Proactive Surveys for Avocado Fruit Feeding Pests in Central or South American Countries Planning to Export Fresh Fruit into California

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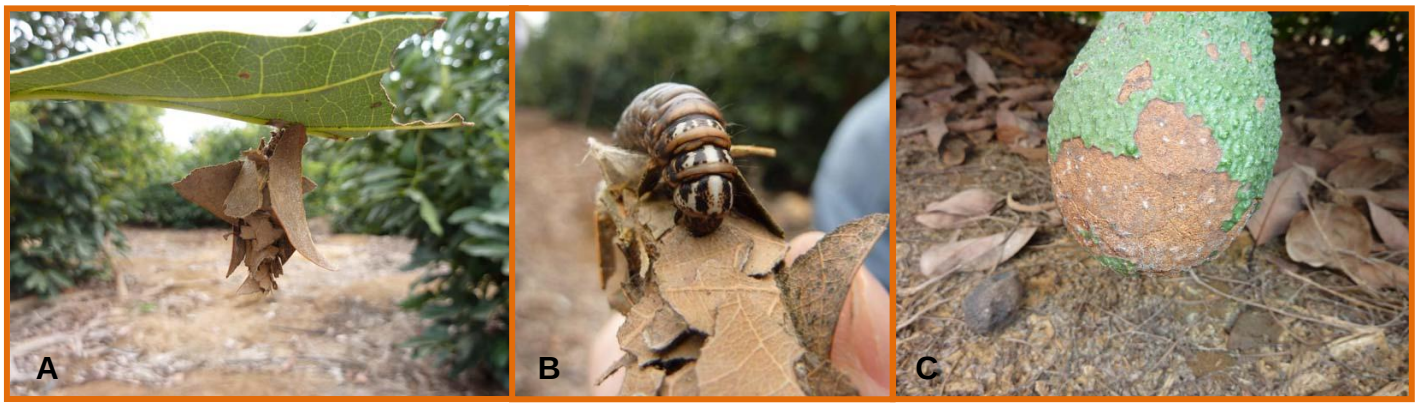
Importation of fresh avocado fruit into California from an ever increasing number of exporting countries from Central and South America is likely to continue for the foreseeable future. USDA-APHIS risk assessment reports for exporting countries are generally not well researched because they are compiled from information that is electronically retrievable from the scientific literature (peer-reviewed and gray), the web, and perhaps museum records. The purpose of this research is to survey countries that are at the very early stages of developing fruit export programs to California (e.g., Perú), and survey fruit in these countries for pests, and when possible, develop pheromone-based monitoring tools for selected species that have invasion potential. Our experiences in Guatemala working on the *Stenoma* pheromone project revealed that many different types of insects feed on avocado fruit. Of this material, much of it was either unknown to science, or if the species did have a name, it's host plants were unknown. For example, in Guatemala two species of fruit feeding moth new to science were discovered, the avocado destroyer, *Histura perseavora*, and *Holcocera plagatola* (the dark streaked holcocera). In addition to these moths, others were found including *Cryptaspasma* sp. and *Amorbia santamaria* (both known to be associated with avocados), and *Netechma pyrrhodelta*, *Euxoa sorella*, *Micrathetis triplex*, *Argyrotaenia* sp., and *Polyortha* sp., none of which were previously known to feed on avocado fruit. These are just examples of moths. In addition to these lepidopteran pests, there were numerous other types of insects, including weevils, scales, flies, and thrips associated with Guatemalan-grown avocados. Similar faunal data sets, if they exist for other countries in Central and South America, are not readily available and this makes it very difficult, if not impossible, to prepare monitoring plans for new invasive species if their identities are unknown.

To better prepare the California avocado industry for potential new insect pests associated with fresh fruit imports, a three month survey of fruit feeding pests associated with avocados in Perú was initiated on May 3 2010 and ceased July 27 2010. Exports of fresh fruit from Perú began in July 2010, and will be significantly ramped up in 2011.

Survey work supported by this grant was run in conjunction with SENASA, the Peruvian equivalent of the USDA-APHIS. Colleagues in SENASA generously provided assistance in locating export-certified and non-certified orchards, arranged access and transportation to and

from these orchards in the states of Lima, Ica, Arequipa, La Libertad, and Junin. In each of these states there are Hass orchards, some of which are certified for fruit exportation to the USA. In addition to surveying fruit directly for damage and associated insect pests, permission was granted to hang *Stenoma* pheromone traps in export orchards to survey for this pest. These traps were inspected by SENASA. Examples of potential pest species from Perú encountered in surveys of export certified orchards are shown below.



