



# AGENDA

## California Avocado Commission Production Research Committee Meeting

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### Meeting Information

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**Date:** Monday, February 17, 2025

**Time:** 2:00 p.m.

**Location:** Hybrid Meeting

**Physical Meeting Location:**

University of California Cooperative Extension Ventura County  
669 County Square Drive, Suite 100  
Ventura, CA 93003

**Web Conference URL:**

<https://californiaavocado.zoom.us/j/5375836823?pwd=aURBZ3BELL29tclBRS1ZRY3QrMkhZQT09&omn=82439256907>

**Conference Call Number:** (669) 900-6833

**Meeting ID:** 537 583 6823

**Passcode:** 348652

**Meeting materials will be posted online at least 24 hours prior to the meeting at:**

<https://www.californiaavocadogrowers.com/commission/meeting-agendas-minutes>

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### Committee Member Attendance

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As of Wednesday, February 12, 2025, the following individuals have advised the Commission they will participate in this meeting:

- Danny Klittich, *PRC Chair*
- Allisen Carmichael
- Jim Davis
- Leo McGuire
- Daryn Miller
- Ryan Rochefort

<b>Time</b>	<b>Item</b>
2:00 p.m.	<b>1. Call to Order</b> a. Roll Call/Quorum
2:05 p.m.	<b>2. Opportunity for Public Comment</b> Any person may address the Committee at this time on any subject within the jurisdiction of the California Avocado Commission.
2:10 p.m.	<b>3. Approval of Minutes</b> a. Consider approval of Production Research Committee Meeting Minutes of January 29, 2025
2:15 p.m.	<b>4. Action Items</b> a. Consider proposal "Surveys for avocado fruit feeding insect pests in Guatemala" b. Consider proposal "Chemical Synthesis and Field Evaluation of an Enantiopure (+)-Grandisol, the Putative Avocado Seed Weevil ( <i>Heilipus lauri</i> ) Aggregation Pheromone" c. Consider proposal "Delimiting cryptic species within avocado seed moth, <i>Stenomoma catenifer</i> for improved management and control of an economically important pest"
3:00 p.m.	<b>5. Adjourn Meeting</b>

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## **Disclosures**

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The times listed for each agenda item are estimated and subject to change. It is possible that some of the agenda items may not be able to be discussed prior to adjournment. Consequently, those items will be rescheduled to appear on a subsequent agenda. All meetings of the California Avocado Commission are open to the public and subject to the Bagley-Keene Open Meeting Act.

All agenda items are subject to discussion and possible action. For more information, or to make a request regarding a disability-related modification or accommodation for the meeting, please contact April Aymami at 949-341-1955, California Avocado Commission, 12 Mauchly, Suite L, Irvine, CA 92618, or via email at [aaymami@avocado.org](mailto:aaymami@avocado.org). Requests for disability-related modification or accommodation for the meeting should be made at least 48 hours prior to the meeting time. For individuals with sensory disabilities, this document is available in Braille, large print, audiocassette or computer disk. This meeting schedule notice and agenda is available on the internet at

<https://www.californiaavocadogrowers.com/commission/meeting-agendas-minutes> and <http://it.cdfa.ca.gov/igov/postings/detail.aspx?type=Notices>.

If you have questions on the above agenda, please contact Tim Spann at [tim@spannag.org](mailto:tim@spannag.org) or 423-609-3451.

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### **Summary Definition of Conflict of Interest**

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It is each member's and alternate's responsibility to determine whether they have a conflict of interest and whether they should excuse themselves from a particular discussion or vote during a meeting. To assist you in this evaluation, the following *Summary Definition of Conflict of Interest* may be helpful.

A Commission *member or employee* has a conflict of interest in a decision of the Commission if it is reasonably foreseeable that the decision will have a material effect, financial or otherwise, on the member or employee or a member of his or her immediate family that is distinguishable from its effect on all persons subject to the Commission's jurisdiction.

No Commission member or employee shall make, or participate in making, any decision in which he or she knows or should know he or she has a conflict of interest.

No Commission member or employee shall, in any way, use his or her position to influence any decision in which he or she knows or should know he or she has a conflict of interest.

**CALIFORNIA AVOCADO COMMISSION  
PRODUCTION RESEARCH COMMITTEE  
MEETING MINUTES**

**January 29, 2025**

A meeting of the Production Research Committee (PRC) of the California Avocado Commission (CAC) was held on Wednesday, January 29, 2025, with the following people participating:

**MEMBERS PARTICIPATING:**

Danny Klittich, Chair  
Victor Araiza  
Allisen Carmichael  
Jim Davis (9:03)  
Consuelo Fernandez  
Leo McGuire  
Daryn Miller  
Ryan Rochefort

**CAC STAFF PARTICIPATING:**

Ken Melban  
April Aymami

**OFFICIALLY PARTICIPATING:**

Dr. Tim Spann, Spann Ag Research & Consulting  
Jesse Landesman, UC Santa Barbara

**GUESTS PARTICIPATING:**

John Berns  
Ohannes Karaoghlanian  
Rachael Laenen

**CALL TO ORDER**

Danny Klittich, Production Research Committee (PRC) Chairman, called the meeting to order at 9:02 a.m. with a quorum present.

**OPPORTUNITY FOR PUBLIC COMMENT**

There were no public comments.

**APPROVAL OF MINUTES OF OCTOBER 29, 2024 PRODUCTION RESEARCH COMMITTEE MEETING**

**MOTION**

*To approve the minutes of the October 29, 2024 Production Research Committee meeting.*

*(Miller/Fernandez) MSC 6 yea, 0 nay, 1 abstain*

***Motion 25-1-29-1***

## **RESEARCH PROGRAM DIRECTOR'S REPORT**

Dr. Spann informed the Committee that CAC had recently learned about the passing of Mary Bianchi, retired UC Farm Advisor for San Luis Obispo and Santa Barbara Counties, in November 2024. A memorial will be held on February 8, 2025, and CAC can provide the details to any industry members who may be interested in attending.

Dr. Spann told the committee that a representative of BASF had recently reached out to CAC about petitioning the IR-4 program to take on the pesticide Sefina for the control of avocado thrips and avocado lace bug. Dr. Spann asked if any Committee member knew of any reason why CAC should not be supportive of this request and there were no objections. Chairman Klittich then mentioned that he was recently contacted by BioWorks for a letter of support for a section 24(c) special local needs registration of their product RootShield for control of Phytophthora in organic avocados.

