

Red Palm Weevils – Food or Foe?

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1. Red palm weevil color morphs.

In October 2010, what was thought to be red palm weevil, *Rhynchophorus ferrugineus*, was discovered inside a dying Canary Island date palm in Laguna Beach, California, USA. This was the first record of this highly invasive palm pest in the USA. Subsequent work indicated that the weevil was actually *Rhynchophorus vulneratus* and that the invading population likely originated from Indonesia, possibly from around Bali. How this weevil made its way to the relatively isolated community of Laguna Beach is largely a matter of speculation. Here I suggest that *Rhynchophorus vulneratus* was deliberately introduced in an attempt to satisfy demand for a traditional food that is eaten in some regions of Southeast Asia.

Red palm weevil, *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae), is a notorious palm pest that has been particularly devastating where it has established in areas outside of its native range. Native to Southeast

Asia, this large and very attractive looking weevil, is a well-recognized menace of coconut palms in its home range. International trade in live palms resulted in the accidental exportation of this pest from its native range,

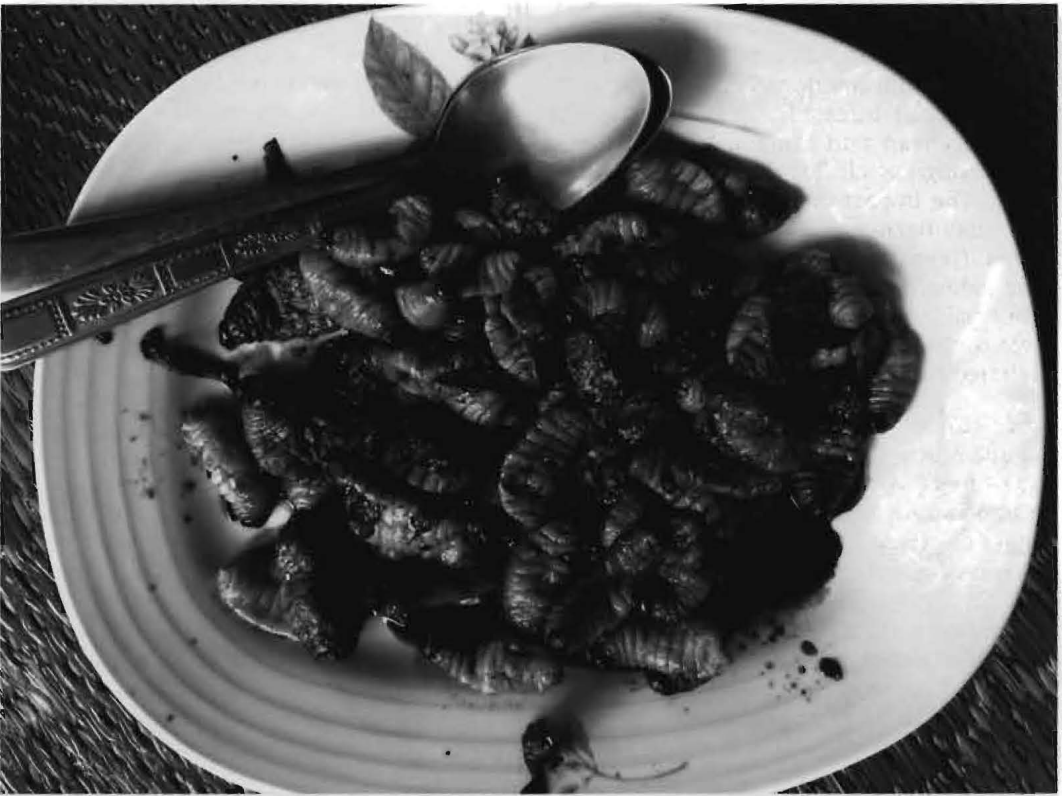
which resulted in its inadvertent introduction into the Middle East in the 1980s. From here it was again unintentionally redistributed via movement of infested live palms into the Mediterranean and the Caribbean (Faleiro 2006, Longo et al. 2011, Murphy & Briscoe 1999). The impact of this weevil in invaded areas has been particularly severe on date palms, *Phoenix dactylifera*, and Canary Island date palms, *P. canariensis*. To a lesser extent other palm species are attacked in invaded areas probably because they are not as highly preferred (Longo et al. 2011).

Red palm weevil was officially detected in Laguna Beach, Orange County, California USA in October 2010 when an adult was recovered from a heavily damaged Canary Island date palm in a private garden (Hoddle 2010). There were several very curious things about this find. First, Laguna Beach is a small (ca. 23,000 inhabitants), somewhat secluded, wealthy residential area that, as its name would suggest, is nestled between the Pacific Ocean on the west and the very dry and relatively undeveloped and uninhabited San Joaquin

Hills to the east. There are few roads in and out of Laguna Beach, there are no airports, seaports or interstate border crossings, which are important infrastructure assets often correlated with invasion likelihood. However, tourism, another indicator of invasion vulnerability, is high in Laguna Beach, with ca. 3 million people visiting the community annually. There was no evidence around invaded areas of large new plantings of ornamental palms, and live palm tree imports into the USA had been banned by the USDA specifically to prevent entry by red palm weevil. Collectively, these characteristics made Laguna Beach a highly unlikely incursion point for red palm weevil into the continental USA. Experts predicted that the likely point of entry and initial area of establishment by red palm weevil would be Florida, with invading populations originating from infested Caribbean Islands. The second thing that was odd about the red palm weevil invasion in Laguna Beach was the color morph of the weevil that was detected; it was black with a red stripe on the thorax. The color morph of the global invader is predominantly orange

2. Red palm weevil larvae (and pupae) may be eaten deep fried. Sometimes larvae are eaten alive after marinating (i.e., swimming!) in soy sauce.





