Biological Control: Protecting Agriculture and Wilderness Areas from Invasive Insect Pests

Dr Mark Hoddle
Dr Mark Hoddle's interest in insects started at a young age, rearing mantids (*Orthodera novaezealandiae*) in his native New Zealand. 'The subsequent mass production of baby mantids inadvertently lead to me executing my first biocontrol program – releasing these tiny nymphs onto Mum's whitefly infested fuschias!' he tells us. During his undergraduate course lectures in basic insect biology, ecology and taxonomy, as well as Integrated Pest Management, Dr Hoddle built upon this interest and started to consider entomology as a career option. It was then that he realised, 'you could actually get a job doing the things I like doing for fun!' Since 1997, Dr Hoddle has worked as an Extension Specialist in biological control in the Department of Entomology and later as the Director for the Center for Invasive Species Research, both at the University of California, Riverside.

**Eradicating an Invasive Palm Weevil**

One of the main focuses of Dr Hoddle’s work is developing biological controls for high risk invasive agricultural pest species like the glassy-winged sharpshooter (*Homalodisca vitripennis*), and when possible, eradicating incipient pest populations such as highly destructive palm weevils. Palm weevils have long been considered a pest species in Asia, where some species originate. In particular, the red palm weevil (*Rhynchophorus ferrugineus*) has killed millions of Canary Island palms and date palms, and is widely considered to be one of the most damaging insects to palm trees in the world. The closely related *Rhynchophorus vulneratus* from Indonesia, is also a palm killer in its native range.

Measuring between 35 and 40 millimetres, this beetle species has several different colour morphs. One variety is black with a distinctive red stripe on the dorsal side of the thorax, and in 2010, a live male weevil with this colour pattern was found in a dead canary palm in Laguna Beach, California. Dr Hoddle and his colleagues identified this weevil as *R. vulneratus* using DNA analysis, contradicting the previous identification of the weevil as the closely related *R. ferrugineus*.

In California alone, the ornamental palm industry is worth $70 million, while the date industry has an estimated value of $68 million per year. Thus, it was important to act quickly to reduce the spread of this damaging palm pest. Dr Hoddle and his colleagues demonstrated that the species of palm weevil in Laguna Beach was highly attracted to two volatile compounds – odours from damaged palm trees and aggregation pheromones released by male weevils that attract more weevils (male and female) to infested palms. The team placed synthetic versions of aggregation pheromones into buckets with fermenting fruit to attract weevils, which...
‘The ultimate goal of a successful biological control program is reducing pest populations to less damaging levels, perhaps to the level where pesticides, for example, are no longer needed. This is good for the environment, and for agriculture as it saves the farmer money on pest control.’
Since its initial introduction into California, the glassy-winged sharpshooter population increased, as did plant diseases associated with feeding insects. In 2000 alone, $6.9 million USD was spent on pesticides in an attempt to manage populations, in response to grape losses in San Diego and Riverside Counties due to X. fastidiosa related diseases, which were estimated in excess of $37 million USD. As glassy-winged sharpshooter populations continued to increase in California, the pest was inadvertently exported to Hawaii and French Polynesia through trading live plants. Populations in French Polynesia reached exceptionally high densities, far greater than anything observed in California. Subsequently, the glassy-winged sharpshooter spread from French Polynesia to Easter Island and the Cook Islands. This pest needed to be urgently controlled, and biological control was identified as the strategy most likely to provide significant and environmentally acceptable pest suppression. Natural enemies, in particular parasitoids that attack glassy-winged sharpshooter eggs, were considered excellent candidates for use in a biological control program targeting this pest. Dr Hoddle and his colleagues quickly identified a key candidate – G. ashmeadi.

‘Parasitoids’ such as G. ashmeadi lay their eggs inside those of the glassy-winged sharpshooter, and the developing larvae kill the sharpshooter egg by feeding on its contents. The team’s use of G. ashmeadi significantly reduced pest populations throughout invaded areas in California. However, the impact of G. ashmeadi has been most spectacular in French Polynesia, where within 7 months of release of this egg parasitoid, glassy-winged sharpshooter populations were reduced by more than 95%. This impressive level of control has resulted in permanently low populations of the glassy-winged sharpshooter in this large island archipelago. A secondary major achievement of the team’s highly successful program was the discontinuation of the spread of the glassy-winged sharpshooter throughout the South Pacific. This pest has not been recorded in any additional island nations following the implementation of this biocontrol program in French Polynesia.

