The South American Palm Weevil

A New Threat to Palms in California and the Southwest

Donald R. Hodel, Michael A. Marika, and Linda M. Ohara

The South American palm weevil (SAPW) (*Rhynchophorus palmarum*), one of a genus of unusually destructive beetles well known for attacking palms, is now killing Canary Island date palms (CIDPs) (*Phoenix canariensis*) in the San Ysidro area of San Diego, California adjacent to the international border with Mexico. This pest poses a serious threat to palms in California and the Southwest.

Since 2010 the SAPW has been attacking and killing palms, primarily CIDPs, in Tijuana, Baja California, Mexico adjacent to San Diego. It had been detected in traps inside the United States along the international border with Tijuana but until recently was never found attacking palms. That situation changed in 2015, or perhaps even earlier, when we observed the SAPW-caused death of at least 10 CIDPs in early 2016 in the neighborhood surrounding San Ysidro Community Park in the San Ysidro area of San Diego near the junction of I-5 and I-805 freeways just north of the international border (**Fig. 1**). About 20 additional CIDPs have died in this area, bringing the total to at least 30 palms killed as of July 2016.

Figure 1. In March, 2016 we observed Canary Island date palms killed by the SAPW in the neighborhood surrounding San Ysidro Community Park in the San Ysidro area of San Diego near the junction of I-5 and I-805 freeways just north of the international border (D. R. Hodel).

About 15 km to the north of the San Ysidro infestation, at Sweetwater Regional Park, at least 20 dead CIDPs were reported in a riparian area (Mark Hoddle, pers. comm.) although it is unclear if the SAPW actually killed these palms or they were the victims of on-going, government effort to eradicate non-native trees from natural areas; however, SAPWs were caught in traps placed at the site. Three unconfirmed reports put the SAPW in Chula Vista, near interstate I-80 in El Cajon, and near Balboa Park. Confirmation of these reports would indicate that the SAPW is on the move, and doing so rather quickly and aggressively.

In addition to the physical damage the SAPW can inflict on palms directly, it is a primary vector of the nematode that causes red ring disease (RRD), a typically fatal wilt disease of palms. Fortunately, RRD has not yet been detected in SAPWs or palms attacked in San Diego.

This attack of the SAPW is the second in five years from this genus of destructive palm weevils in California. In 2010, what was thought to be the most feared and destructive weevil of this group, the red palm weevil (*Rhynchophorus ferrugineus*), killed several CIDPs in Laguna Beach, California (Hodel et al. 2011). Later, DNA evidence showed that this Laguna Beach infestation was not the dreaded red palm weevil but a closely related weevil, *R. vulneratus*, which has since been eradicated (Hoddle 2015, Rugman-Jones et al. 2013). Nonetheless, the discovery of two infestations of this particularly destructive group of palm weevils within five years in California underscores how global warming and national and international trade have enhanced the spread of exotic pests.

Here we provide information about the names, a description, hosts, distribution, natural history, damage symptoms, potential involvement in red ring disease, detection and management, and disposal strategies of the SAPW.

Names

Scientific Name: *Rhynchophorus palmarum*.

Synonyms: *Calandra palmarum*, *Cordyle barbirostris*, *C. palmarum*, *Curculio palmarum*, *Rhynchophorus cycadis*, *R. depressus*, *R. languinosa*.

Common Names: South American palm weevil, giant palm weevil, palm marrow weevil, American palm weevil; *casanga*, *gorgojo prieto de la palma, picudo negro* (Spanish); *charançon du palmier* (French).

Description

The description is mostly from Hagley (1965), CABI (2016), and Molet et al. (2011), and supplemented from our field observations.

Eggs: 1-2 mm inside soft tissue and protected by brown waxy secretions, 2-2.5 × 0.85-1 mm, elongate-ovoid, pearly white, pitted with 7 circumscribing grooves.

Larvae: caterpillar-like, legless, cannibalistic,1st instar 2.4 × 0.8-1.1 mm, head orange-brown with sclerotized mouth parts and a pair of stout, strong mandibles, abdomen creamy white, semi-transparent, each segment bearing tuft of hairs; later instars vary greatly in size, mature larvae 44-60 × 20-29 mm, head dark brown, abdomen reddish brown, migrating to periphery of tunnels or galleries prior to pupation.

Pupae: inside tough, fibrous, brown, cylindrical, shredded-wheat-like cocoon made from vascular bundles of the host palm, cocoon 65-90 × 27-40 mm (**Figs. 2-3**).

Adults: 30-35 × 14-16 mm, deep glossy black aging to dull black (**Figs. 4-5**), hard

Figure 2. Pupae of the SAPW are enclosed in a tough, fibrous, brown, cylindrical, shredded-wheat-like cocoon made from vascular bundle of the host palm, (D. R. Hodel).

Figure 4. Adult SAPWs are 30-35 × 14-16 mm with a long, ventrally curved rostrum (D. R. Hodel).

Figure 3. The cocoons are 65-90 × 27-40 mm (D. R. Hodel).

Figure 5. Bodies of adult SAPWs are deep glossy black, aging to dull black (D. R. Hodel).

body; head small and rounded with characteristically long, ventrally curved rostrum, gender dimorphic with males having a “comb” of hairs on rostrum, females lack “comb” (**Fig. 6**)

Hosts

The SAPW has been reported on 35 plant species in 12 families and is especially economically important on plantation crops like coconut (*Cocos nucifera*) and African oil palm (*Elaeis guineensis*) (CABI 2016; Dean 1979; EPPO 2007a; Esser and Meredith 1987; Fenwick 1967; Griffith 1968, 1987; Jaffe and Sánchez 1990; Sanchez and Cerda 1993; Wattanapongsiri 1966) although it can also attack ornamental landscape palms and non-palms, such as sugarcane, banana and cacao, and cause significant damage (EPPO 2005, Wattanapongsiri 1966). It can also be found in virgin forest (CABI 2016).

Primary Hosts: coconut palm, African oil palm, assai palm (*Euterpe edulis*), sago palm (*Metroxylon sagu*), Canary Island date palm, date palm (*Phoenix dactylifera*), and sugarcane (Arango and Rizo 1977, EPPO 2007a, Restrepo et al. 1982, Thomas 2010).

Figure 6. Adult SAPWs are gender dimorphic with males (top) having a "comb" of hairs on rostrum while females lack this "comb" (bottom) (D. R. Hodel).

Secondary Hosts: pineapple, custard apple, breadfruit, papaya, citrus, mango, banana, avocado, guava, and cacao (EPPO 2007a).

Over 30 additional plant species are susceptible to adult SAPWs, which mostly feed on stems of several palms and fruits of several non-palms, causing insignificant damage (CABI 2016, Hagley 1965).

Distribution

The SAPW is a New World weevil. Historically it was known from Argentina and Paraguay north through South America and Central America to central Mexico and into the Caribbean (Barbados, Dominica, Grenada, Guadeloupe, Martinique, Saint Lucia, Saint Vincent, Grenadines, Trinidad and Tobago, and perhaps Cuba, Dominican Republic, and Puerto Rico)(CABI 2016; EPPO 2005, 2006, 2007b).

In at least the past six years, though, the SAPW arrived in Tijuana, Baja California, Mexico, likely carried north on landscape palms and or produce like bananas or coconut. It probably flew across the international border, and was detected in the border area of California and Baja California [Calexico/Mexicali and Tecate/San Ysidro (San Diego)/Tijuana] in 2011 (USDA-APHIS PPQ 2011, NAPPO 2011). In 2012, the SAPW was detected in Alamo, Texas within eight km of the US/Mexico border (USDA-APHIS PPQ 2012). It is now considered transient in the United States in California (NAPPO 2011), Arizona (NAPPO 2015), and Texas (NAPPO 2012) and is under eradication or surveillance.