The native bagworm, *Oiketicus kirbyi* (Guilding) (Lepidoptera: Psychidae), has recently emerged as a serious pest of avocados in Perú, especially in the desert areas ~ 200 km south of Lima (e.g., orchards around Ica, Chincha, and Chilca). Bagworm larvae form protective bags **(A)** within which they feed (**B** female larva emerging from bag) and the thick tough silk of these bags makes them impervious to most contact insecticides. Larvae feed on avocado leaves but they also graze the skin of avocados causing extreme cosmetic damage **(C)**. This pest has had its sex pheromone identified. It is also attacked by parasitoids but their identities have not been determined or their impacts quantified.

(A) Eggs on a Hass fruit exhibiting a characteristic egg trail for an unidentified species of whitefly in the genus *Aleurodicus* (?) (Hemiptera: Aleyrodidae). **(B)** Nymphs of this whitefly exhibit an extraordinary behavior, they form exquisite rows along the lateral veins on the undersides of leaves. **(C)** Adults of *Aleurodicus* (?) feeding and laying eggs on the underside of a Hass avocado leaf. This whitefly was associated with Hass avocados grown near Chilca.

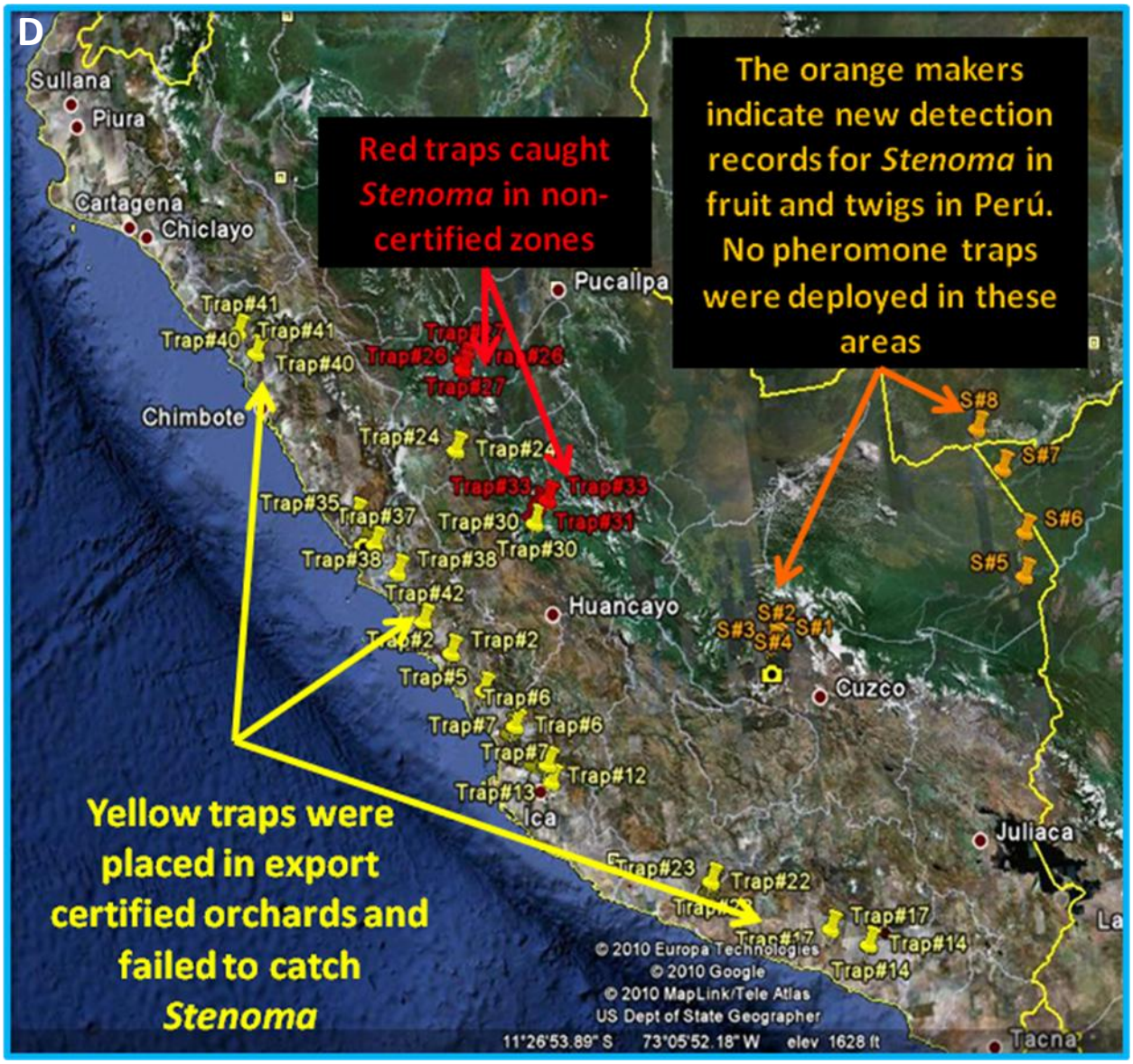
Work in Perú with SENASA evolved during our interactions with SENASA scientists to cover three objectives: (1) To place *Stenoma* pheromone traps in export certified orchards in coastal desert zones to monitor for the presence of this pest. (2) To determine if the *Stenoma* pheromone worked in Perú and attracted *Stenoma* in areas with known infestations. (3) To collect and examine avocados for fruit feeding pests from production areas of Perú that were not part of the export program.

