 20 days (Wysoki et al., 2002). Larvae also feed inside tunnels within young branches. Larvae pass through five instars and take about 21 to 28 days to develop. Once larval development is complete, the larvae tunnel out of the fruit and drop to the ground to pupate (USDA, 1980). Some larvae may stay in the fruit and pupate either inside the seed or occasionally in cavities within the fruit.

After settling in a spot, larvae will spin a loose, fragile silk tent within which they pupate (Hoddle, 2013). The pupal stage lasts 11 to 19 days (Wysoki et al., 2002).

The entire life cycle lasts between 44 and 49 days (Wysoki et al., 2002).

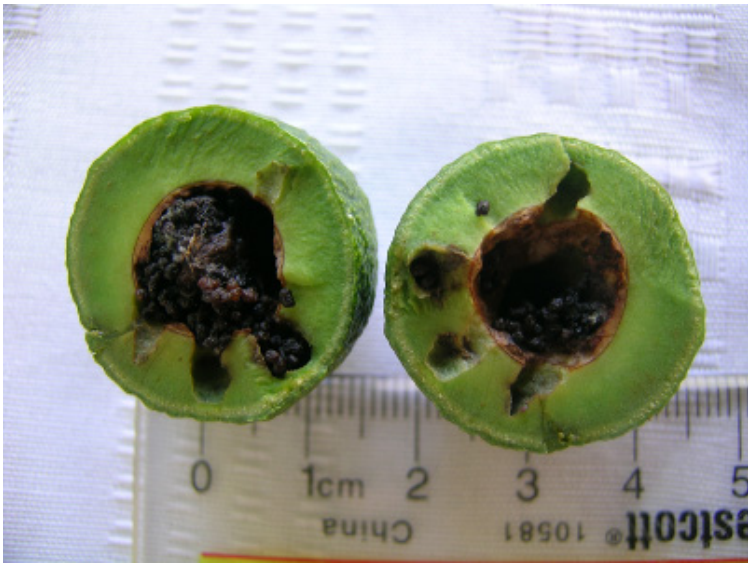

Figure 7. Destroyed seed in avocado fruit filled with frass of *Stenoma catenifer.* Image taken in Guatemala (Mark Hoddle, Department of Entomology, University of California Riverside).

Damage

The first signs of damage are usually seen about one month after the fruit forms. Landry and Roque-Albelo (2003) state that this species can be detected in large fruits because of the appearance of white, chalky looking spots and the accumulation of frass by the entrance hole. Infested fruits fall prematurely (Landry and Roque-Albelo (2003).

This species can cause several types of damage: 1) Larvae can bore into terminal twigs causing the twigs to wither and die. Heavy infestations in small trees can result in tree death. 2) Larvae can bore into and cut the stems or bases of small fruit which then fall to the ground (Fig. 8). 3) Larvae can feed on large and nearly mature fruit, eating through the flesh of the seed and expelling their excrement from the fruit (Fig. 9). The first type of damage can cause death of young trees while the second and third types of damage can lead to large fruit losses in the crop (reviewed in Ebeling, 1959).

Figures 8 & 9. Avocado stem with *Stenoma catenifer* larva (left). Seed with *S. catenifer* frass and pupa (right). Image 8 taken in Peru; image 9 taken in Guatemala (Mark Hoddle, Department of Entomology, University of California Riverside).

Pest Importance

This species is considered one of the most damaging avocado pests in many tropical and subtropical areas (Ebeling, 1959) and has been recorded damaging avocado in Argentina, Colombia, El Salvador, Guatemala, Guyana, Honduras, Mexico, Peru, and Venezuela (reviewed in Hoddle and Hoddle, 2008a). It is the major pest limiting commercial avocado production in Brazil (Hohmann et al., 2003). Losses from 60 to 100% have been recorded in Brazil despite heavy broad-spectrum pesticide use (Nava et al., 2005b; reviewed in Hoddle et al., 2008). Losses of 80% have been recorded in Venezuela with heavy pesticide use (reviewed in Hoddle et al., 2008). Fruit damage in some commercial orchards in Guatemala can reach 45% even with insecticide applications. Some avocado plantations in Mexico have reported up to 94% fruit damage (USDA, 1980).