## **DISCUSSION ITEMS**

### **A. PhD research project ideas from FFAR Fellow Jesse Landesman**

Chairman Klittich introduced Jesse Landesman and reminded the Committee that CAC is supporting her PhD Fellowship through the FFAR program. Ms. Landesman provided the Committee with a brief update on where she is at in her PhD program. She will be taking her PhD qualifying exams in Spring 2025 and hopes to begin her research project by summer 2025. Her primary interest is understanding how salinity in irrigation water affects the performance of avocado trees by understanding salinity's effects soil organic carbon. Her concept is to work from a broad overview of the problem (all California avocados) down to specific applied research.

Her concept is to break her research into three components: 1. Modeling soil salinity risk in California avocado orchards, 2. Assessing soil salinity in avocado orchards with different soil organic carbon content, and 3. An applied research study at Pine Tree Ranch with two potential options either looking at the effects of biochar on salt accumulation and tree growth, or study how removing chloride from irrigation water affects salt accumulation and tree growth.

Discussion ensued about the ideas Jesse presented and their potential benefits to the California avocado industry. Committee members provided specific ideas for Jesse to consider for each of the three components of her research. The Committee was in favor of Jesse developing a more detailed research proposal and funding request for their review at the next meeting.

## **ACTION ITEMS**

### **A. Consider concept proposals submitted in response to September 2024 request for concept proposals**

Chairman Klittich explained that he would like to review the concept proposals by asking each Committee member to provide their comments on each concept proposal. Following the opportunity for each member to provide comments on each concept proposal an informal straw poll vote would be taken as to whether to request a full proposal or not. There were no objections to this process and discussion ensued.

Concept Proposal: Concept proposal for research at the San Luis Obispo rootstock trial site (2025-2027)

Submitted By: Loren Garner

Discussion Summary: The committee feels that there is a lot of value in maintaining this trial site given its location and that the trees are coming into full production. There were questions about whether using the rootstocks in this trial, many of which are not yet commercially available, would be the best place to study the nutritional needs for different rootstocks. Additionally, since the planting wasn't originally designed to answer the nutrition and mulch/temperature questions, the reliability of the data generated to address those objectives were questioned. The committee would like to receive a full proposal for Objectives 1 and 4 only of the concept proposal.

Committee vote: 7 yes, 0 no

Concept Proposal: Integrating chemical and cultural practices for bot canker control in avocado

Submitted By: Fatemeh Khodadadi

Discussion Summary: There is still some debate among the committee members about how great a problem avocado branch canker really is in the industry. Some concern was expressed regarding lab screenings of active ingredients as this work may have already been done [see previous work by Themis Michailides]. Overall, the committee feels it is a problem that is widespread enough to justify some investment in developing management practices for it. The committee felt the concept proposal showed a good research plan with a high likelihood of success for a reasonable budget. A full proposal is requested.

Committee vote: 5 yes, 2 no

Concept Proposal: Using the Sample Costs of Production Budgets to Estimate Costs and Returns of Alternative Avocado Practices

Submitted by: Karen Jetter, Eta Takele, Ben Faber

Discussion Summary: The committee agrees that current cost studies are old and outdated. There was consensus that the proposed budget was reasonable for the scope of the project. However, the committee struggled to understand just how valuable these studies are to the average grower in their day-to-day operation, seeing the value more for insurance companies and attorneys. More than one committee member asked the question, "Will having these studies help me grower more/better avocados?" That said, the committee did like the idea of surveying high producing growers to understand what practices they have in common that could help growers improve their production. Given the number of proposals received, this project did not rank high enough to request a full proposal.

Committee vote: 1 yes, 5 no, 1 abstain

Concept Proposal: Gaining a better understanding of the impact of gibberellic acid application to California avocados from enhancing fruit set, fruit size and delaying senescence of the mature crop

Submitted by: Peggy Mauk, Mary Lu Arpaia, Carol Lovatt

Discussion Summary: Overall, the committee feels like there is a lot of GA being applied in the industry, but the benefit is still questionable. This may, in part, be due to the difficulty that growers can have in timing applications. There was some feeling that with the amount of GA being applied, the answers to the questions posed will come to light in time. One committee member stated, "I've used it and will continue to use it; good data on holding fruit is needed but could Valent pay for it?" Another consideration for the committee was that GA is still available to the avocado industry under an SLN and it is unclear if Valent will be able to secure a full registration. Given that, there was some question of whether pursuing more research when the future of the product is unknown was a good use of resources. Lastly, no budget estimate was provided in the concept proposal.

Committee vote: 0 yes, 6 no, 1 abstain

Concept Proposal: Validation of the use of flowers at the cauliflower stage for nutrient analysis to better time fertilizer applications

Submitted By: Mary Lu Arpaia, Peggy Mauk, Ben Faber

Discussion Summary: No estimated budget was provided, but it was the Committee's understanding that Fruit Growers Lab may be willing to cover the costs of analysis for this project. The consensus from the committee was that this would be a great tool for growers to have, if it works, since it has been widely known that the leaf sampling protocols the industry currently uses are somewhat problematic. A couple of potential concerns that came up were whether the industry and the labs in California would be able to analyze all the samples for the industry if they switched to flower sampling? The concern being that flowering occurs over a relatively short time, whereas leaf samples can be collected over a longer period in the fall. Overall, the committee felt that this could be a great tool for the industry, and they would like to review a full proposal.

Committee vote: 7 yes, 0 no

Concept Proposal: Development and demonstration of a cost-effective electro dialysis reversal (EDR) process for chloride removal from avocado irrigation water

Submitted By: Haizhou Liu

Discussion Summary: The committee liked that idea of finally being able to answer the question of whether removing chloride from irrigation water will really make a difference in avocado production in California. They felt this is very promising work based on the previous analysis that was conducted. Although the estimated cost of the project is high, the potential benefit to the industry is high. A full proposal is requested.

