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ASPECTS OF THE FIELD ECOLOGY OF *STENOMA CATENIFER* (LEPIDOPTERA: ELACHISTIDAE) INFESTING HASS AVOCADOS IN GUATEMALA

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Stenoma catenifer Walsingham (Lepidoptera: Elachistidae) is native to neotropical areas and is an important pest of avocados *Persea americana* Miller (Lauraceae) in Mexico, and Central and South America (Wysoki et al. 2002). The principal economic loss to *S. catenifer* is caused by larvae feeding internally on fruit pulp and seeds which disfigures fruit and can promote premature fruit drop (Núñez 2008). Heavy infestations of stem-mining larvae can kill twigs and young avocado trees (Núñez 2008; Wolfenbarger & Colburn 1979). Larvae pupate within the top 0.5-2.0 cm of soil (Boscán de Martínez & Godoy 1984). Adult *S. catenifer* moths are nocturnal and hide on the ground during the day (Cervantes Peredo et al. 1999). Eggs are parasitized by trichogrammatids (Hohmann et al. 2003), and larvae are attacked by braconid and ichneumonid parasitoids (Cervantes Peredo et al. 1999; Hoddle & Hoddle 2008; Nava et al. 2005).

Field infestation rates by *S. catenifer* in commercial Hass avocado orchards can average 45% (Hoddle & Hoddle 2008). California is the largest producer of Hass avocados in the U.S.A., and the industry in California does not have specialist avocado fruit feeding insect pests. Thus, large-scale imports of Hass avocados that originate in the home range of *S. catenifer* are viewed as a major biosecurity threat to California because movement of infested fruit has been identified as the major conduit for moving this pest into new areas (Núñez 2008).

To better understand the field ecology of *S. catenifer* during a 6-week field study conducted in a commercial Hass avocado orchard in Guatemala, we investigated (1) the natural enemy fauna associated with *S. catenifer* larvae, (2) the diurnal flight behavior of deliberately released moths, and (3) the predation risk to *S. catenifer* larvae, pupae, and adults from lycosid spiders.

A commercial Hass avocado orchard (approximately 5 ha) consisting of about 800 trees in San Miguel Dueñas, Sactepéquez, Guatemala (N14°31.461; W90°46.579; elevation 1500 m) was used for this study over the period Nov 13, 2007 to Dec 21, 2007. Trees in the Hass orchard were about 7 years old, around 5-6 m in height, and separated by 5 to7 m of clear ground allowing full sun exposure. The orchard was treated monthly with a rotating schedule of malathion and endosulfan. A total of 561 fruit showing external signs of *S. catenifer* damage were removed from the study orchard from Nov 13 to 27, 2007.

Harvested fruit were held in the laboratory for 10-14 d in insect rearing cages (BugDorm-2120, 60 cm × 60 cm × 60 cm; from MegaView Science Education Services, Taiwan) at 22.56°C ± 0.19 and RH 71.33% ± 4.89 under L:D 12:12. Fruit were inspected daily, and emerged mature *S. catenifer* larvae were isolated and kept in labeled, ventilated plastic cups. After 10-14 d, all fruit from a particular harvest date were opened, and avocado seeds showing *S. catenifer* activity were isolated individually. All rearing cups were observed daily until the fate of larvae was recorded as having pupated or died from parasitism or unknown causes.

Survivorship of larvae to adulthood was 38% (Table 1). Two species of primary hymenopterous parasitoid were reared from larvae. A gregarious *Apanteles* sp. (Braconidae: Microgastrinae) (UCRC ENT 149607-149611) parasitized 60% of *S. catenifer* larvae. The sex ratio of *Apanteles* sp. was 64% female, and 93% of parasitoids emerged successfully from cocoons. The mean number of cocoons per host was 7.51 ± 0.28 (range = 1 to 13).