Host maps and climate data show that the SAPW is a potentially serious problem on ornamental landscape palms in Florida, other southern states along the Gulf Coast, southwestern Arizona, and southern and central California. Commercial date palm orchards in California and Arizona are also at risk.

The SAPW is moved long distances in infested nursery stock and short distances by adult flight (EPPO 2005, Hagley 1965), and has been intercepted numerous times at entry ports into the United States (airports, land borders, maritime ports), mostly on banana and coconut (AQUS 2011).

Natural History

Nearly all the information about the natural history of the SAPW was developed in tropical locales on tropical palms, mostly plantation crops like coconut and oil palms; this information will likely vary somewhat in cooler, drier, subtropical or warm temperate areas like California with subtropical landscape palms.

The SAPW is one of about nine species of weevils in the genus *Rhynchophorus* (Wattanapongsiri 1966), most of which attack palms (Giblin-Davis 2001). Weevils are a group of beetles of the Curculionidae family characterized by having mandibles positioned at the apex of an elongated snout or rostrum. The shape and length of the rostrum correlate to the weevil's specific life history and function in creating access to internal tissues in plants and seeds. Many weevils, including *Rhynchophorus* spp., possess an especially elongated snout that allows penetration deep within plant tissue creating entry wounds in which eggs are deposited. These wounds provide a protected site for the development of the young larvae and may facilitate entry of symbiotic yeasts or bacteria, which help create favorable conditions for larval development within the host tissue.

The life cycle of the SAPW in coconut palms is from 80 days (Griffith 1987) to 180 days, including 30 to 60 days as an adult (Sánchez et al. 1993). Typically life cycles are shorter in warm, humid tropical climates and longer in dry, cooler Mediterranean climates.

Hagley (1965) determined life cycles under laboratory conditions of 21 to 33 C and 62 to 92% relative humidity. Female SAPWs laid 100 to 400 eggs in 15 to 45 days although Sánchez et al. (1993) noted that females can lay up to 700 eggs. Incubation took two to four days. First instar to adult took 40 to 60 days. The pre-pupal stage, during which the larvae construct cocoons, took 4 to 17 days. Pupation lasted 8 to 23 days and adults remained in the cocoon for 4 to 11 days before emerging. Male adults lived for 27 to 61 days while females lived for 25 to 55 days.

Semiochemicals or insect behavior-modifying chemicals (IBMCs), which act as signals between organisms, play a critical role in SAPW behavior and management, including detection, monitoring, and control. The two general classes of IBMCs are pheromones, which act intraspecifically, and kairomones, which act interspecifically (Dusenberry 1992). Pheromones are produced by the insect pest while kairomones are produced by the plant or plant products.

Moisture in palm leaf bases and petioles, kairomones produced by wounds on healthy palms or by stressed palms, and/or male-produced aggregation pheromones attract both genders of adult SAPWs for mating and oviposition (Giblin-Davis 1996). Adult female SAPWs oviposit in holes made with their rostrum, typically in distal portions of the trunk just below the leaves or in leaf bases and proximal areas of the petiole. Each adult female can oviposit 120 to 150 eggs in 30 days (Wattanapongsiri 1966, Weissling and Giblin-Davis 1994). Larvae bore into the trunk, tunneling vertically between the vascular bundles (Hagley 1965), where they feed on live vegetative tissues (CABI 2016, Molet et al. 2011), and can kill the palm if they destroy the apical meristem (Giblin-Davis 2001). As few as 30 larvae are sufficient to kill a mature coconut palm (Fenwick 1967, Griffith 1968).

Adult SAPWs emerge and can fly at speeds up to 6 m/s and up to 1.6 km in 24 hours (Griffith 1987, Hagley 1965). Their preferred habitat is among the tightly packed palm leaf bases, which provide protection where they can hide during the day. They are most active in the early morning and later afternoon. Although they only fly during daylight, they avoid the hottest part of the day (Hagley 1965).

In Central America, adult SAPW populations peak during the dry season. The altitudinal range of the SAPW is from sea level to about 1,200 m (Jaffe and Sánchez 1990, Sánchez et al. 1993).

Natural enemies of the SAPW include a parasitic fly, *Paratheresia menezesi* (Moura et al. 1993), and the entomoparasitic nematodes of the Steinernenamtidae and Heterorhabditidae families (Griffith and Koshy 1990). *Praecocilenchus rhaphidophorus*, an entomoparasitic nematode that was described from *Rhynchophorus bilineatus* (Nickle 1970), might also attack the SAPW.

Symptoms and Signs

Symptoms and signs of the SAPW are similar to those of the red palm weevil outlined in Hodel et al. (2011). Damage to the palms is variable and depends on the palm species and cultivar, size, health, and cultural practices. Because of its numerous, tightly packed, bulbous, fleshy, moist petiole and leaf bases, which provide abundant food and cracks and crevices for shelter and hiding, the CIDP offers little resistance and is, by far, the most attractive, susceptible, and preferred landscape host or species of the SAPW in California. Thus, detection will likely occur first on this species. However, if SAPW populations are sufficiently high and the CIDP is unavailable, the SAPW can attack other species. Other common landscape palms that could be attacked include the date palm (*Phoenix dactylifera*), California fan palm (*Washingtonia filifera*), and Mexican fan palm (*Washingtonia robusta*), all of which have many-leaved canopies and close, tightly packed leaf bases that provide food and shelter. The potential for the date palm to be attacked is also especially worrisome because of extensive commercial date groves in the Coachella and Imperial Valleys and the increasing presence of date palms as landscape subjects throughout southern and central California.

SAPWs are somewhat difficult to detect in the early stages of infestation but symptoms, which typically appear first in the top or center leaves of the canopy, include truncated or cut off leaf tips (**Fig. 7**) or chewed off or missing mid-blade pinnae (**Fig. 8**), damage that occurred when larvae tunneled through the leaf when it was still folded up in the spear stage near the apical meristem (Giblin-Davis 2001). Such

Figure 7. Initial symptoms of an SAPW infestation often occur in the center or top of the canopy and include truncated or cut off leaf tips (D. R. Hodel).

truncated leaf tips or chewed pinnae can have other causes, though, including diseases, rodent feeding damage, and nutrient disorders. See Hodel (2009a-b, 2010a-d) for illustrated discussions about diseases and nutrient disorders of palms that may mimic early SAPW damage. Another early symptom of SAPW infestation is simply reduced growth of newest leaves emerging from the top or center of the canopy, causing the top of the canopy to appear flat or even depressed (Giblin-Davis 2001).

With training and experience and the use of a good pair of binoculars, tunneling and grooving at the petiole base/leaf base area (**Figs. 9-10**) can sometimes be observed from the ground. These grooves and tunnels often are filled with cocoons and/or frass (**Fig. 10**). In some cases, fallen cocoons or dead weevils can be found around the base of the palm, and this area should be thoroughly examined (CABI 2016).

Infested leaves in the center or top of the canopy will often droop and can be either brown or green but because of the structural damage at the leaf base they may eventually collapse and/or typically pull off rather easily. Larval tunnels are often seen entering farther into the palm on the freshly cut or broken surfaces of the remaining leaf bases after leaves have been pruned or have fallen off. Fibrous, cloth- and net-like leaf base margins, which have fallen or are still attached to old persistent leaf bases below the living canopy, may exhibit characteristic "Swiss-cheese" or gunshot-like holes made by the SAPW as it tunneled from one leaf base to another (**Fig. 11**).