Committee vote: 7 yes, 0 no

Concept Proposal: Tree Stress Monitoring Tools Review

Submitted By: Andrew Krajewski

Discussion Summary: There was agreement among the committee that the concept of the project was interesting, but they struggled to understand what the practical outcome would be. The committee recognized that the primary job of a grower is to manage plant stress for optimum production. And there is currently a lot of technology that is being marketed to growers with a lot of questions around what works and what doesn't. That said, the cost seemed high to the committee and, given the numerous other concept proposals received, this project did not rank high enough to request a full proposal. Committee vote: 0 yes, 7 no

Concept Proposal: Understanding genetic, ionic and physiological bases of salt tolerance in avocado rootstocks

Submitted By: Jorge Ferreira, Devinder Sandhu

Discussion Summary: The committee agreed that salt tolerant rootstocks are one of the greatest needs of the California avocado industry. They felt that the stated objectives were good and there could be significant benefit to bringing in new research partners that the industry has not previously funded. Some questions were raised since there was no estimated budget provided for the work. Additionally, the question was raised about the benefit to the industry of identifying genetic markers for salinity tolerance since there currently is not a trained plant breeder in the UC system or within USDA assigned to work on avocado rootstock breeding. The committee would like the opportunity to review a full proposal.

Committee vote: 4 yes, 3 no

Concept Proposal: Assessing the role of plant immune activators to improve avocado resilience to salinity and major avocado diseases under greenhouse and field conditions

Submitted By: Patty Manosalva

Discussion Summary: Overall, the concept of plant immune activators was generally unfamiliar to the committee, and it was difficult for them to judge the potential for success. They viewed the project as having a high likelihood of failure. Given the proposed budget, the consensus was that the risk was too high.

Committee vote: 0 yes, 7 no

Concept Proposal: Improve Phytophthora cinnamomi control management by monitoring field populations for changes in fungicide sensitivity and conducting efficacy field trials

Submitted By: Patty Manosalva, Jim Adaskaveg

Discussion Summary: The committee recognizes that PRR is still a primary concern for the avocado industry. Despite most growers using tolerant rootstocks, management tools are still needed since those rootstocks are not resistant. Growers spend a lot of money managing PRR and they need to know they are spending money on effective products and following the best protocols. The cost of the proposed research is high, and the question was raised whether there could be some contribution from the chemical companies whose products will be tested. A full proposal is requested.

Committee vote: 6 yes, 1 no



Concept Proposal: Leveraging and establishing rootstock/scion trials to determine the effect of rootstocks on improving scion's abiotic and biotic stress resilience

Submitted By: Patty Manosalva

Discussion Summary: The committee believes that there is a lot of value in maintaining the rootstock trials that were established in 2019 since these trees are not reaching maturity and will start generating good yield data. However, there was no support for establishing new rootstock trials. Furthermore, the interest in objective 2 was only for commercially available rootstocks. Thus, the committee would like to review a full proposal that includes the scope of objective 1, only screens and generates data for commercially available rootstocks (part of objective 2), and does not include objective 3. Committee vote: 4 yes, 2 abstain

Concept Proposal: Updated cost studies (Northern regions)

Submitted By: Michael McCullough

Discussion Summary: There was general agreement that a study such as this would be beneficial to growers looking to make expansion and/or new planting decisions in the north. That said, there was a feeling that the concept proposed was overly complex and perhaps the project could be pared down as a senior student project. Although the information was viewed as valuable, given the numerous other concept proposals received, this concept did not rank highly enough to request a full proposal. Committee vote: 2 yes, 4 no, 1 abstain

Concept Proposal: Weather station network for avocados

Submitted By: Andre Biscaro, Ben Faber

Discussion Summary: The committee felt that there is a lot of potential to help the industry by providing growers with quality, actionable weather data that can be used to improve their management practices. There was agreement that CIMIS is a poor system that does not reflect the many microclimates that avocados are grown in and is only getting worse. That said, identifying cooperating growers with sufficient turf grass is going to be a challenge. A question was asked whether it would be possible to integrate data from existing grower weather stations, of which there are many, to help build out the network more quickly. A full proposal is requested. Committee vote: 7 yes, 0 no

Concept Proposal: Assessing irrigation management tools on avocado fruit quality and yield impacts

Submitted By: Ali Montazar

Discussion Summary: The committee commented that water makes all the difference and anything that can increase water use efficiency is good for growers. There was also recognition that knowing exactly what an avocado tree needs for optimum fruit quality is important information to have to fight regulatory challenges to water allocations. The committee also commented that Dr. Montazar has a good track record on previously funded projects. A full proposal is requested. Committee vote: 6 yes, 1 abstain

Concept Proposal: Chloride removal from irrigation water

Submitted By: Tailwater Systems

Discussion Summary: Overall, the committee expressed a large degree of skepticism of the claims made and that the technology can do everything claimed. That said, chloride is recognized as a major issue for the industry and the relatively low cost of the project make it appealing. Questions the committee would specifically like addressed in a full proposal are the scalability of the technology and what is the potential throughput? A full proposal is requested.

Committee vote: 7 yes, 0 no

Concept Proposal: Impact of natural vegetation on insect pollinators in agroecosystems

Submitted By: Carson Loudermelt, Hamutahl Cohen, Adam Lambert, Elizabeth Scordato

Discussion Summary: The committee liked the concept of the proposal and recognizes the critical importance of pollinators. They also recognized the potential benefit of natural areas for harboring beneficial insects and not just as habitat for pollinators, and the fact that these natural areas become self-sustaining after being established. That said, there was some question of how much benefit would actually be had from this. Many growers are bee-safe certified and already take measures to protect pollinators. Also, there's no actual documented evidence of flies, solitary bee species, or other insects actually pollinating avocados. However, the low cost of the project is appealing. A full proposal is requested, with the stipulation that Jim Davis, Avocado PCA and research committee member, be able to help with the trial design.

Committee vote: 4 yes, 3 no

Concept Proposal: A pesticide resistance monitoring program for avocado thrips

Submitted By: Hamutahl Cohen, Bodil Cass, Laura Leger, Ben Faber

Discussion Summary: The committee recognizes the importance of resistance monitoring and acknowledges there are many reports of abamectin failure. Establishing a system to monitor for thrips resistance would be very beneficial to growers and once such a system is in place the populations could be monitored on an ongoing basis every few years. Although thrips are not a major issue in all parts of the industry, especially in the south, everyone recognizes the importance the data from this project. A full proposal is requested.

Committee vote: 6 yes, 1 no

Concept Proposal: Investigate and evaluate current research into soil health

Submitted By: Andrew Krajewski

Discussion Summary: Overall, the committee thought the information that the project would generate would be beneficial but viewed it as very broad information that it would be difficult to develop actionable plans from. As one committee member stated, "We know there's lots of ways and things to measure about soil health, but what do we do with that information?" There were also concerns raised whether an Australia-based researcher was the best voice for California soil health.