This species was accidentally introduced into the Galápagos Islands in 2001 and rapidly established on the islands that have avocado production (Santa Cruz and San Cristóbal). The infestation rate on fruit is close to 90% for the bi-annual crop. The infested fruits either drop from the trees prematurely or are so damaged that they cannot be used for consumption. Avocado is no longer a viable crop in the Galápagos Islands. This has led to increased importation of fresh avocados from mainland South America, increasing food costs for locals and the potential for additional pests to enter (Hoddle, 2013).

According to Hoddle et al. (2009a) the risk this species posed to the California avocado industry was so great that it led to the development of a female produced sex pheromone. This was a collaborative project between the University of California, Riverside, the California Avocado Commission, and cooperating growers and grower organizations in Guatemala.

Known Hosts

This species has only been recorded on members of the Lauraceae family (Cervantes Peredo et al., 1999).

Major hosts

Persea americana (avocado), *P. schiedeana* (coyo), wild *Persea* spp., and *Beilschmedia* spp. (reviewed in USDA, 1980).

Minor hosts

Chlorocardium rodiei (greenheart tree), *Cinnamomum camphora* (camphor tree), and *Nectandra megapotamica* (Cervantes Peredo et al., 1999; Link and Link, 2008).

Hoddle and Hoddle (2008a) found that this species prefers Hass to non-Hass avocados, laying up to 2.69 times more eggs on Hass avocados.

Pathogens or Associated Organisms Vectored

This species is not known to vector any pathogens or other associated organisms.

Known Distribution
This species is native to the Neotropical region (Nava et al., 2005a).

Central America: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama; **North America:** Mexico; **South America:** Argentina, Bolivia, Brazil, Colombia, Ecuador, Galápagos Islands (Santa Cruz and San Cristóbal), Guyana, Peru, and Venezuela (USDA, 1980; reviewed in Hoddle and Hoddle, 2008a; Hoddle et al., 2009; EPPO, 2013; reviewed in Hoddle, 2013).

Pathway
This species can move through human-mediated movement. Larvae are internal feeders and are not likely to be affected by surface postharvest treatments (example: washing and culling) (USDA, 2009).

There are 486 interceptions of this pest listed in the Agricultural Quarantine Activity Systems (AQAS) database during the time period of January 1, 1984 through February 29, 2016. The vast majority of these interceptions occurred on *Persea* sp. from baggage. Over 100 interceptions occurred on material heading towards California and Florida where avocado is grown commercially (Agricultural Quarantine Activity Systems, 2016, queried February 29, 2016.)

This species was intercepted in avocado fruit in the Galápagos Islands during 2000. It is now established on the island of San Cristóbal and Santa Cruz (Landry and Roque-Albelo, 2003; Hoddle, 2013).

Movement of live avocado plants may inadvertently move this pest into new areas if undetected larvae are feeding inside branches, stems, and twigs.

Potential Distribution within the United States
The main commercial host, avocado, occurs in a small part of the United States and territories, including California, Florida, Hawaii, Puerto Rico, and the U.S. Virgin Islands (USDA-NRCS, 2015). According to FAVIR (2015, queried March 5, 2015), avocado fruits are allowed entry into the continental United States from Peru, which is known to have this species. Avocado fruits are also allowed from Mexico; however, certain requirements have to be met, which have been designed to reduce the chances that *S. catenifer* would enter from these shipments.

Survey
Approved Method for Pest Surveillance*:
The approved method is a trap and lure combination. The approved trap is the wing trap. The wing trap is available in a plastic or paper version; either type may be used for this target.

IPHIS Survey Supply Ordering System Product Names:

1) Wing Trap Kit, Paper
2) Wing Trap Kit, Plastic

3) *Stenoma catenifer* Lure

Note, surveys should focus on adults; however, if suspected larvae are observed, they may be submitted for identification. Relatively few species of borers would be found in avocado fruit in the United States. Suspect larvae from avocado trees can be placed in a vial with household vinegar (5% acetic acid) and forwarded to the APHIS National Specialist for confirmation (S. Passoa, personal communication, 2015).