Figure 8. Initial symptoms of an SAPW infestation can also include chewed off or missing mid-blade pinnae (D. R. Hodel).

Figure 9. Tunneling and grooving at the petiole base/leaf base area caused by the SAPW can sometimes be observed from the ground (D. R. Hodel).

Figure 10. Tunnels and grooves caused by the SAPW (as here with the red palm weevil) often are filled with cocoons and/or frass (D. R. Hodel).

Figure 11. Fibrous, cloth- and net-like leaf base margins, which have fallen or are still attached to old persistent leaf bases below the living canopy, may exhibit characteristic "Swiss-cheese" or gunshot-like holes made by the SAPW (as here with the red palm weevil) as it tunneled from one leaf base to another (D. R. Hodel,).

Advanced stages of an SAPW infestation on CIDP palms can include many drooping or collapsed leaves, especially in the center or top of the canopy, canopy "shifting" or lodging, and a characteristic strong, foul odor (CABI 2016, Hagley 1965). Very early symptoms might show as unusual or little growth from the center of the canopy, which might not be discernable from the ground (**Fig. 12**). Typically, within a year or two in cooler subtropical areas, the infestation has moved from leaf bases into the apical meristem, resulting in death and collapse of the center or newest leaves (**Fig. 13**). Such palms typically lack center leaves but have a lower fringe or skirt of green leaves. Because the apical meristem has been destroyed the palm is effectively dead although it can continue to stand for up to a year or more with its intact fringe of lower, green leaves. Eventually, even the fringing green leaves in this lower skirt will die and turn brown but they persist on the palm (**Fig. 14**). In dead and sometimes even live palms larval feeding damage and associated rot can be so severe that trunk tissue is compromised and the palm canopy can fall off.

In tropical areas palm damage and death can occur rapidly. Older instars, which are capable of causing the most damage, can excavate tunnels to 40 cm long and two to three cm in diameter within 24 to 36 hours while particularly heavy infestations can

Figure 12. Very early symptoms of a SAPW infestation might show as unusual or little growth from the center of the canopy, which might not be discernable from the ground (D. R. Hodel) (March 17, 2016, 241 W. Park Ave., San Diego).

destroy internal tissues and the apical meristem, killing the palm, within five to six weeks (Hagley 1965).

Red Ring Disease (RRD)

If the nematode *Bursaphelenchus* (formerly *Rhadinaphelenchus*) *cocophilus*, which the SAPW vectors (Griffith 1968,1987; Brammer and Crow 2002, Sullivan 2013), is present, RRD will likely become another serious problem. The name of this disease is derived from the diagnostic, brick red or reddish brown ring three to six cm wide and three to four cm in from the periphery of the trunk, which is clearly evident on infected coconut palms when the trunk is cut into transverse sections just above the soil line (Griffith 1987).

Bursaphelenchus cocophilus and RRD historically have occurred over the natural range of the primary vector, the SAPW; however, and somewhat fortuitously, neither has yet been detected in California, Arizona,

Figure 13. A SAPW infestation will eventually move from leaf bases into the apical meristem, resulting in death and collapse of the center leaves although the palm can continue to stand for up to a year or more with its intact fringe of lower, green leaves (D. R. Hodel) (March 17, 2016, E. Beyer Blvd. just S. of San Diego Trolley bridge, San Diego).

Figure 14. Eventually, even the fringing green leaves will die and turn brown but they persist on the palm (D. R. Hodel) (March 17, 2016, 2281 Fantasy Lane, San Diego).

and Texas (USDA-APHIS-PPQ 2011, 2012). Why they have not been detected in the United States is interesting and is not well understood although the phenomenon of "establishment bottlenecks," where, because of the size of the colonizing group and/or quantity of introduction events, an insect is introduced or migrates without its normal nematode associate (Giblin-Davis et al. 2013). Indeed, the current range of the SAPW exceeds that of RRD, which is moving more slowing and still has not yet arrived at the distal regions of the SAPW distribution (Giblin-Davis et al. 2013).

RRD can lead to serious economic losses of commercial coconut and oil palm plantations in Central and South America (Giblin-Davis 1993, Sullivan 2013) and can also damage or kill ornamental landscape palms (EPPO 2005). Most palms are susceptible to RRD although severity and symptoms vary (Griffith and Koshy 1990, Giblin-Davis 1993). Common palms susceptible to RRD include the coconut palm, which is considered very susceptible, African oil palm, Canary Island date palm, date palm, and Cuban royal palm (*Roystonea regia*) (Brammer and Crow 2005, Giblin-Davis 2001, Sullivan 2013).

Adult female SAPWs are the primary vector of *Bursaphelenchus cocophilus* when they deposit the juvenile stage of the nematode during oviposition. However, the palm and sugarcane weevils *Dynamis borassi* and *Metamasius hemipterus* can also vector *B. cocophilus* to palms. Individual SAPWs and other palm weevils can each carry up to 10,000 juvenile nematodes (Gerber and Giblin-Davis 1990; Gerber at al. 1990, Mora et al. 1994). The nematodes, which likely have obligatory relationships with both insect and palm hosts because they survive poorly without either (Giblin-Davis 2001), enter through the oviposition wound, feed, reproduce, and eventually kill the palm by destroying the vascular system, producing typical wilt symptoms.

Palms dying from RRD produce kairomones that attract SAPWs and, thus, increase the number of potential hosts for the pest. The cross attraction to host kairomones and aggregation pheromones increases the probability of associating and vectoring *Bursaphelenchus cocophilus* (Giblin Davis 2001).

Juvenile *Bursaphelenchus cocophilus* associate with SAPW larvae and persist in the weevil through metamorphosis (EPPO 2005, Giblin-Davis 2001). Nematode-infested adult SAPWs emerge from the cocoon and disperse to another palm host, completing the life cycle. RRD can cause the death of the infected palms in just a few months after symptoms are first noticed (EPPO 2005). Coconut palms showed symptoms within 28 days of infection (Goberdhan 1964) and coconut palms three to ten years of age died from RRD within two months of inoculation (Griffith 1987). Other palms showed symptoms of RRD within 23 to 28 days and died within three to four months of inoculation (Brathwaite and Siddiqi 1975, Thurston 1984).

Classic RRD symptoms include wilt; premature fruit drop (especially in coconut palms); chlorosis and death of leaves progressively from older to younger leaves (lower to higher in the canopy); petiole failures that cause leaves to hang; and transverse sections showing anthocyanin-red pigments in a ring just inside trunk, root, and petiole periphery (Giblin-Davis 2001, Sullivan 2013). Sometimes, RRD nematodes are associated with a chronic condition called "little leaf" (Chinchilla 1988), which is typically associated with abiotic disorders or other diseases like pink rot (Hodel 2009a-b, 2010a-d). In the former instances, RRD nematodes can be found deep, down among the adjacent leaf bases near the apical meristem where they cause necrotic lesions and stunt new leaves, giving the canopy its classic "little leaf" appearance.

Detection and Management of SAPW and RRD

Management strategies must recognize that SAPW is direct, deadly pest but that it can vector the nematode that causes the equally deadly RRD. Because there is no effective control of the nematode, control of RRD is only possible through control of the SAPW vector (CABI 2016). A judicious integrated pest management program, including monitoring and trapping, adult mass trapping, field sanitation, prophylactic treatment, eradication of severely infested and/or diseased palms, placement of quarantines, and training and education are necessary to manage SAPW and RRD successfully. In some instances, curative pesticide applications of infested palms might be warranted.