Committee vote: 0 yes, 7 no

Concept Proposal: Provide Complete Nutrition, beneficial microorganisms and soil conditioners to withstand biotic and abiotic stressors increasing at the same time overall soil and tree health for a higher fruit yield and quality performance

Submitted By: Tomas Aguayo

Discussion Summary: The committee found it difficult to evaluate this concept proposal since there was no research question posed and no stated objective(s). Additionally, no estimated budget was provided.

Committee vote: 0 yes, 7 no

Following the concept proposal discussion, Dr. Spann asked the Committee to recommend a timeline for researchers to submit full proposals. A mid-March timeframe was recommended for proposal submission so that the Committee could review full proposals and make recommendations for the Board's consideration at their June meeting.

### **ADJOURN MEETING**

Danny Klittich, Production Research Committee (PRC) Chairman, adjourned the meeting at 1:07 p.m.

Respectfully submitted,

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Timothy Spann

### **EXHIBITS ATTACHED TO THE PERMANENT COPY OF THESE MINUTES**

EXHIBIT A January 29, 2025, Production Research Committee AB 2720 Roll Call  
Vote Tally Summary

EXHIBIT B Slide set: "Research Updates" from Jesse Landesman

EXHIBIT C Concept Proposals reviewed by the Committee

**PROJECT SUGGESTION:** Surveys for avocado fruit feeding insect pests in Guatemala

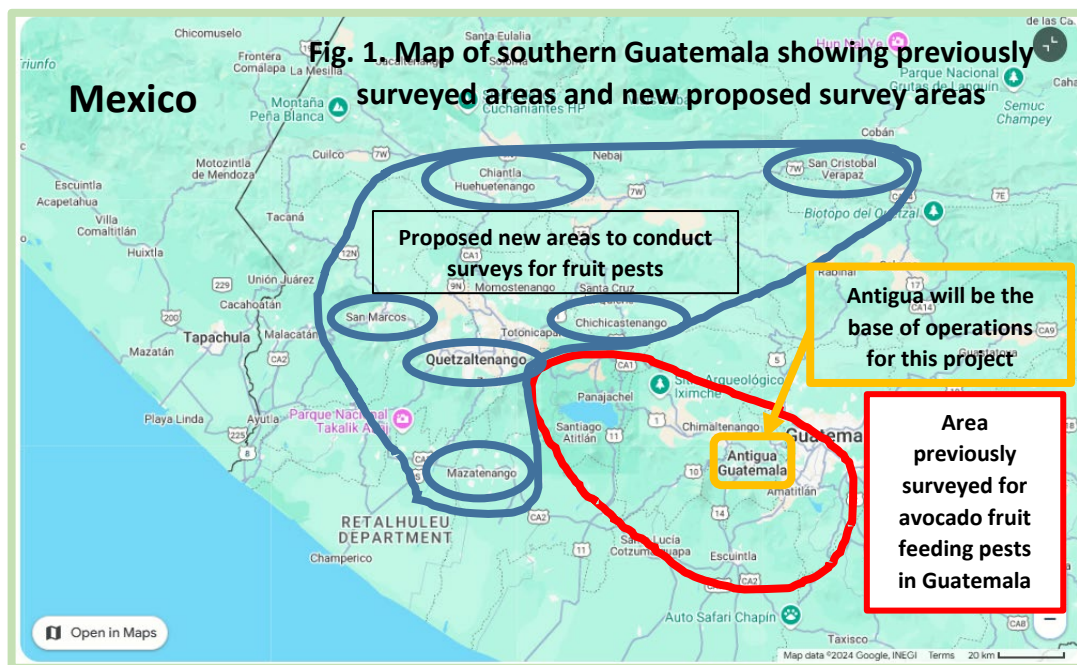
**PI:** Mark Hoddle, Department of Entomology, University of California Riverside

**1. Pest Research Highlight Priority Topic:** This project addresses *High Priority Research Topic 24:* Imported fruit poses a risk of introducing unknown pests and diseases that could be detrimental to the California avocado industry. Avocado fruit from Guatemala was recently approved for importation into the US by USDA-APHIS and insects associated with fruit in Guatemala may pose an unknown risk to California avocado growers.

**2. Concept Synopsis:** At the request of the California Avocado Commission, surveys for fruit feeding pests associated with avocado fruit in Guatemala will be conducted. This project will build on previous research conducted on avocado fruit feeding moths in Guatemala from 2006-2009. However, unlike previously completed studies, fruit surveys will focus primarily on areas in Guatemala that were not intensively surveyed in earlier studies that were conducted around Antigua, Chimaltenango, Santiago Atitlán, and Escuintla over 2006-2009. One large previously unsurveyed area to the north of previously surveyed areas that is of particular interest is encompassed by moderate to high elevation avocado growing areas such as Quetzaltenango, Huehuetenango, San Marcos, Chichicastenango, San Cristóbal Verapaz, and one lower elevation production area to the west, Mazatenango. Hass avocado production within parts of this circumscribed area was “up and coming” when earlier surveys for fruit feeding pests were conducted.

**3. Project Objectives:** This project has one simple objective:

- i. To collect as much avocado fruit as possible from six distinct geographic locations: (1) Quetzaltenango, (2) Huehuetenango, (3) San Marcos, (4) Chichicastenango, (5) San Cristóbal Verapaz, and (6) Mazatenango that have not been previously surveyed for avocado fruit pests (Fig. 1).



ii. Fruit from these six areas of interest will either be collected with permission from small scale low input avocado growers, or as was done previously and with great success, purchased in large quantities from street vendors (Fig. 2A). Fruit will be placed in bugdorms (Fig. 2B) labeled by locality and date and all insects infested fruit will be reared out and preserved in 95% ethanol for future identification and DNA analyses. Fruit collections will be made in Guatemala over the “dry season,” December – June.



**Fig. 2A.** Hoddle holding a sack of avocado fruit purchased from roadside vendors. These fruit were held in bugdorms and insects were subsequently reared from them.



**Fig. 2B.** A spare bedroom in a rented house in Antigua was used as a laboratory to rear out insects from avocado fruit held in labeled bugdorms. The plastic tables, rearing bins under tables, and free standing heater/fan were all purchased in Guatemala to set up this lab.