In response to the threat that ACP-HLB poses to commercial citrus in California, a $3 billion (USD) industry, Dr Hoddle and Christina Hoddlle undertook a biological control program to target it. To do this, they needed to work for extended periods of time in Punjab Pakistan – part of the native range of ACP. In collaboration with Pakistani colleagues at the University of Agriculture Faisalabad, they searched for and identified natural enemies of ACP that could be imported into California under permit for safety evaluations in quarantine. Two parasitoids, Tamarixia radiata and Diaphorectyus aligarhensis, which attack and kill different developmental stages of ACP nymphs were identified and approved for release by federal regulators. One of these parasitoids, T. radiato, established readily and spread rapidly by taking advantage of the widespread and dense ACP populations that were infesting urban citrus. This parasitoid, in combination with predatory insects like syrphid fly larvae, have greatly reduced ACP densities, and have probably contributed to its reduced spread in California. However, there is much more work to be done on this problem to prevent a catastrophe similar to that seen in Florida.

**Protecting Wildlife**

The goldspotted oak borer (Agrilus auroguttatus) is a beetle native to southern Arizona, which was first detected in California in 2004. By 2008, it was found to be adversely affecting three species of ‘red oak’ in the Cleveland National Forest, San Diego. Many infected oaks are large and very old, and as such a keystone species, their loss severely impacts biodiversity. Dr Hoddle and his colleagues collected data on the origin, biology and life history of the goldspotted oak borer, including information on its natural enemies. They also investigated its flight capabilities, including the total distance flown, by using a computerised flight mill. To estimate the distances that insects are capable of flying, entomologists attach insects to the arm of the flight mill, which rotates on a near frictionless spindle. As the insect flies, the arm of the mill rotates on this spindle and a computer records distances flown.

Flight mill data indicated that adult goldspotted oak borers would not have had the ability to cross the Sonoran and Mojave deserts, natural and hostile barriers separating the native range of goldspotted oak borers from the invaded area in southern California. This work suggests that this pest was introduced into the Cleveland National Forest by humans transporting oak firewood from Arizona to California. Human movement of firewood in California has resulted in goldspotted oak borers becoming established in additional areas. This problem is likely to continue as there is no regulation of moving infested oak firewood from contaminated areas to uninfested parts of California. As part of their project, Dr Hoddle and this team identified two species as potential parasitoids of the goldspotted oak borer. Unfortunately, further work suggested that these natural enemies were unlikely to provide adequate biological control of goldspotted oak borers and California’s iconic oak forests and savannas remain threatened by this highly destructive pest.
Meet the researcher

Dr Mark Hoddle
Department of Entomology
Center for Invasive Species Research
University of California, Riverside
California, USA

Dr Mark Hoddle is an entomologist and biological control specialist in the Department of Entomology at the University of California, Riverside, where he is also the Director for the Center for Invasive Species Research. Dr Hoddle received his BSc from the University of Auckland, New Zealand, prior to completing an MSc in Zoology also at the University of Auckland. Following this, he undertook his PhD in Entomology at the University of Massachusetts, Amherst. Since 1997, Dr Hoddle’s research at UC Riverside has focused on biological control as a tool to reduce the impact of invasive pest species to agriculture, urban, and natural areas, with a primary focus on issues affecting California. These programs often require long periods of overseas research in the home range of the target pest, and searching for and studying natural enemies for possible use in biological control programs in California.

CONTACT
E: mark.hoddle@ucr.edu
T: (+1) 915 827 4714
W: www.biocontrol.ucr.edu
W: www.cisr.ucr.edu

FUNDING
Citrus Research Board
California Avocado Commission
USDA-APHIS
USDA-NIFA
USDA-CPHST
California Department of Food and Agriculture Specialty Crops Program
California Department of Pesticide Regulations
Western Region IPM Program
W-4185
Generous Private Donors

REFERENCES


VM Lopez and MS Hoddle, Native and introduced range surveys for egg parasitoids of Agrilus auroguttatus, an invasive pest of native oaks in California, Biocontrol Science and Technology, 2015, 25, 645–655.