A solitary *Macrocentrus* sp. (Braconidae: Macrocentrinae) (UCRC ENT 101108-101111) was reared from 40% of the larvae. The sex ratio for *Macrocentrus* sp. was 67% female; 80% of parasitoids emerged successfully from cocoons, and 17% of larvae failed to spin cocoons and died. A solitary hyperparasitoid, *Perilampus* sp. (Hymenoptera: Perilamidae), was reared from 0.7% of *Apanteles* sp. pupae (UCRC ENT 101112-101114), and 5% of *Macrocentrus* sp. pupae (UCRC ENT 147087-147088).

On 3 separate occasions (Dec 15, 17, and 20, 2007 in the mid-afternoon), a cumulative total of 45 adult *S. catenifer* reared from field collected larvae were returned to the study orchard, and released individually in 1 of 3 different areas: (1) open ground between trees (n = 15), (2) in the shade immediately beneath the canopy of an avocado tree (n = 15) at a height of ~1.25 m, and (3) at a height of ~3.5 m inside the tree canopy (n = 15). Upon release, each moth was tracked visually to its resting place, and the linear distance flown from release point to final resting place was measured.

Regardless of release site, all adult moths immediately flew to the ground and hid. The mean distance flown was 3.17 m ± 0.13 (range 1-12 m), and 73% of moths flew ≤3 m, and were extremely recalcitrant to movement when probed after landing.

A spider, *Hogna* sp. (Araneae: Lycosidae), was a common predator on the orchard floor. The po-

TABLE 1. PARTIAL LIFE TABLE FOR *STENOMA CATENIFER* LARVAE REARED FROM HASS AVOCADOS COLLECTED FROM A COMMERCIAL ORCHARD IN SAN MIGUEL DUEÑAS, SACATEPÉQUEZ, GUATEMALA.

Life Stage of *S. catenifer*	No. Entering Stage	Cause of Mortality	No. *S. catenifer* Dying in Stage
Larvae	283	Parasitism: *Apanteles* sp.	63
		Macrocentrus sp.	42
		Unknown Causes	49
Pupae	129	Unknown Causes: Females	8
		Males	13
Adults: Females	68		
Males	40		

Larval to adult survivorship: 38%; Parasitism: 37%; Sex ratio: 59% female.

tential impact this spider could have on fifth instar *S. catenifer* seeking pupation sites, exposed pupae, or resting adults was investigated in the laboratory. Twenty spiders were captured in the field, held individually in ventilated plastic vials, and starved for 24 h. After this starvation period, each of 5 randomly selected spiders was either provisioned with a single fifth instar *S. catenifer* larva, pupa, or adult moth. Five starved spiders were held as controls. After an 8-h period, spider survivorship was assessed, and all spiders provisioned with a *S. catenifer* life stage were held for an additional 36 h to determine survivorship post-exposure to prey.

All life stages of *S. catenifer* encountered by starved *Hogna* sp. (UCRC ENT 138337) were attacked immediately upon introduction into vials. All *S. catenifer* larvae (n = 5) and adults (n = 5) were consumed, and 4 out of 5 pupae were eaten. All spiders that fed on *S. catenifer* were still alive 36 h post-exposure. Four of 5 control spiders also survived the experiment.

Hector Leal and Oscar Coy provided unlimited access to the Hass avocado orchard used in this study. John Luhman, John Heraty, and Serguei Triapitsyn identified parasitoids. Tom Prentice identified the *Hogna* sp. This work was supported in part by the California Avocado Commission.

SUMMARY

Larvae of *Stenoma catenifer* reared from Hass avocados in Guatemala were parasitized by 2 species of primary parasitoid, *Apanteles* sp. and *Macrocentrus* sp. Observations of the diurnal flight activity of adult *S. catenifer* indicated that 73% of moths fly less than 3 m during the day. Laboratory experiments demonstrated that lycosid spiders are voracious predators of fifth instar larvae, pupae, and adults.

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