**4. Anticipated Project Duration:** 2 years. Starting December 2025.

**5. Total Estimated Project Cost:** \$510,202

**Personnel:** Funds to hire a Specialist II at 100% time for years 1 and 2 of this project are requested. Annual salary is \$90,000 in year 1 and \$92,700 in year 2. The Specialist is fluent in Spanish, is very familiar with Guatemala having worked with the PI on fruit pest surveys in this country previously. Specialist will assist with all aspects of field and lab work in Guatemala and will take the lead in logistics organization pre and post travel and for curating and processing all collected insects after returning from Guatemala. Total salary request = \$182,700.

**Benefits:** Benefits are set at 43.7% and are estimated to be \$39,330 in year 1 and \$40,510 in year 2. Total benefits = \$79,840.

**Total Salary and Benefits:** Year 1 = \$129,330, year 2 = \$133,210. Grand total requested = \$262,540.

**Supplies:** Funds to purchase bugdorms (light weight collapsible insect rearing cages) for rearing insects from collected fruit are requested and estimated by to be \$6,000 in year 1 and \$4,000 in year 2. Total request for bugdorms = \$10,000. Funds are requested to purchase fruit from roadside vendors in areas

being surveyed for avocado fruit pests. \$1,500 is estimated in year 1, and \$1,575 for year 2. Total request for fruit purchases = \$3,075. Field supplies (i.e., vials, note books, ethanol, flagging tape, indelible markers, Stenoma pheromone, heaters and fans to moderate temperature in the insect rearing “labs” (i.e., the spare bedrooms) is estimated at \$2,200 in year 1 and \$2,310 in year 2 for a grand total of \$4,510 for both years of this project.

**Total Supply Costs:** Year 1 estimated at \$9,700, year 2 at \$7,885 for a grand total of \$17,585 for both years of this project.

**Publications:** One publication in a peer reviewed entomological journal is anticipated in year 1 at \$3,800 and year 2 at \$3,990. Total publication costs for two peer reviewed articles on the results of fruit surveys is estimated at \$7,790.

**Travel:**

**Airfares and excess luggage costs:** Round trip airline tickets, LAX to Guatemala City are estimated at \$800 per person. Cost of tickets for two people in year 1 is estimated at \$1,600 and in year 2 at \$1,648. Excess baggage to move all necessary materials from California to Guatemala is estimated at \$120/bag and up to four extra suitcases per person are likely to be needed. Cost is estimated at \$960 in year 1 and \$989 in year 2 for a total of \$1,949 for both years of this project.

**Accommodation:** This project will be based in Antigua, a relatively safe city in Guatemala and one that is popular with foreigners. Consequently, accommodation in this city is expensive. An Air BnB search for a 4 bedroom house (spare bedrooms are needed as labs for setting up rearing cages [see Fig. 2B above]) in Antigua in a secure guarded compound (24 hr security) returned a monthly rental estimate of \$5,500. For six months in year 1, rental accommodations are estimated at \$33,000 and in year 2 at \$33,900. Total rental estimates for year 1 and year 2 are estimated at \$66,900.

Because the proposed new survey areas are long distances from Antigua (See map, Fig. 1) it will be necessary to rent hotel rooms/Air BnB outside of Antigua for multiple multi-day excursions into areas where fruit will be collected. Decent and secure accommodation in these towns can be expensive, and may require stays within private and secure residences. Estimated cost per night of overnight stays is estimated at \$120/night, with 10 nights per month for each of 6 months being required to achieve survey goals. Total cost of hotel stays outside of Antigua is estimated at \$7,200 in year 1 and \$7,416 in year 2. Total hotel costs for years 1 and 2 are estimated at \$14,616.

**Incidentals:** The Federal Govt. daily incidentals and expenses cost for areas in Guatemala outside of Guatemala City are set at \$80/day/person. Total incidentals/meals costs for two people for 6 months is estimated at \$26,880 in year 1 and \$27,686 in year 2 for a grand total of \$54,566 for both years of this project.

**Transportation:** Overland travel in Guatemala is difficult. Roads are often in poor condition (the exceptions are toll roads which can be expensive to travel on) and drivers are outrageously dangerous. Therefore to accommodate the demands of bad roads, especially in rural areas where avocados are grown a 4WD SUV will be needed to get to sites and to have “secure” storage for purchased fruit. Vehicle rental and insurance costs are very high in Guatemala because of risk of theft and accidents. The best estimate for a mid-size SUV hired at Guatemala City International Airport with full insurance is

\$200/day. Total rental cost for 6 months for year 1 of this project will be \$33,600 and in year 2 the cost is estimated at \$34,608. Total vehicle rental for both years of this project is estimated at \$68,208.

Gas in Guatemala is expensive and a lot of driving is anticipated to get to field sites each month of this project. Total gas cost is estimated at \$450/month and will cost \$2,700 in year 1 and \$2,835 in year 2 for a total cost of \$5,535 for both years of this project.

Whenever possible toll roads will be taken in and out of major cities. Toll roads tend to be in reasonable condition and are regularly patrolled by police which reduces risks to drivers. Additionally, parking of vehicles on streets is very risky and secure 24 hr parking areas are needed to park vehicles overnight, especially when staying in hotels or even when visiting small towns to buy fruit during the day. Cost of tolls and secure parking in year 1 is estimated at \$500 and in year 2 at \$525. Total cost of tolls and secure parking for year 1 and 2 of this project is estimated at \$1,025.

**Professional Meeting:** Funds are requested to attend one professional entomology conference in years 1 and 2 of this project to present results of field surveys. Cost of meeting attendance (registration, flights, hotel, meals) is estimated at \$3,000 in year 1 and \$3,150 in year two for a grand total of \$6,150.

**Total Travel Costs:** Six months in Year 1 = \$109,440, six months in year 2 = \$112,847. Grand total for 12 months of travel in Guatemala spread over 2 years = \$222,287.

**Grand Totals:** Total project cost in year 1 is estimated at \$252,270, year 2 = \$257,932, total project costs for years 1 and 2 combined = \$510,202.