Figure 10. Wing trap baited with a gray rubber septum loaded with *Stenoma catenifer* sex pheromone (Mark Hoddle, Department of Entomology, University of California Riverside).

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).

Survey Site Selection: This species feeds on a very limited number of host plants. The main commercial host is avocado. Surveys can occur wherever avocado trees or orchards are present.

Trap placement: Traps should be hung inside the tree canopy at 1.75 m (5 ¾ feet) (Hoddle et al., 2011).

Trap density:
Hoddle (2013) reported that 10 to 13 traps randomly deployed throughout a commercial orchard for seven days will catch at least one male moth with about 90% confidence. Regardless of orchard size (even for large orchards of over 100 acres), 10 to 13 traps are sufficient for early detection surveys (M. Hoddle, personal communication, 2015). For a large area, traps could be evenly placed over the area (for example, 15 traps over 300 acres) (M. Hoddle, personal communication, 2015).

Time of year to survey: Surveys for this species can occur year round as larvae feed on avocado fruit and inside young branches, twigs, and stems.

*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.

Literature-Based Methods:

Trapping: The pheromone for this species consists of a single component: (9Z)-9,13-tetradecadien-11-ynal (Miller et al., 2008). A field evaluation by Hoddle et al. (2009) found that "blends of this compound with a range of ratios of the corresponding alcohol and acetate, or with (6Z,9Z)-tricosadiene, which was present in pheromone gland extracts, were equally or less attractive to male moths than the single component." Also, dose ranges from 10µg to 1mg were equally attractive. Lures remained attractive for several weeks.

Field tests by Hoddle et al. (2011) found that gray and white rubber septa were of equal efficacy as pheromone dispensers and height of the wing traps did not significantly affect the number of catches. Hoddle et al. (2011) suggested that gray rubber septa in wing traps should be hung inside the tree canopy at 1.75 m (5 ¾ feet) for monitoring purposes. The height was chosen due to its convenience for monitoring the traps (Hoddle et al., 2011).

Not recommended: Adults have been trapped using mercury vapor lights in the Galápagos Islands (Landry and Roque-Albelo, 2003). For CAPS surveys, light traps are not an approved method for this species as they are not species-specific.

Key Diagnostics/Identification

Approved Method for Pest Surveillance*:

Morphological: Confirmation of *Stenoma catenifer* is by morphological identification. Adults of *S. catenifer* can be identified in sticky traps by their wing color pattern. A "C" shaped row of spots at the distal end of the forewings is characteristic for *S. catenifer*. In addition, the sharp, upturned labial palpi, typical of gelechioid moths, are an important feature to help recognize *S. catenifer* (S. Passoa, personal communication, 2015). *Stenoma catenifer* can also be distinguished by genitalic characters. If even a vague curved pattern of dots is observed, dissection of genitalia is required (S. Passoa, personal communication, 2015; J. Brambila, personal communication, 2016). Species of Stenomatinae, including *S. catenifer*, have forked setae on the male genitalia.

Figures 11 & 12. Female (left) and male (right) *Stenoma catenifer*. (Mark Hoddle, Department of Entomology, University of California Riverside).

A photograph of the male genitalia is posted at http://mothphotographersgroup.msstate.edu/genitalia.php?hodges=19660.

A key to Lepidoptera larvae that threaten avocado production in California (including *S. catenifer*) is found in Gilligan et al. (2011). A detailed description of the life stages with drawings can be found in Cervantes Peredo et al. (1999). Suspect larvae from avocado trees may be submitted for identification.

*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.

Easily Confused Species

According to Plant Health Australia (2013), "other moths from the Stenomatinae family can look similar to the avocado seed moth but *S. catenifer* can be readily identified by the "C" shape formed by the dark spots on the forewing."

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Reviewers

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