Results:

Objective 1: *Stenoma monitoring in export orchards.* Sixteen export-certified orchards were visited in four different Departments (the equivalent of States). (A) Lima, six orchards were visited; (B) Ica, six orchards were visited; (C) Arequipa, two orchards were visited; (D) La Libertad, 2 orchards were visited. A total of 25 pheromone traps were deployed across these orchards. Lima orchards received 10 traps, Ica received eight traps, Arequipa received 4 traps, and La Libertad was treated with three traps. Approximately 50 traps were left with SENASA with pheromones to allow SENASA to continue monitoring after this project ended in July 2010. All pheromone traps were placed in trees that were being used as part of the Mediterranean Fruit Fly monitoring program. These trees were already being inspected by SENASA, Med-fly traps had their GPS coordinates recorded, and trees were flagged and readily recognized by SENASA field crews. Incorporating the *Stenoma* traps into the Med-fly monitoring program is simple, cheap, and extremely cost effective. This piggy-back approach should be recommended by the CAC to APHIS and SENASA for monitoring *Stenoma* in Perú. SENASA field workers **(Photo A)** were shown how to construct traps, place the pheromone inside traps, and six power point presentations in Spanish(!) were given by Hoddle on the biology, ecology, biological control, and monitoring of *Stenoma* to SENASA staff in all areas that had commercial Hass avocado production sites permitted for export.

(B) Ingress to all commercial Hass export orchards was highly restricted and included vehicle washing, presentation of photo identifications for recording by armed guards, and bag

inspections for fruit being brought into orchards. **(C)** Many commercial orchards had their own insectaries for mass producing natural enemies for release on trees to reduced pesticide use.



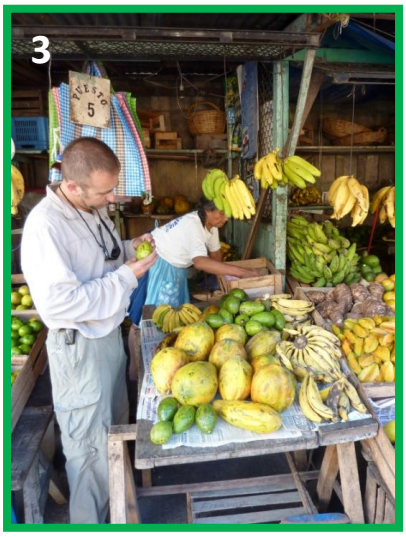
The Google Earth Map above **(D)** shows the locations where pheromone traps were deployed for the detection of *Stenoma* (yellow and red markers) and new areas of Perú where *Stenoma* was officially recorded for the first time infesting avocado fruit, twigs, stems, and branches of trees (orange markers).

Objective 2: *Demonstrating that the Stenoma pheromone works in Perú.* The *Stenoma* pheromone attracted male moths in all areas it was deployed where populations of this pest were known to exist. Captures were made in Huánuco (orchards around Tingo Maria) and Junin (orchards around La Merced and San Ramón). Successful trapping of male *Stenoma* in pheromone traps are shown in **Fig. D** above (i.e., the red markers on the Google Earth Map).

Objective 3: *Collect, examine and rear out Lepidoptera infesting avocados in Huánuco, Junin, Cusco, Madre de Dios.* Approximately 405 damaged or infested avocados were collected from

Huánuco and Junin from which *Stenoma* and its natural enemies were reared out. An additional 50 and 100 fruit were collected in Cusco and Madre de Dios, respectively, and inspected in the field for *Stenoma*. *Stenoma* larvae were collected from these infested fruit and branches and preserved for future study.