**PROJECT SUGGESTION:** Chemical Synthesis and Field Evaluation of an Enantiopure (+)-Grandisol, the Putative Avocado Seed Weevil (*Heilipus lauri*) Aggregation Pheromone

**PI:** Kevin Kou, Department of Chemistry, UC Riverside

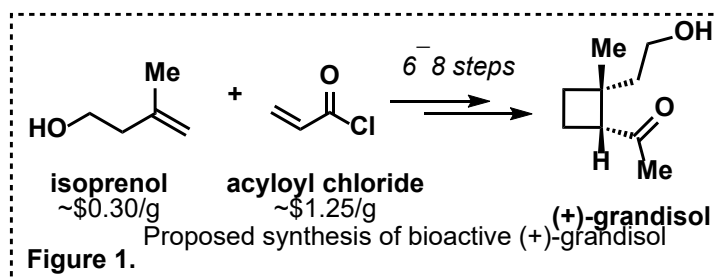
**Co-PI:** Mark Hoddle, Department of Entomology, UC Riverside

**1. Pest Research High Priority Topic:** *Risk of importing Heilipus weevil-infested avocados that could be detrimental to the California avocado industry.*

**2. Concept Synopsis:** The aggregation pheromone of the avocado seed weevil, *Heilipus lauri* has been identified from a previously supported CAC project. This complex molecule is grandisol and simple syntheses result in mixtures of several different forms (i.e., enantiomers) of this molecule. Unfortunately, field evaluations of these impure mixtures were not attractive to weevils in heavily infested Hass orchards in México. This finding has led us to conclude that weevils may only respond to the pure biologically-active form of grandisol and the impurities when present do not attract weevils. Despite over thirty synthetic strategies reported for the preparation of grandisol, most yield a mixture of biologically-active and inactive enantiomers, while methods targeting a single enantiomer produce impractical milligram quantities of the pheromone.<sup>1,2</sup> We propose developing a concise synthesis approach to access significant quantities of bioactive (+)-grandisol. The pure bioactive form of grandisol will be field tested in weevil infested Hass avocado orchards in México. If successful, this aggregation pheromone will be a very powerful tool for monitoring for weevil presence in export areas of México where this weevil is native, and Colombia where this pest is invasive. Additionally, the pheromone will be invaluable for monitoring for weevil incursions into California.

### 3. Project Objectives:

- I. Synthesize >1 gram of (+)-grandisol starting from racemic ( $\pm$ )-grandisol. We will develop a kinetic resolution method using the Corey-Bakshi-Shibata reagent to separate the inactive (–)-enantiomer. This is a low-risk approach to quickly generate enough of the active pheromone for initial field studies.
- II. Advance a short synthesis route to (+)-grandisol starting from readily accessible reagents isoprenol and acryloyl chloride (Figure 1). Two approaches are envisioned: one incorporates the method established in **Project Objective I**, while the other explores a novel chemical reaction to construct the pheromone's four-membered ring as a single enantiomer. The latter approach offers a 100% increase in yield, as it avoids the 50% yield loss from the kinetic resolution method, which requires removal of the inactive (–)-pheromone that accounts for half the material. Both methods are designed to be scalable for manufacturing.
- III. Conduct field studies in México to evaluate the efficacy of enantiopure (+)-grandisol in trapping *Heilipus* weevils, as previous field testing showed racemic ( $\pm$ )-grandisol to be ineffective.



**4. Anticipated Project Duration:** 2 years

**5. Estimated Total Project Cost:** Total \$349,212

- I. **Salaries and Benefits:** One post-doctoral fellow (\$71,362) + employee benefits (\$15,974 @ 22.4%) at 100% time in year 1 and 50% time in year 2. Post-doctoral fellow will conduct



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experiments, record observations and results, as well as analyze data. Total salary (\$108,113) and benefits (\$24,217) = \$132,331. Specialist II, Entomology, to assist with field work in México at 33% time in yr 1 and 2, salary = \$29,568 (yr 1) and \$30,455 (yr 2) and benefits at 26% = \$7,688 (yr 1) and \$7,918 (yr 2). Total salary and benefits for yrs 1 & 2 = \$75,629. **TOTAL SALARIES FOR PROJECT = \$219,615**

- II. **Supplies:** Consumable supplies and reagents (\$12,000 in yr 1 and \$4,000 in yr 2. Total reagents = \$16,000) will support chemical synthesis experiments. Sticky cards for field trials (white, blue, green, yellow, and purple) to test attraction for weevils with pheromone = \$6,000 yr 1 and \$3,000 in yr 2. Total cost of sticky cards = \$9,000. Field supplies for pheromone testing in México (flagging tape, vials, ethanol, note books, markers), \$1,500 in yr 1 and \$500 in yr 2. **TOTAL SUPPLIES FOR PROJECT = \$27,000**
- III. **Equipment:** UV Photoreactor (\$7,000). The photoreactor provides ultraviolet (UV) irradiation for photochemical experiments and synthesis of grandisol and this equipment safely encloses and isolates reactive UV radicals. **TOTAL EQUIPMENT COST = \$7,000**
- IV. **Analytical Services:** Analytical Chemistry Instrumental Facilities needed for confirming and characterizing chemical intermediates and products synthesized. Estimated cost is \$5,000 in yr 1 and \$2,500 in yr 2. **TOTAL ANALYTICAL SERVICES COST = \$7,500**
- V. **Publication Costs:** Estimated publication costs in yr 2 of project for grandisol synthesis = \$3,000 and for entomological field trials with grandisol in México = \$3,000. **TOTAL PUBLICATION COSTS = \$6,000.**
- VI. **Travel to Meetings and México for Field Work:** Cost to attend one professional O-Chem conference, PacifiChem, to present results of grandisol synthesis work = \$3,000. Travel to one professional entomology meeting to present results of field work in México = \$3,000. Return air flights from LAX to México City for 2 people at \$600 round trip = \$1,200 in yr 1 and \$1,236 in yr 2, total air flights = \$2,436. Air BnB, three bedroom house in Malinalco at \$250/night for 56 nights (i.e., 8 weeks) = \$14,000 in yr 1 and \$14,420 in yr 2, total accommodation = \$28,420. Meals and incidentals for two people in Malinalco based off of the US Federal rate for México City = \$122/day. Malinalco is close to MX City and estimated at \$80/day per person for 56 days = \$8,960 for yr 1 and \$9,229 in yr 2, total for yr 1 and 2 = \$18,189. Rental car to get to field sites in and around Malinalco with full insurance estimated at \$150/day. For 56 days rental car cost = \$8,400 in yr 1 and \$8,652 in yr 2, total rental car cost = \$17,052. **TOTAL TRAVEL COSTS FOR YR 1 AND 2 = \$72,097.**
- VII. **Contract with Cooperators in México:** We have previously conducted field work on *Heilipus* weevils in México with Dr. Armando Martínez-Equihua, a professor in entomology at the post-graduate college in Texcoco México. This has been an excellent arrangement. Dr. Martínez-Equihua is a preeminent avocado pest researcher in México whose previous assistance has been invaluable in procuring access to field sites for medium-term field studies on *Heilipus*. Assistance with Mexican cooperators for this project will be essential if it is to be successful. To facilitate this cooperation, Dr. Martínez-Equihua will require \$5,000 in yr 1 and yr 2 for a **total of \$10,000** to help with negotiations with Comité Estatal de Sanidad Vegetal del Estado de México, in Malinalco and Coatepec-Harinas, México to locate and access field sites and to get permission from orchard owners, to assist with on the ground logistics, and to participate in planning and execution of field trials.