Early detection and monitoring of SAPW populations by using kairomone- and pheromone-baited traps have been successful (Jaffe at al. 1993; Chinchilla and Oehlschlager 1992, Sánchez and Jaffe 1993). SAPW populations inside palms, though, are difficult to detect prior to lethal damage to the apical meristem; once damage is evident, it is typically too late to salvage the palm (Giblin-Davis 2001). Early detection and proper removal, destruction, and disposal of infested palms and those infected with RRD are critical management strategies to reduce SAPW populations and disease incidence (Blair 1970: Giblin-Davis 1993, 2001: Griffith 1987: Victoria et al. 1970).

Traps

Knowledge of traps and trapping strategies contributes to an overall understanding of the SAPW and is an integral part of the integrated pest management approach. Traps can be made from 11- or 19-liter plastic buckets and placed on non-palm objects (other trees, power poles, etc.) at least 60 feet from preferred hosts (**Fig. 15**). Light

Figure 15. Traps for SAPWs can be made from three- or five-gallon plastic buckets and placed on non-palm objects (other trees, power poles, etc.) at least 60 feet from preferred hosts (note the burlap cover to assist the SAPW in crawling into the trap) (D. R. Hodel).

colors are better than dark ones to limit heating from sun exposure although yellow traps appear to be the most effective (Camino-Lavín 1975). Several holes, two to three inches wide, are cut into the side of the bucket near the top. Traps placed at the perimeter and at intervals throughout the planting have shown good results (Chinchilla et al. 1993).

SAPWs typically do not fly directly into the trap but land on a nearby surface and crawl/walk into the trap. Nonetheless, holes are positioned so they are not directly opposite each other to discourage non-trapping direct fly-through. The outside of the trap is covered with burlap to assist SAPWs to crawl into the trap and to make the trap less obvious to humans and more visually acceptable in the landscape (**Fig. 15**).

Traps are typically baited with kairomone-producing foods (e.g. foods like pineapple, apples, dates, molasses, sugarcane, and even palm petioles) and commercially available pheromones. A funnel is often placed below the side holes to prevent SAPWs from crawling out. Food baits are covered with a mixture of water, non-toxic anti-freeze, and/or soap to kill and preserve trapped SAPWs for inspection (**Fig. 16**). Traps are inspected every seven days.

Although typically used to detect and monitor pest populations and for timing of insecticide applications, kairomone-producing food baits and/or aggregate pheromones to attract and capture adult SAPWs traps have proven successful in lowering pest populations (Chinchilla and Oehlschlager 1992; Dean 1979; Gentry 1988; Giblin-Davis 2001; Griffith 1987; Jaffe et al 1993; Morin et al. 1986; Moura et al. 1990, 1993; Oehlschlager et al. 1992a, 1992b; Sánchez and Jaffe 1993; Vera and Orellana 1998). Such traps are used to lure pests to traps containing delayed action biocontrol agents and/or pesticides that the visiting pests can pick up and spread about their populations and, because they are species specific, they can target an individual pest (Giblin-Davis 2001). Or, once captured, the pests can be killed with a pesticide placed in the traps (Dean 1979). For example, in Costa Rica where RRD is a problem in oil palm plantations, traps baited with an aggregation pheromone of the SAPW are placed one for every five hectares and have reduced SAPW populations in African oil palm plantations and RRD incidence (Oehlschlager et al. 1995a).

Figure 16. Food baits in traps are covered with a mixture of water, non-toxic anti-freeze, and/or soap to kill and preserve trapped SAPWs for inspection (D. R. Hodel).

Prophylactic Treatment

Contact adulticides provide preventive, prophylactic treatment, especially when palms are wounded (Giblin-Davis 2001, Giblin-Davis and Howard 1989b). Treat all CIDPs within a high-risk area immediately with an appropriate, soil-applied systemic insecticide, such as imidacloprid, dinotefuran, or similar material, at least four times a year and monitor the palm judiciously as described above. Because the soli-applied, systemic material moves somewhat slowly from the roots into the canopy, consider a foliar application at the same time as the soil application to provide immediate protection of the leaves. Injecting into palm trunks is discouraged because the resulting wounds never heal or cover over. When injection is the only alternative, injection holes must be plugged with silicon or other non-degradable plug and well covered with a tree wound sealant.

Where possible, the preferred method of foliar/canopy application is to apply the insecticide at high volume and large droplets or a drench. Thoroughly apply the material to the central leaves and leaf and petiole bases of all leaves.

Soil treatment with imidacloprid and canopy treatment with imidacloprid and dinotefuran appeared to be effective in providing prophylactic protection and even helping to eradicate the 2010 Laguna Beach infestation of *Rhynchophorus vulneratus*.

Natural Enemies

Use of natural enemies to control the SAPW is encouraging (Giblin-Davis 2001). For a recent general review of natural enemies of *Rhynchophorus* palm weevils see Mazza et al. (2014). Entomopathogenic nematodes in the Steinernematidae and Heterorhabditidae and even the bacterium *Micrococcus roseus* might be effective (Griffith 1987). Tachinid (fly) parasites *Billaea rhynchophorae* (Candia and Simmonds 1965, Moura et al. 2006) and *B. menezesi* (Moura et al. 1993) also show promise. Further investigation of a cytoplasmic polyhedrosis virus found on *Rhynchophorus ferrugineus* in India might yield promising results (Gopinadhan et al. 1990).

Cultivation Practices

While SAPWs are just as likely to attack healthy palms as stressed or weakened ones, it would be prudent to maintain palms in optimal health because such palms would likely recover from an attack more rapidly after treatment.

In CIDPs, SAPWs preferentially deposit eggs in softer tissue, such as the cut ends of leaves and other wounds and cracks. Thus, avoid making wounds, especially within a medium- or high-risk area, such as those from leaf pruning, “pineapple sculpting”, trunk peeling, and, in the case of the date palm, offshoot removal, because they open up fresh, soft, moist tissue and emit kairomones that attract SAPWs and can increase the likelihood of an infestation. Similarly, avoid the use of climbing spikes or other techniques that wound trunks and make fresh, moist tissue attractive and available to the SAPW.

Confine pruning, if it is done, to dead leaves only as this leaf tissue is not as soft and is less attractive to SAPWs. Removal of green leaves and other trimming are best performed in the late fall to winter (November to February) when adult SAPW activity is much reduced due to cool temperatures. However, cutting an inspection/treatment window into the palm canopy (as described below) in medium- and high-risk areas may be necessary and can be done at any time of the year. All wounds, regardless of the time of year, should be immediately treated with an appropriate, systemic insecticide. Consider applying a tree wound seal to remaining cut leaf base ends but a combination of insecticide and tree seal has been shown to be more effective than tree seal alone.

Avoid irrigation patterns that maintain the base of the palm trunk and leaf bases in a moist state because soft, moist tissue is more attractive to the SAPW and may facilitate infestation.

Other Concerns

The presence of wild, naturalized CIDPs along creeks, steams, washes, flood control channels, and other places with a mostly steady supply of water is of special concern. Although efforts to rid these areas of CIDPs as part of a program to return them to native vegetation have been on-going for years, significant stands of CIDPs and other palms are still present in many locales. Because these wild, naturalized stands of CIDPs are beyond the purview of nearly all managed landscapes, they serve as a potential preserve for the SAPW. These stands of palms must be eradicated or, at the least, treated for the SAPW as if they were landscape palms. Not to do so would undermine region-wide efforts to manage and eventually eradicate the SAPW.