Fruit for this rearing study were collected in three different ways (see photos below): **(1)** directly from trees in infested orchards, **(2)** from bins at distribution centers were fruit from farms were brought in and sold to distributors, and **(3)** from venders at local markets who were selling avocados.



Infested fruit (~405) were held in BugDorms in a converted meeting room at the SENASA office in San Ramón in Junin **(Photo 1 below)**. Fruit were inspected weekly (this required an obnoxious 8 hour over night bus ride from Lima to San Ramón. Violent protests by miners at the Doe Run mine in La Oroya made this travel by bus exceptionally challenging), opened, cleaned **(Photo 2 below)** and infested seeds were isolated individually in ventilated plastic cups, and larvae and their associated parasitoids inside seeds were reared out to determine the fate of *Stenoma* (i.e., whether larvae were parasitized, became pupae, or emerged as adult moths).

Life table analyses from the rearing studies detailed here are pending. Several different types of natural enemies were encountered attacking *Stenoma* larvae in Perú, and all species differed from those previously recorded from Guatemala. The most common parasitoids were an *Apanteles* species **(see Photo 1 below)**, and a parasitic tachinid fly (the adult is shown in **Photo 2a, and 2b** shows the fly pupa inside the pupa of *Stenoma*). Identifications for both of these parasitoids by experts are pending. Fungal infections of larvae and pupae were not uncommon (**Photos 3 and 4**, respectively).

The most interesting and new discovery from field work was the finding that *Stenoma* larvae can do immense amounts of damage to green stems and woody avocado branches. Unintentional movement of *Stenoma* via infested plants (as well as fruit) is highly likely. Discussions with nursery managers in Cusco indicated that at certain times of the year they have a "*Stenoma* season" when branches of young plants in the nursery are heavily infested with *Stenoma* larvae.

The photos above show: **(A)** an avocado nursery in Cusco, Perú that regularly suffers from infestations of *Stenoma* larvae that mine the young green branches. **(B)** A large *Stenoma* larva inside a green Hass avocado branch. **(C)** *Stenoma* doesn't limit its attacks to green stems and twigs, large larvae are capable of boring through the centers of mature wooden branches. This particular branch (Hass) had two larvae feeding inside it! **(D)** A *Stenoma* larva "swimming" in viscous fluids in the center of a young green Hass avocado twig. **(E)** Frass piles pushed to the openings of feeding tunnels in a branch of a Hass avocado. **(F)** Stem dieback caused by *Stenoma* larvae feeding inside in this Hass branch. The tunnel openings and frass are clearly evident in this photo.

Conclusions from Fieldwork in Perú: Limited inspections of commercial Hass avocado orchards that had been certified for export to California appear to be very professionally maintained with high standards of pest and weed control. We did not verify SENASA's reports that *Stenoma* traps hung in export certified orchards failed to catch this pest. We were not provided opportunities to return to export certified orchards in which traps were hung to verify the presence or absence of *Stenoma*. In commercial production areas outside of the export certified coastal zone fruit infestations by *Stenoma* (both Hass and non-Hass avocados) are extraordinarily high, often running at 50-100% infestation levels. Hass and non Hass avocados are vulnerable to twig, stem, and branch boring by *Stenoma*. This type of boring damage by *Stenoma* was very high in Cusco. Several new natural enemy species were discovered attacking *Stenoma* in Perú. Levels of larval parasitism do not appear to be as high as those observed in Guatemala. However, this tentative observation needs verification and will be done when this work is formally analyzed for publication. A major weakness in protecting the commercial and export zones in the coastal areas Perú were identified during this study. Avocado fruit from *Stenoma*-infested zones is moved into Lima daily in large quantities. The major distribution center for this fruit is the exceptionally large fresh fruit market in La Victoria, Lima **(Photo A below)**. As part of this study, we easily found and purchased three crates of avocados from the Chanchamayo region (there are Hass avocado orchards in this area), an area heavily infested with *Stenoma* **(Photo B below)**. Approximately 60% of this purchased fruit was infested with *Stenoma* **(Photo C below)** and larvae of an unknown lepidopteran (we were unable to rear these unknown larvae to adults because we ran out of time do so in Perú). We recommended to SENASA that this pathway be closed to prevent *Stenoma* escaping from this market in Lima and establishing in or near export certified orchards. Another concern, is that infested Hass fruit originating from uncertified areas that have *Stenoma* may illegally enter the supply line of fruit that is being shipped to the USA, and California, in particular.