**References Cited:** 1) dos Santos, M. K. *et al. Mini-Rev. Org. Chem.* **2021**, *18*, 690.

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2) Bartlett, W. R. *et al.* *Synthesis* **2022**, *54*, 3209.

## **Delimiting cryptic species within avocado seed moth, *Stenoma catenifer* for improved management and control of an economically important pest**

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### **California Avocado Commission priority research area**

Pest Research High Priority number 24: Identification of unknown pests that could be introduced into the U.S. that would be detrimental to the California avocado industry

### **Concept synopsis**

The avocado seed moth, *Stenoma catenifer*, is an avocado pest of major economic importance in the Neotropics, which encompasses its native range. This pest is a significant threat to the California avocado industry, where it is not yet established. Identifying this species is challenging, as adults possess few distinguishing external morphological characteristics besides a “C” pattern of black dots on the forewings. The lack of identifying characteristics may have led to an overly broad and phylogenetically uninformative species description of *S. catenifer*, which may be better defined as a species complex.

Nucleotide sequences of the mitochondrial DNA barcoding region (cytochrome oxidase 1) that are available in publicly available databases provide preliminary but compelling evidence that cryptic species can be resolved within the current delimitation of *S. catenifer*. Based on these 32 mtDNA sequences, *S. catenifer* is comprised of six Barcode Index Numbers (BINs). Although recognition of BINs does not always indicate discrete species, they do indicate that further investigation into their species status is necessary. A phylogenetic tree based on available sequences for specimens considered to be *S. catenifer* is shown in Figure 1. The tree shows evidence for three major clades – one from French Guiana, a second from South America, and a third from Mexico and Central America. The three sequences from Mexico can be divided into two well supported lineages (likely species), and the nine from Peru can be divided into three well supported lineages (likely species). Photographs of the sequenced specimens all show the pattern of dots on the forewing that is characteristic for *S. catenifer*. Since these sequencing results are based on a small number of specimens from a limited part of the geographic range for *S. catenifer*, extensive sampling and sequencing of a much greater number of individuals throughout the range of the species, including at different elevations, is crucial. With this increased sampling, it can reasonably be expected that *S. catenifer* could be divided into more species than are shown on the tree. The primary objective of this study is therefore to sample *S. catenifer* from Mexico, Guatemala, Costa Rica, Belize, Honduras, Panama, Colombia, Venezuela, Ecuador, Peru, Brazil, Bolivia, Guyana, Argentina, Paraguay, and Uruguay, and to evaluate and delimit cryptic species from these regions based on DNA barcode sequences (including ITS, CO1, and EF1-

alpha). Following this objective, the morphology of each cryptic species will be described in detail, including images of the morphological characters most useful for separating species. Species complexes that include morphologically similar species can vary remarkably in aspects of their biology, including their host range, specificity, and behavior. Recognizing cryptic species is therefore essential not only for effective targeted pest management, but also has important implications for agriculture since each lineage may cause differing degrees of damage. The confirmation of cryptic species and the delimitation of each species within *S. catenifer* would justify a revision of current quarantine regulations.

Nucleotide sequence data potentially allows the identification of the geographic origin of a specimen. Haplotype network analysis and the identification of single nucleotide variants (SNVs) that are associated with geography are helpful for identifying the source of an invasive species. For *S. catenifer*, this data would be particularly useful for individuals from Mexico and Guatemala, since both countries are now exporting fruit into California from different areas. The DNA barcode sequences that will be generated as part of the first objective of the study can be used to examine genetic variation within each cryptic species, and this variation could pinpoint the origin of each haplotype. If *S. catenifer* is introduced into California, knowledge of geographic variation within each species would be crucial for identifying the origin of the invasion, and could inform future quarantine and pest eradication measures, as well as the development of biological control programs with natural enemies from the pest's accurately identified native range.

The objectives of this study are therefore to confirm cryptic species within *S. catenifer* using genetic data to delimit species, to provide comprehensive morphological descriptions for each species, and to associate *S. catenifer* genotypes with their geographic origin to allow the determination of the area of origin of a specimen. The resulting data would identify new pest species in the Neotropics that threaten the California avocado industry via the potential risk of invasions through commercial fruit export and improved understanding of this putative species complex would be an essential foundation for the development of biological control programs should such an effort be needed in the future.

### **Main project objectives**

1. Evaluate cryptic species within *S. catenifer* based on DNA barcode sequences from across the range of the species. A limited number of sequences are already available. This project will generate additional sequence data and use a variety of species delimitation methods to confirm that *S. catenifer* is a species complex, and to delimit cryptic species.
2. Describe the external morphology of *S. catenifer*, including all cryptic species, to enable unequivocal identification. High-resolution images will be taken of all relevant morphological characteristics to enhance identification.
3. Examine within-species variation based on nucleotide sequence data that will include DNA barcodes and potentially other genes. This information would facilitate the identification of the geographic origin from which an interception originated.

### **Anticipated project duration**

The project is anticipated to be conducted over a 2-year period. During the first year, specimens will be collected, their DNA will be sequenced, and the results will be analyzed. These genetic data will be used to inform morphological descriptions during the second year of the project.