Detecting and Managing SAPWs in Especially Valuable Landscapes

Several treatment options are available for infested palms depending on the nature of the infestation. In a relatively recent, small, confined infestation, the most appropriate action is removal and proper disposal of infested palms. In some instances, though, a judicious, vigilant program of sanitation and insecticide treatments may be warranted to protect and/or treat extremely valuable palms, especially CIDPs in high-end landscapes. Hodel et al. (2011) outlined the following procedures and tactics for managing the red palm weevil and these can be modified and applied to manage the SAPW in valuable landscape situations. Also, Ferry and Gomez (2015) proposed a new strategy involving injection of insecticide by infusion that might prove beneficial for managing the red palm weevil and that might also be adaptable for the SAPW.

It is suggested that CIDPs within a high-risk area (within 1.5 km of an officially designated infested site) be monitored weekly and those in a medium-risk area (from 1.25 to 4.5 km of an officially designated infested site) be monitored monthly. Access with a bucket truck for monitoring and treatment, if necessary, may be difficult and dangerous, and is expensive. A sufficiently tall ladder positioned at a suitable angle and securely anchored and attached to the palm may provide adequate access to the center of the canopy for many, shorter CIDPs.

However, CIDPs are often tall and have densely placed leaves, which make frequent access into the canopy to detect and/or treat difficult. Thus, if required, cut an inspection/treatment "window" into the palm canopy. To make such a "window," remove leaves as necessary, cutting as close as possible to the leaf bases, in an area 18 to 24 inches wide from the base of the canopy up to the center, vertical, spear leaves. This leaf removal results in a slot into the canopy that is sufficiently wide to accommodate a person for inspection/treatment (**Figs. 17-18**). Be careful of and cut out the basal pinnae on leaves bordering the "window" because they are rigid, long, sharp, dagger-like organs that pose a hazard to anyone entering the canopy. Treat all cut surfaces and/or the entire open area of the window with an appropriate, systemic insecticide, such as imidacloprid, dinotefuran, or similar material, to prevent new infestations of SAPW that may be attracted to the pruning wounds and with a fungicide to prevent pink rot disease (**Fig. 19**). For esthetic reasons locate inspection "windows" and permanent ladders on the

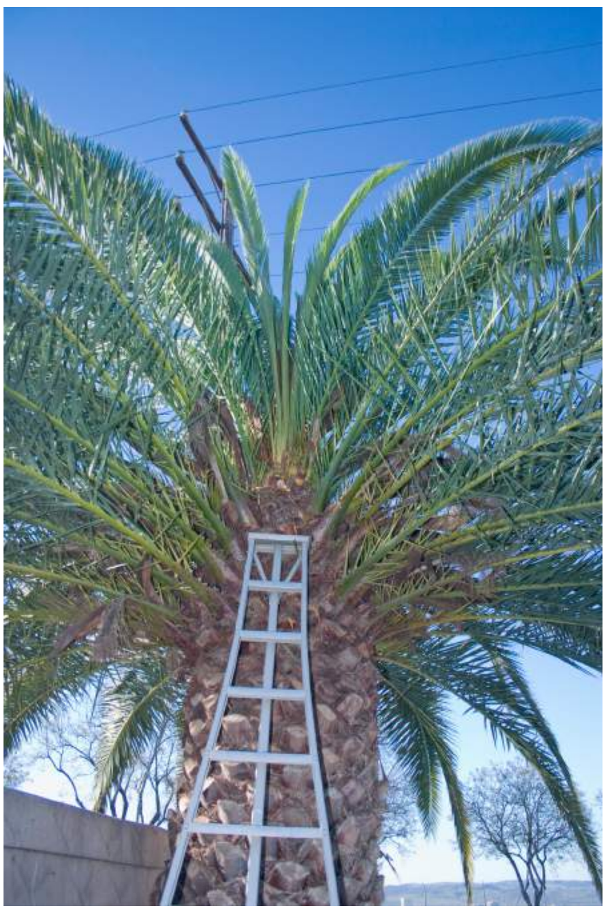

Figure 17. CIDPs are often tall and have densely placed leaves, which make frequent access into the canopy to detect and/or treat for SAPW infestations difficult. Thus, consider cutting an inspection/treatment "window" sufficiently wide to accommodate a person into the palm canopy from the base or lowest leaves up to the center, vertical, spear leaves.

Figure 18. The inspection/treatment "window" in a CIDP facilitates inspection, monitoring, and, if necessary, treatment (D. R. Hodel).

Figure 19. After making the treatment "window," treat all cut surfaces and any wounds with an appropriate, systemic insecticide to prevent new infestations of SAPW that may be attracted to the pruning wounds and with a fungicide to prevent pink rot disease (D. R. Hodel).

sides of palms where they will be less conspicuous.

Because of the presence of Fusarium Wilt disease in California, all pruning tools should be thoroughly brush cleaned and then soaked in bleach for five minutes prior to use on each palm. Chain saws are discouraged because they cannot be adequately disinfected.

A drastic procedure allowing for more in-depth inspection and treatment, the sanitation method opens up the palm canopy by complete removal of all the leaves as low and closely as possible to the base or trunk without damaging the apical meristem (**Fig. 20**). In some cases only a lower, horizontal fringe of uninfested, healthy, green leaves is retained. The apical meristem area can then be thoroughly sprayed or drenched with an appropriate insecticide and fungicide (**Figs. 21-22**). Severely opening the crown in this manner removes infested tissue, makes monitoring and detection easier, and allows for targeted insecticide and fungicide applications.

Infested palms should be treated with soil applications of an appropriate, systemic insecticide two to four times a year and foliar/canopy applications of an appropriate, systemic insecticide or a fast knock-down, contact material (frequency by label recommendation) as outlined above under Prophylactic Treatment. The most effective time to apply insecticide to the canopy is just

Figure 20. The sanitation technique, a drastic procedure for more in-depth inspection and treatment, opens up the palm canopy by removal of all leaves, thus eliminating hiding places, food, and infested tissue. Treat all cut surfaces and any wounds with an appropriate, systemic insecticide to prevent new infestations of SAPW that may be attracted to the pruning wounds and with a fungicide to prevent pink rot disease (D. R. Hodel).

Figure 21. The sanitation treatment opens up the apical meristem for targeted pesticide applications like spraying (D. R. Hodel).

Figure 22. The sanitation treatment opens up the apical meristem for targeted pesticide applications like drenching (D. R. Hodel).

Figure 23. Because entry into the canopy for frequent applications of pesticides is difficult, dangerous, and time consuming, consider the installation of a fixed, in-place pipe with spray nozzle at top attached to the trunk, starting about six feet above the ground and extending into the canopy, as here on this valuable Chilean wine palm (*Jubaea chilensis*) in Spain (D. R. Hodel).

prior to pupation as the adults and larvae tend to move closer to the surface at that time. The soil drench targets young larvae through its systemic activity while the foliar/canopy applications target adults and emerging pupae. Soil and foliar applications are both essential because as the larvae approach pupation, they may have sufficiently damaged the palm's conducting tissue that adequate transport of the soil-applied insecticide is seriously compromised and, thus, the foliar/canopy-applied contact insecticide becomes critical.