3. Farm-fresh red palm weevil larvae stir fried with a traditional sauce of Thai herbs and spices – an excellent accompaniment to steamed rice.

with black markings, and this color form of the weevil was expected to be found in the USA should a successful incursion occur (Fig. 1). The red and black morph (now known as *Rhynchophorus vulneratus*) had not been previously collected outside of its native range (also Southeast Asia), and both color morphs were considered to be color variants of the same species, *R. ferrugineus* (Hallett et al. 2004). Three major research questions needed to be answered following the red palm weevil invasion in Laguna Beach: (1) was this red and black weevil really *R. ferrugineus* as suggested by Hallett et al (2004) or was it *R. vulneratus*, which Hallett et al. (2004) synonymized with *R. ferrugineus*? (2) Where did the invading population in Laguna Beach originate? and (3) how was this weevil introduced into southern California?

To determine the taxonomic identity of the black and red color morph in California (question 1), extensive collecting was done throughout the native range of the red palm weevil, and colleagues in Europe, the Middle East, and North Africa graciously provided samples of invasive red palm weevils from a variety of different countries. These samples

were subjected to two forms of analysis, (1) morphological measurements, similar to those used by Wattanapongsiri (1966), and (2) molecular analyzes of the mitochondrial cytochrome oxidase subunit I (COI) gene and additional nuclear gene regions from sampled populations throughout the native and invaded ranges.

Statistical analyses of key morphological features failed to provide evidence to identify populations or species collected from different areas. The DNA analyses on the other hand were extremely informative. Analyses of COI haplotype data provide conclusive support, corroborated by analyses of nuclear gene sequences, for the existence of at least two predominantly allopatric species of palm weevil in the native range. The true *R. ferrugineus* is native only to the northern and western parts of continental Southeast Asia, Sri Lanka and the Philippines and is the culprit in almost all invasive populations worldwide. In contrast, the second species, which has been resurrected under the name *R. vulneratus*, has a more southern distribution across Indonesia and is responsible for only one invasive population, that in California, USA (Rugman-



4. Harvesting red palm weevil first requires locating a coconut palm exhibiting signs of infestation.

Jones et al. 2013). These two species, given their current geographic distributions may have evolved from a common ancestor after the splitting of the Isthmus of Kra in Thailand by ancient seaways.

Another interesting result from these studies pertains to the taxonomic work by Hallett et al. (2004) in which *Rhynchophorus ferrugineus* and *R. vulneratus* were synonymized. In these studies, which were conducted in Java,



5. Harvesting red palm weevil requires felling and dissecting the trunk with a chain saw.

Indonesia, Hallett et al. (2004) correctly determined that they were working on just one species, despite pronounced color variations, as their test weevils mated, produced offspring, were sympatric in infested coconut palms and responded to the same aggregation pheromone. DNA analyses showed no differences to imply different species were being studied. The problem with this work was that Hallett et al. (2004) were actually studying *R. vulneratus*, not *R. ferrugineus* (which is not present in Indonesia) as they assumed, and their recommended synonymy was incorrect.

A further issue that arises from this error pertains to the aggregation pheromone that is available commercially and used to monitor and, in some instances, help control invasive *Rhynchophorus ferrugineus* populations (Hoddle et al. 2013). The pheromone was actually derived from *R. vulneratus* and not *R. ferrugineus* (Hallett et al. 1993). The identity of the aggregation pheromone for *R. ferrugineus* is currently unknown, and its identification could possibly improve detection, monitoring and control programs for this pest, assuming it is different to the pheromone produced by *R. vulneratus*.

The DNA analyses conducted by Rugman-Jones et al. (2013) also helped to answer the second question pertaining to the potential geographic area of origin for the *R. vulneratus* population that was detected in Laguna Beach. Results of molecular studies indicated that the California population is of Indonesian origin, and specimens collected from Bali, an island that lies to the east of Java, most closely (but not exactly) match weevils collected in Laguna Beach.

If *Rhynchophorus vulneratus* in California originated from Bali or an island close by (e.g., Lombok which lies to the east of Bali), how did it arrive in Laguna Beach? The possible answer to this third question presented itself somewhat unexpectedly while my colleagues and I were collecting weevils in Indonesia and Thailand and our hosts informed us that larvae and pupae are considered by some to be culinary delicacies (Figs. 2 & 3)!

