LEVERAGING THE INSECT AND FRUIT MICROBIOMES TO CONTROL AN INVASIVE FRUIT FLY

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INTRODUCTION

Invasive fruit flies are global threats to food security and the economy as they can destroy crops and inflict multi-billion dollar losses to fruit and vegetable production. In the US, regions with subtropical climates such as Florida, Georgia and California have a unique production system whereby year-long availability of cultivated crops and non-crop hosts offer ongoing opportunities for fly invasion and spread. Incidences of Tephritid fly invasion have resulted in substantial eradication efforts and costs (*1*). An invasive Drosophilidae the spotted wing *Drosophila* (SWD), is widely established. Taking Florida as an example, SWD was first detected in Hillsborough County in 2009 (*2*), in just over 4 years, the pest has spread to 28 counties, incurring $10-15 million annual losses in small fruit production (*3*).

Currently, fruit fly controls rely on heavy use of chemical insecticides, which drives up production cost and is environmentally unsustainable. Efficacy is also limited because insecticides only act on adult flies but not larvae that feed inside fruits. Novel methods for control are greatly needed and the microbiome offers some promising opportunities. There is now solid evidence that the gut microbiome plays a pivotal role in insect nutrition and physiology (*4, 5*). Symbiotic microbes can provision essential amino acids and B vitamins, degrade plant cell materials, and detoxify plant chemicals, thus enabling the insects to thrive by modifying their growth environment (*6-9*). The ten years of research by the project PI (Wong) and colleagues on the gut microbiome of *Drosophila melanogaster*, a species closely related to SWD, demonstrated that the microbiome can accelerate larval development, affect host foraging preference, and increase reproduction (*6, 10-12*), all important parameters for invasion. **A critical, yet unresolved question is how the interactions among the community of gut microbes and flies may facilitate fly larval success on new host plants, and thus establishment of invasive flies as pests when they switch to new areas.** During oviposition, the maternal insect deposits its microbiome onto the egg surface. Newly hatched larvae are exposed to a variety of microbes, including egg-associated and fruit-associated microbes (*13*). The oviposition site also creates an entry point for opportunistic bacterial and fungal pathogens into the fruit. These complex microbial interactions likely vary among host plants and seasonally throughout the year, which may present opportunities (exploit new host plants, faster development, etc.), but also risks (failing to colonize, pathogen infections, etc.) to the SWD larvae (*14*). A major goal of this proposal is to identify microbial taxa and gene activities that affect larval success across host plants. From a management perspective, larval microbiomes are a promising target if we can identify critical microbial functions for larval development because larvae are restricted to feed on single hosts during its development.

Recent work published by two independent groups, including one from the PI Wong shows that *Drosophila* flies not only search for nutrients, they navigate through and carefully select from different microbial sources in foraging (*10, 15*). The ability to locate microbes that are beneficial while avoiding harmful microbes is reliant on chemical signals and is an important trait for SWD survival and reproduction. The varied foraging response of SWD toward different microbes inspires the idea of leveraging the fruit and fly microbiomes to develop microbial-based attractants and repellents for SWD management.

Relevance to faculty's broader research program and goals

The goals of this project are two-fold: 1) obtain new knowledge and mechanistic insights into the role of insect microbiome in invasive insect's abilities to colonize host plants, and 2) develop effective and sustainable strategies to manage insect invasion. The work represents my lab's core interests in insect-microbe interactions and their relevance to significant agricultural issues. My expertise and motivation will ensure timely delivery of the project. I have a broad background in host-microbe interactions, microbial physiology and genomics, rooted in my undergraduate internship in engineering *Escherichia coli* to produce recombinant proteins. Over the past 10 years, I have established the fruit fly *Drosophila* as a model to