Whether treating prophylactically or for a current infestation, treatments should continue for at least three years. Because access into the dense canopy of CIDPs for frequent applications of pesticides is difficult, consider the installation of a fixed, in-place pipe with spray nozzle at top attached to the trunk, starting about six feet above the ground and extending into the canopy (**Fig. 23**). For esthetic purposes paint the pipe gray or black or other color to match the trunk color and attach it to the least visible side of the trunk. Attach a quick coupler at the lower end and an appropriate spray head/nozzle at the upper end in the canopy. With this method, applicators simply hook up at the quick coupler, apply the necessary material, drain the line back into the tank, and uncouple. This method eliminates the more expensive, time-consuming, cumbersome, and dangerous bucket truck. Continue insecticide treatment and monitoring for three years. No trapping of SAPWs or new infestations during this period would indicate control or eradication was achieved.

Insecticide treatments do not necessarily guarantee eradication of SAPW. Indeed, infested palms, even after treatment, could still be a source SAPW and sub-lethal residues from knock-down, contact insecticides, such as pyrethroids, may actually repel newly emerging adults, encouraging their dispersal to new hosts. A judicious detection and monitoring program must accompany any treatment program.

Disposal

In most cases SAPW-infested palms should be remove and disposed immediately

Figure 24. Remove an infested palm with as little cutting, grinding, and jarring as possible. Consider removing the palm in one intact unit, root ball, trunk, and canopy together, for transport to the processing/disposal site (D. R. Hodel).

when an infestation is detected; a delay in palm removal allows adults to emerge and disperse to adjacent palms (Giblin-Davis 2001). However, even removal is not 100% effective because movement of the palm during the removal process may prompt adults to fly off and/or dislodge larvae or pupae-bearing cocoons. Thus, employ the steps described below to eliminate or reduce these possibilities.

Removal activities that agitate or jar the palm may prompt SAPW adults to leave the palm and/or dislodge larvae and pupae. Thus, consider treating the crown with an appropriate insecticide prior to removal. Also, consider killing the palm with an herbicide like monosodium acid methanearsonate (MSMA) (100 to 150 ml of 48.3% active ingredient) injected into the trunk (Chinchilla 1988, Griffith and Koshy 1990) prior to removal. Remove the infested palm with as little cutting, grinding, and jarring as possible. Consider removing the palm in one intact unit, root ball, trunk, and canopy together, for transport to the processing/disposal site (**Fig. 24**).

Cover the ground around the palm with plastic sheeting to trap and collect fallen pupae or other infested debris during removal. If the lower part of the trunk and root ball is not removed, grind them out as much as possible so they are unattractive to other SAPWs. Consider treating the remnants with an appropriate insecticide.

Double wrap in plastic and tape the palm, any parts of the palm, and collected debris securely to prevent escape of adult SAPWs during transport to the approved disposal/processing site (**Fig. 25**).

At the approved disposal processing site, grind up all palm material into pieces no larger than 1 1/4 inch square (**Fig. 26**). Ground up material can be disposed of at the approved site in a covered landfill.

Quarantine regulations may specify removal and disposal procedures for specific quarantined areas. Check the California Department of food and Agriculture website for updates on quarantine status: *www.cdfa.ca.gov/phpps/.*

Figure 25. Double wrap and tape the palm, any parts of the palm, and collected debris securely to prevent escape of adult SAPWs during transport to the approved disposal/processing site (D. R. Hodel).

Figure 26. At the approved disposal processing site, grind up all palm material into pieces no larger than 1 1/4 inch square (D. R. Hodel).

Additional Information

The University of California Riverside Center for Invasive Species Research has additional information on the SAPW. Visit:

http://cisr.ucr.edu/palmarum.html

http://cisr.ucr.edu/blog/invasive-species/palmaggedon-are-california%e2%80%99s-palms-about-to-face-the-perfect-storm/

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Literature Cited

AQAS. 2011. Interception data on *Rhynchophorus*. On-line: *http://www.usda.gov/documents/APHIS_AQAS_PIA.pdf*. Accessed 1 May 2016.

Arango, G. and D. Rizo. 1977. Algunas consideraciones sobre el comportamiento de *Rhynchophorus palmarum* y *Metamasius hemipterus* en caña de azúcar. Rev. Colombiana Ent. 3(1-2): 23-28.

Blair, G. 1970. Studies on red ring disease of coconut palm. Oleagineux 25: 19-22.

Brammer, A. S. and W. T. Crow. 2005. Red Ring Nematode, *Bursaphelenchus cocophilus* (Cobb) Baujard (Nematoda: Secernentea: Tylenchida: Aphelenchina: Aphelenchoidea: Bursaphelenchus) formerly *Rhadinaphelenchus cocophilus*. Univ. Florida, I. F. A. S. Ext. Publ. EENY236.

Brathwaite, C. W. D. and M. R. Siddiqi. 1975. *Rhadinaphelenchus cocophilus*. C.I.H. Description of Plant Parasitic Nematodes, Set 5, No. 72.

CABI. 2016. *Rhynchophorus palmarum*. On-line: *http://www.cabi.org/isc/datasheet/47473*. Accessed 1 May 2016.

Camino-Lavín, M. 1975. Capture of *Rhynchophorus palmarum* (L.), a coconut palm pest in colored traps in three plant communities in Sánchez Magallanes and Paraíso, Tabasco, México. Folia Ent. Mexicana 33: 63-64.

Candia, J. D. and F. J. Simmonds. 1965. A tachinid parasite of the palm weevil, *Rynchophorus palmarum*. Comm. Inst. Biol. Control, Tech. Bull. 5: 127-128.

Chinchilla, C. M. 1988. El sindrome del anillo rojo-hoja pequeño en palma aceite y cocotera. ASD Bol. Tecnico 2: 113-136.

Chinchilla, C. M. and A. C. Oehlschlager. 1992. Capture of *Rhynchophorus palmarum* (L.) in traps baited with the male-produced aggregation pheromone. ASD Oil Palm Papers. No. 5: 1-8.

Chinchilla, C. M., A. C. Oehlschlager, and L. M. Gonzalez. 1993. Management of red ring disease in oil palm through pheromone-based trapping of *Rhynchophorus palmarum*, pp. A428-A441 *In*: PORIM International Oil Palm Conference (September). Kuala Lumpur, Malaysia.

Dean, C. G. 1979. Red ring disease of *Cocos nucifera* L. caused by *Rhadinaphelenchus cocophilus*. An annotated bibliography and review. Technical Communication No. 47 of Commonwealth Institute of Helminthology, St. Albans. Commonwealth Agricultural Bureaux.

Dusenbery, D. B. 1992. Sensory Ecology. W. H. Freeman, N. Y.

EPPO. 2005. Data sheets on quarantine pests, *Rhynchophorus palmarum*. EPPO Bulletin 35: 468-471.

EPPO. 2006. Distribution maps of quarantine pests for Europe, *Rhynchophorus palmarum*. European and Mediterranean Plant Protection Organization.

EPPO. 2007a. *Rhynchophorus ferrugineus* and *Rhynchophorus palmarum*. EPPO Bulletin 37: 571-579.

EPPO. 2007b. EPPO Plant Quarantine Retrieval System (PQR), version 4.6. European and Mediterranean Plant Protection Organization.

Esser, R. and J. Meredith. 1987. Red Ring Nematode. Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Nematology Circular No. 141. Gainesville, FL.

Fenwick, D. 1967. The effect of weevil control on the incidence of red ring disease. J. Agric. Soc. Trinidad Tobago 67: 231-244.

Ferry, M and S. Gómez. 2015. La stratégie de la dernière chance por sauver les palmier. Princeps 1: 125-134.

Genty, P. 1988. Manejo y control de plagas en palma africana. VI. Seminario sobre problemas fitopatológicos de la palm Africana. IICA-BID-Prociandino (Colombia): 101-112.