A video, with commentary, showing the eating of these cooked weevil larvae in Sumatra Indonesia is available (www.youtube.com/watch?v=-8m_ijKqNI). To find larvae in



6. Extracting larvae from the infested trunk.

nature is time consuming, as it means doing one of two things: (1) cutting down infested coconut palms and dissecting them with a chainsaw to access the larvae living within the apex of the trunk (Figs. 4–7), or (2) deliberately felling sago palms (*Metroxylon sagu*) to promote weevil colonization, after which larvae can be

reliably harvested for several months (see video https://www.youtube.com/watch?v=aL8nAzTty_M). Unfortunately when I made the title for this video I misidentified the palm from which weevil larvae were being extracted as a nipah palm, *Nypa fructicans*, when it was actually *M. sagu*.



7. Larvae are stored temporarily until they can be cooked.

An alternative and much more efficient approach is to farm red palm weevil. This is a commercial enterprise in Thailand (see this video from Thailand – even though it is in Thai it is still fascinating and basically self-explanatory www.youtube.com/watch?v=mmTOXLwJELI).

Red palm weevil farms (Fig. 8), are as the name suggests, places where weevils are commercially mass reared (interestingly, commercially farmed insects are sometimes referred to as “micro-livestock.”) Red palm weevil larvae are ideally suited to farming in closed plastic containers – after all this is pretty much how they live inside an infested palm trunk, which is in reality a large rearing container! The farming process is relatively straight-forward; coconut palm fronds are ground up using a mechanical grinder, and this “saw dust” is then soaked in water. Excess water is squeezed out to make a palm mash and amended with pellets of pig food (I suspect these may provide a necessary protein supplement). The amended palm mash is packed into large plastic

containers (Fig. 9) and adult weevils are added and left to oviposit (slabs of palm wood and bark are placed on top of the packed palm mash to provide shelter for the adult weevils and to later provide palm fibers for larvae to spin cocoons). An alternative approach is to inoculate palm trunk “cookies,” which are essentially cut disks of palm trunk that are stood vertically and inoculated with adult palm weevils – which surprisingly do not abandon these uncaged logs as long as slabs of palm wood are placed on top of the log for shelter (Fig. 10). Adults lay eggs, which hatch, and the tiny grubs burrow into the logs. They are later harvested as they approach the pre-pupal stage (Hoddle 2013a).

The really neat thing about these farming practices is that the “waste” products are very useful and can be sold as well. For example, waste water which drips from plastic containers can be harvested and sold as fertilizer. The mash from which weevil larvae are extracted can be sold as a soil amendment, and the hollowed out palm trunks can be sold



8. A roadside sign advertising red palm weevil larvae for sale in Thailand.

as containers for growing plants! It is not surprising therefore that the FAO is promoting insect farming as a cheap and efficient alternative to rearing pigs, cows and goats for protein (van Huis et al. 2013).

So this brings us to our conclusion and the answer to research question 3 – how did *R. vulneratus* arrive in Laguna Beach? One hypothesis (for which there is no evidence!) is that this pest was deliberately introduced for food so it could be harvested locally without the need for smuggling through customs at airports. Live red palm weevil larvae, as a traditional food item, are impossible to source commercially in southern California. For certain ethnic groups in and around the Laguna Beach area, palm weevil larvae may have high cultural significance, as they are an important food for family gatherings, festivities and some religious observances. At one weevil farm in Thailand, we were told by a customer that cooked larvae are a traditional monthly treat for his family, and for this, he was willing to pay more per kilo than chicken or fish at the local supermarket. Humans are notorious for introducing desirable food items into areas where they do not exist naturally; smuggling of fruit, for example, is a common problem. So

it is not too much of a stretch to imagine people smuggling food insects into new areas with the intent of establishing them as a local food source where they do not currently exist. California after all has a bewildering number of palms and a high diversity of palm species in urban and natural areas – some of which would be excellent hosts for red palm weevil.

So what is the status of the *Rhynchophorus vulneratus* incursion in Laguna Beach? In early 2015, monitoring programs failed to detect a single live adult weevil for three consecutive years. Enhanced trapping trials using cut date palm logs and aggregation pheromone, have failed to capture *R. vulneratus* (Hoddle 2012). There appears to be no problem with the commercially-available aggregation pheromone used in trapping trials, as it was shown to be very attractive to *R. vulneratus* in its home range, Sumatra, Indonesia (Hoddle, unpublished). It is highly likely that *R. vulneratus* has been eradicated from Laguna Beach as a result of swift actions by the California Department of Food and Agriculture, the USDA, Orange County Agricultural Commissioner's Office and the University of California. This rapid multi-agency response



9. A bowl of palm mash tipped out to show the developing larvae.

identified infested palm trees and treated them with contact and systemic insecticides (Hoddle 2011a & b). Later examination of treated palm trees that were felled and dissected failed to detect any evidence of *R. vulneratus* activity (Hoddle 2013b). If *R. vulneratus* is declared to

have been eradicated after three years of no detections this will be a significant achievement. However, California's palms are likely to come under assault from the South American palm weevil, *Rhynchophorus palmarum*, which is being detected with



10. Palm trunks being used to grow larvae at a red palm weevil farm in Thailand.

increasing frequency as it enters southern California from Mexico (Hoddle 2011c).

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