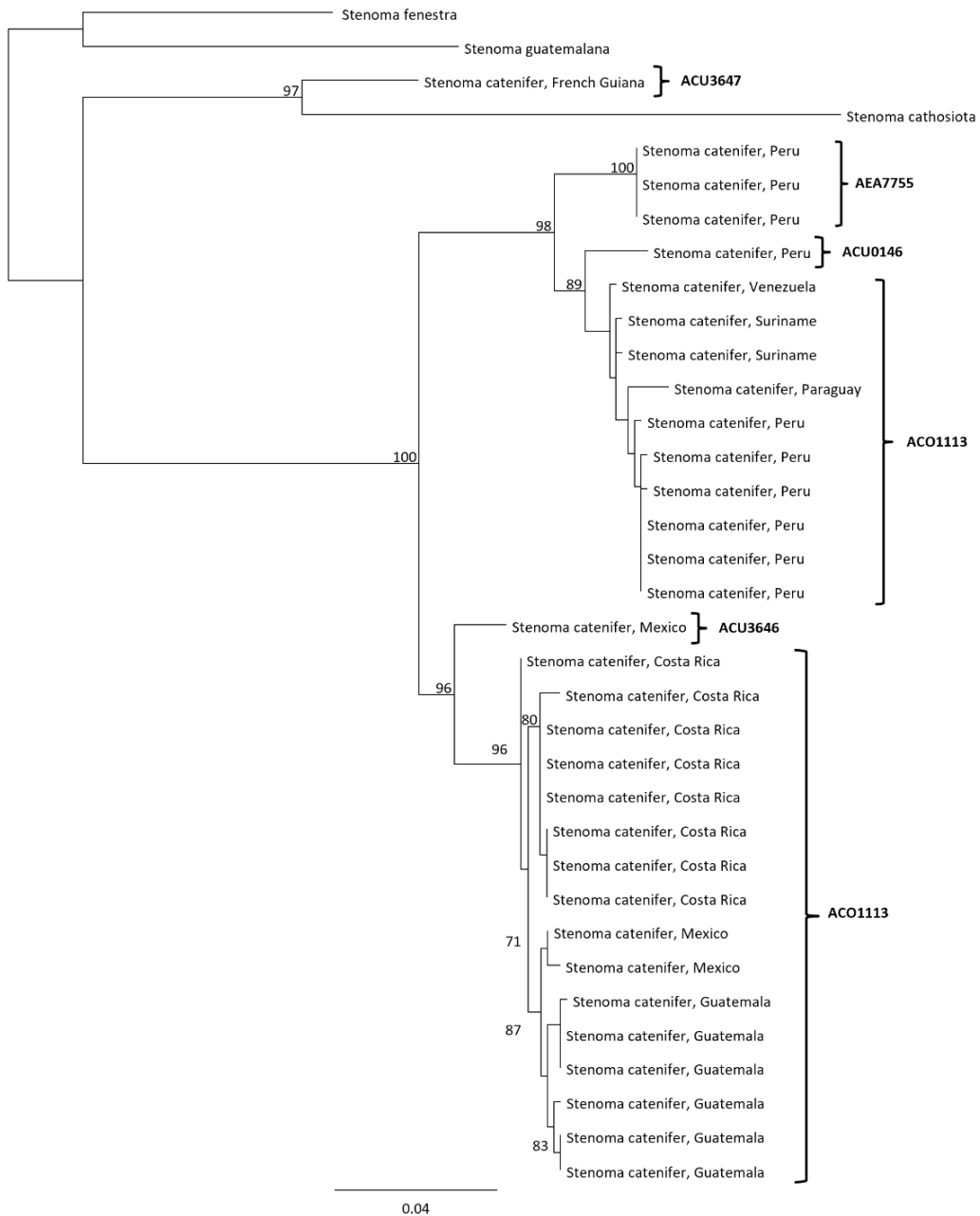
**Estimated project cost**

ITEM	DOLLAR AMOUNT	DETAILS AND JUSTIFICATION
<b>PERSONNEL:</b>		
Postdoctoral fellow	\$130,000	Base salary for two years for a post-doctoral fellow to collect specimens, conduct laboratory work, analyze data, and write manuscripts
<b>Subtotal</b>	<b>\$130,000</b>	
<b>FRINGE BENEFITS:</b>		
13% of post-doctoral fellow salary during the first year	\$8,450	Fringe benefits associated with post-doctoral fellow salary, in accordance with CSU policies
28% of post-doctoral fellow salary during the second year	\$18,200	
<b>Subtotal</b>	<b>\$26,650</b>	
<b>TRAVEL:</b>		
<i>International travel</i>		
Airfare	\$20,000	Foreign travel for two researchers to collect <i>S. catenifer</i> throughout its range in Mexico, Central, and South America. Potential collecting locations include Mexico, Guatemala, Costa Rica, Belize, Honduras, Panama, Colombia, Venezuela, Ecuador, Peru, Brazil, Bolivia, Guyana, Argentina, Paraguay, and Uruguay.
Accommodation	\$16,000	
Ground transportation	\$15,000	
Gas, tolls and parking	\$2,000	
Per diem / meals	\$15,000	
Incidentals	\$5,000	
<i>Domestic travel</i>	\$3,000	
<b>Subtotal</b>	<b>\$76,000*</b>	Travel to entomological meetings to present findings
<b>SUPPLIES</b>		
<i>Molecular laboratory supplies</i>		
Capillary array cartridges	\$6,000	Supplies necessary for extracting DNA from specimens and generating sequence data.
DNA extraction kits	\$3,000	
Flowcells and kits for high throughput sequencing	\$4,000	
Tips, tubes, gloves, etc	\$2,000	
<i>Imaging supplies</i>		
Mounting media, imaging software, slides, etc.	\$1,000	Supplies necessary for imaging species to provide high resolution images of relevant morphological characteristics
<i>Insect collecting supplies</i>		
Pheromones for attracting moths	\$1,200	Supplies required for collecting <i>S. catenifer</i> throughout its native range
Traps for collecting moths	\$500	
Material to remove moths from traps	\$30	
Vials and ethanol to preserve moths	\$250	
Shipping specimens to partner institutions	\$1,000	
<b>Subtotal</b>	<b>\$18,980</b>	
<b>OTHER</b>		
Page charges for publications	\$8,000	Page charges for 2-3 publications resulting from this study

Subtotal	\$8,000	
<b>TOTAL COSTS</b>	<b>\$129,630</b>	
Total 2 year project cost:	\$259,630	

**\*SUBCONTRACT TO UC RIVERSIDE:** We estimate that approximately 50% (~ \$38,000) of the travel funds for this project will be used by Mark Hoddle, Department of Entomology UC Riverside, to collect *Stenoma* specimens for this project.

**Figure 1.** Maximum likelihood tree, of *S. catenifer* mtDNA sequences (CO1) available in public databases, along with three outgroup species. BIN numbers, each indicating a putative species, are indicated next to brackets.



**Figure 2.** Map showing the known distribution of *S. catenifer*. Countries indicated in blue show localities from which samples have been sequenced, along with the number of sequenced samples from each. Countries indicated in orange show unsampled localities.