Gerber, K., and R. M. Giblin-Davis. 1990. Association of red ring nematode, *Rhadinaphelenchus cocophilus*, and other nematode species with *Rhynchophorus palmarum* (Coleoptera: Curculionidae). J. Nematology 22: 143-149.

Gerber, K., R. M. Giblin-Davies, and J. Escobar-Goyes. 1990. Association of red ring nematode, *Rhadinaphelenchus cocophilus*, with weevils from Ecuador and Trinidad. Nematropica 20: 39-49.

Giblin-Davis, R. M. 1993. Interactions of nematodes with insects, pp. 302-344 *In*: M. W. Khan (ed.), Nematode Interactions. Chapman & Hall, London.

Giblin-Davis, R. M. 2001. Borers of palms, pp. 267-304 *In*: F. W. Howard, D. Moore, R. M. Giblin-Davis, and R. G. Abad, Insects on Palms. CABI, N. Y.

Giblin-Davis, R. M. 2016. Biology and management of palm weevils. On-line: *https://cisr.ucr.edu/pdf/giblin-davis,robin-biology_and_management_of_palm_weevils.pdf*. Accessed 1 May 2016.

Giblin-Davis, R. M. and F. W. Howard. 1989a. Notes on the palmetto weevil, *Rhynchophorus cruentatus*. Proc. Flor. State Hort. Soc. 101: 101-107.

Giblin-Davis, R. M. and F. W. Howard. 1989b. Vulnerability of stressed palms to attack by *Rhynchophorus cruentatus* (Coleoptera: Curculionidae) and insecticidal control of the pest. J. Econ. Ent. 82: 1185-1190.

Giblin-Davis, R. M., N. Kanzaki, and K. A. Davies. 2013. Nematodes that ride insects: unforeseen consequences of arriving species. Florida Ent. 96: 770-780.

Giblin-Davis, R. M., A. C. Oehlschlager, A. Perez, G. Gries, R. Gries, T. J. Weissling, C. M. Chinchilla, J. E. Peña, R. H. Hallett, H. D. Pierce, and L. M. Gonzalez. 1996. Chemical and behavioral ecology of palm weevils (Curculionidae: Rhynchophorinae). Florida Ent. 79: 153-167.

Goberdhan, L. C. 1964. Observations on coconut palms artificially infested by the nematode *Rhadinaphelenchus cocophilus* (Cobb, 1919) Goodey, 1960. J. Heminthology 38: 25-30.

Gopinadhan, P. B., N. Mohandas, and K. P. Vasudaven. 1990. Cytoplasmic polyhedrosis virus infecting red palm weevil of coconut. Curr. Sci. 59: 577-580.

Griffith, R. 1968. The relationship between red ring nematode and the palm weevil. J. Agric. Soc. Trinidad Tobago. 68: 342-356.

Griffith, R. 1970. Control of red ring disease in coconut. Crop. Bul. Mist. Agric. Trinidad Tobago 17: 1-3.

Griffith, R. 1987. Red ring disease of coconut palm. Plant Disease 71(2): 193-106.

Griffith, R. and P. K. Koshy. 1990. Nematode parasites of coconut and other palms, pp. 363-385 *In*: M. Luc, , R. A. Sikora, and J. Bridge (eds.), Plant Parasitic Nematodes in Subtropical and Tropical Agriculture. C.A.B.I. Wallingford, United Kingdom.

Hagley, E. A. C. 1963. The role of the palm weevil as a vector of red ring disease of coconuts. J. Econ. Ent. 56: 375-380.

Hagley, E. A. C. 1965. On the life history and habits of the palm weevil, *Rhynchophorus palmaricum* [sic]. Ann. Ent. Soc. America 58(1): 22-28.

Hoddle, M. 2015. The palm weevil, *Rhynchophorus vulneratus*, successfully eradicated from California. UC Riverside CISP Blog. On-line: http://cisr.ucr.edu/blog/mark-hoddle/the-palm-weevil-rhynchophorus-vulneratus-successfully-eradicated-from-california/. Accessed 1 May 2016.

Hodel, D. R. 2009a. Palms in the landscape, Part 4. Palm diseases and their management, Part I. West. Arb. 35(1): 20-28.

Hodel, D. R. 2009b. Palms in the landscape, Part 5. Palm diseases and their management, Part II. West. Arb. 35(2): 20-27.

Hodel, D. R. 2010a. Palms in the landscape, Part 8. Abiotic disorders: nutrition and fertilizers, Part I. West. Arb. 36(1): 20-30.

Hodel, D. R. 2010b. Palms in the landscape, Part 8. Abiotic disorders: nutrition and fertilizers, Part II. West. Arb. 36(2): 20-29.

Hodel, D. R. 2010c. Palms in the landscape, Part 8. Abiotic disorders, 3: non-nutrient disorders, Part I. West. Arb. 36(3): 20-30.

Hodel, D. R. 2010d. Palms in the landscape, Part 8. Abiotic disorders, 3: non-nutrient disorders, Part II. West. Arb. 36(4): 20-30.

Hodel, D. R., C. A. Wilen, and N. Nisson. 2011. The red palm weevil: a devastating pest and serious threat to palms in California and the desert southwest. West. Arb. 37(2): 34-50.

Jaffé, K. and P. Sánchez. 1990. Informe final. Proyecto para el studio etólogico de R. palmarum. Universidad Simón Bolivar-FONAIAP. Caracas.

Jaffé, K., P. Sánchez, H. Cerda, N. Urdaneta, J. V. Hernández, J. V. Guerra, R. Jaffé, R. Martínez, and B. Miras. 1993. Chemical ecology of the palm weevil *Rhynchophorus palmarum* (L.)

(Coleoptera: Curculionidae): attraction to host plants and to male-produced aggregation pheromone. J. Chem. Ecol. 19: 1703-1720.

Mazza, G., V. Francardi, S. Simoni, C. Benventuuti, R. Cervo, J. R. Faleiro, E. Llácer, S. Longo, R. Nannelli, E. Tarasco, and P. F. Roversi. 2014. An overview on the natural enemies of *Rhynchophorus* palm weevils, with focus on *R. ferrugineus*. Bio. Control 77: 83-92. On-line: *https://www.senato.it/application/xmanager/projects/leg17/attachments/documento_evento_procedura_commissione/files/000/002/350/Articolo_scientifico_CRA.pdf*.

Molet, T., A. L. Roda, L. D. Jackson, and B. Salas. 2011. CPHST Pest Datasheet for *Rhynchophorus palmarum*. USDA-APHIS-PPQ-CPHST. On-line: *https://www.aphis.usda.gov/plant_health/plant_pest_info/palmweevil/downloads/Rhynchophoruspalmarum_v5.pdf*. Accessed 1 May 2016.

Mora, L. S., H. Calvache, and M. Avila. 1994. Diseminación de *Rhadinaphelenchus cocophilus* (Cobb) Goodey, agente casual del anillo rojo-hoja corta de la palms de aceite en San Carlos de Guaroa (Meta). Palmas (Colombia) 15: 15-27.

Morin, J. P, A. A. C. Lucchini, J. M. S. Ferreira, and L. S. Fraga. 1986. Control de *Rhynchophorus palmarum* (L.) mediante trampas construidas por pedazos de palma. Oleagineux 41: 61-63.

Moura, J. I. L., D. Mariau, and J. H. C. Delabie. 1993. Efficacy of *Paratheresia menezesi* Townsend (Diptera: Tachinidae) for natural biological control of *Rhynchophorus palmarum* L. (Coleoptera: Curculionidae). Oleagineux 48: 219–223.

Moura, J. I. L., M. L. V. de Resende, J. M. S. Ferreira, and D. Santana. 1990. Táticas para o controle integrado de *R. palmarum* (L.). Bol. Tec. CEPLEC, Brasil.

Moura, J. I. L., R. Toma, R. B. Sgrillo, and J. H. C. Delabie. 2006. Natural efficiency of parasitism by *Billaea rhynchophorae* (Blanchard) (Diptera: Tachinidae) for the control of *Rhynchophorus palmarum* (L.) (Coleoptera: Curculionidae). Neotrop. Ent. 35: 273–274.

NAPPO (North American Plant Protection Organization). 2011. Detection of South American palm weevil (*Rhynchophorus palmarum*) in California. Phytosanitary Alert System. On-line: *http://www.pestalert.org/oprDetail.cfm?oprID=495*. Accessed 1 May 2016.

NAPPO (North American Plant Protection Organization). 2012. Detection of South American palm weevil (Rhynchophorus palmarum) in Texas. Phytosanitary Alert System. On-line: *http://www.pestalert.org/oprDetail.cfm?oprID=519*. Accessed 1 May 2016.

NAPPO (North American Plant Protection Organization). 2015. Detection of South American palm weevil (*Rhynchophorus palmarum*) in Arizona. Phytosanitary Alert System. On-line: *http://www.pestalert.org/oprDetail.cfm?oprID=626*. Accessed 1 May 2016.

Nickle, W. R. 1970. A taxonomic review of the genera of the Aphelenchoidea (Fuchs, 1937) Thorne, 1949 (Nematoda: Tylenchida). J. Nematology 2(4): 375-392.

Oehlschlager, A. C., C. M. Chinchilla, and L. M. Gonzalez. 1992a. Management of the American palm weevil *Rhynchophorus palmarum* and the red ring disease in oil palm by pheromone-based trapping. ASD Oil Palm Paper. No. 5: 15-23.

Oehlschlager, A. C., H. D. Pierce, B. Morgan, P. D. C. Wimalaratne, K. N. Slessor, G. G. S. King, G. Gries, R. Gries, J. H. Borden, L. F. Jiron, C. M. Chinchilla, and R. Mexon. 1992b. Chirality and field testing of rhynchophorol, the aggregation pheromone of the American palm weevil *Rhynchophorus palmarum* (L.). Naturwissenschaften 79: 134-135.

Oehlschlager, A. C., R. S. McDonald, C. M. Chinchilla, and S. N. Patschke. 1995. Influence of a pheromone-based trapping system on the distribution of *Rhynchophorus palmarum* (Coleoptera: Curculionidae) in oil palm. Env. Ent. 24: 1004-1012.

Poplin, A., A. Roda., S. Bhotika, and L. Sobel. 2013. Palm weevils. On-line: *http://entnemdept.ifas.ufl.edu/hodges/Collaborative/Documents/Palm_weevils.pdf*. Accessed 1 May 2016.

Restrepo, L., F. Rivera, and J. Raigosa. 1982. Ciclo de vida, hábitos y morfometrfa de *Metamasius hemipterus* Oliver y *Rhynchophorus palmarum* L. (Coleóptera: Curculionidae) en caña de azúcar (*Saccharum officinarum*) Acta Agron. 32: 33-44.

Rugman-Jones, P. F., C. D. Hoddle, M. S. Hoddle, and R. Stouthamer. 2013. The lesser of two weevils: moleculargenetics of pest palm weevil populations confirm *Rhynchophorus vulneratus* (Panzer 1798) as a valid species distinct from *R. ferrugineus* (Oliver 1790), and reveal the global extent of both. PLOS One 8 (10): 1-15.

Sánchez, P. A. and H. Cerda. 1993. El complejo *Rhynchophorus palmarum* L. (Coleóptera: Curculionidae) - *Bursaphelenchus cocophilus* (Cobb) (Tylenchida: Aphelenchoididae), en palmeras. Bol. Ent. Venezolana 8(1): 1-18.

Sánchez, P. A. and K. Jaffé. 1993. Monitereo y control integrado del picudo del cocotero: plaga de palma aceitera. Bol. Tecnico FONIAP Ser. B.

Sánchez, P. A., K. Jaffé, J. V. Hernández, and H. Cerda. 1993. Biología y comportamiento del picudo del cocotero *Rhynchophorus palmarum* L. (Coleóptera: Curculionidae). Bull. Ent. Venezolana 8(1): 83-93.

Sullivan, M. 2013. CPHST Pest Datasheet for *Bursaphelenchus cocophilus*. USDAAPHIS-PPQ-CPHST. On-line: *https://www.aphis.usda.gov/plant_health/plant_pest_info/palmweevil/downloads/RedRingNematodeFactSheet.pdf*. Accessed 1 May 2016.

Thomas, M. C. 2010. Pest Alert. Giant Palm Weevils of the Genus *Rhynchophorus* (Coleoptera: Curculionidae) and their Threat to Florida Palms. DACS-F-01682. Florida Dept. Agric. Consumer Services, Div. Plant Industry.

Thurston, H. 1984. Red ring disease of coconut, pp. 161-164 *In*: American Phytopathological Society Tropical Plant Diseases. American Phytopathological Society, St. Paul, MN.

USDA-APHIS PPQ. 2010. New Pest Response Guidelines Red Palm Weevil *Rhynchophorus ferrugineus*. On-line: *https://www.aphis.usda.gov/import_export/plants/manuals/emergency/downloads/nprg-redpalmweevil.pdf*. Accessed: 1 May 2016.

USDA-APHIS PPQ. 2011. Detection of South American Palm Weevil (*Rhynchophorus palmarum*) in California. Letter to State Plant Regulatory Officials.

USDA-APHIS PPQ. 2012. Detection of South American Palm Weevil (*Rhynchophorus palmarum*) in Texas. Letter to State Plant Regulatory Officials.

USDA-APHIS PPQ. 2015. South American palm weevil detected in Arizona. On-line: *content.govdelivery.com/accounts/USDAAPHIS/bulletins/10e9519*. Accessed 1 May 2016.

Vera, D. and F. Orellana. 1988. Combate de la gualpa *Rhynchophorus palmarum* en plantaciones de cocotero y palma africana, mediante la captura con trampa del insecto adulto. Bol. Tecnico Inst. Nac. Invest. Agrop (Ecuador).

Victoria, K., P. A. Sánchez, and O. Barriga. 1970. Erradicación de palmas de cocotero afectadas por el anillo rojo *Rhadinaphelenchus cocophilus* (Cobb, 1919). Rev. Inst. Colombiano Agrop 5(3): 185-197.

Wattanapongsiri. A. 1966. A revision of the genera *Rhynchophorus* and *Dynamis* (Coleoptera: Curculionidae). Dept. Agric. Sci. Bull. Bangkok 1: 1-328.

Weissling, T. J. and R. M. Giblin-Davis. 1994. Fecundity and fertility of *Rhynchophorus cruenatus* (Coleoptera: Curculionidae). Florida Ent. 77: 75-78.

Donald R. Hodel is landscape horticulture advisor for the University of California Cooperative Extension in Los Angeles. *drhodel@ucanr.edu*.

Michael A. Marika is arborist for the city of San Diego Park & Recreation. *MMarika@sandiego.gov.*

Linda M. Ohara is a biology sciences lab technician at El Camino College in Torrance, CA, a horticulturist, and a former nurserywoman. *lohara@elcamino.edu*.