Proceedings of the Caribbean Food Crops Society. 46(1): 87-96. 2010

THE RED PALM WEEVIL, *RHYNCHOPHORUS FERRUGINEUS*, A NEW PEST THREAT IN THE CARIBBEAN: BIOLOGY AND OPTIONS FOR MANAGEMENT…

Moses T.K. Kairo[1], Amy Roda[2], Richard Mankin[3], Wayne De Chi[4], Teophilo Damian[5], Facundo Franken[5], Kenny Heidweiller[5], Clinton Johanns[5], and Jorge Leon[6].
[1]Center for Biological Control, Florida A&M University, Tallahassee, FL 32307-4100, Moses.Kairo@FAMU.EDU; [2]USDA-APHIS-CPHST, Miami, FL; [3]USDA-ARS-CMAVE, Gainesville, FL; [4]USDA-APHIS-IS, Port of Spain; [5]DLVV-Aruba, DLVV-Curacao; [6]USDA-APHIS-IS, Caracas, Venezuela

ABSTRACT. The red palm weevil (RPW) *Rhyncophorus ferrugineus*, is a serious pest of palms. RPW is native to Asia, but over the last few decades it has spread to the Middle East, Africa, and Europe, where it has caused major economic damage. This pest was accidentally introduced to the Caribbean (Curacao and Aruba) probably around 2008 through trade in ornamental palms. In these localities, the pest has caused considerable damage and death to several palm species, and it now poses a serious threat to the rest of the region. This paper provides a brief summary of the current knowledge of the pest with particular reference to the neotropics.

INTRODUCTION

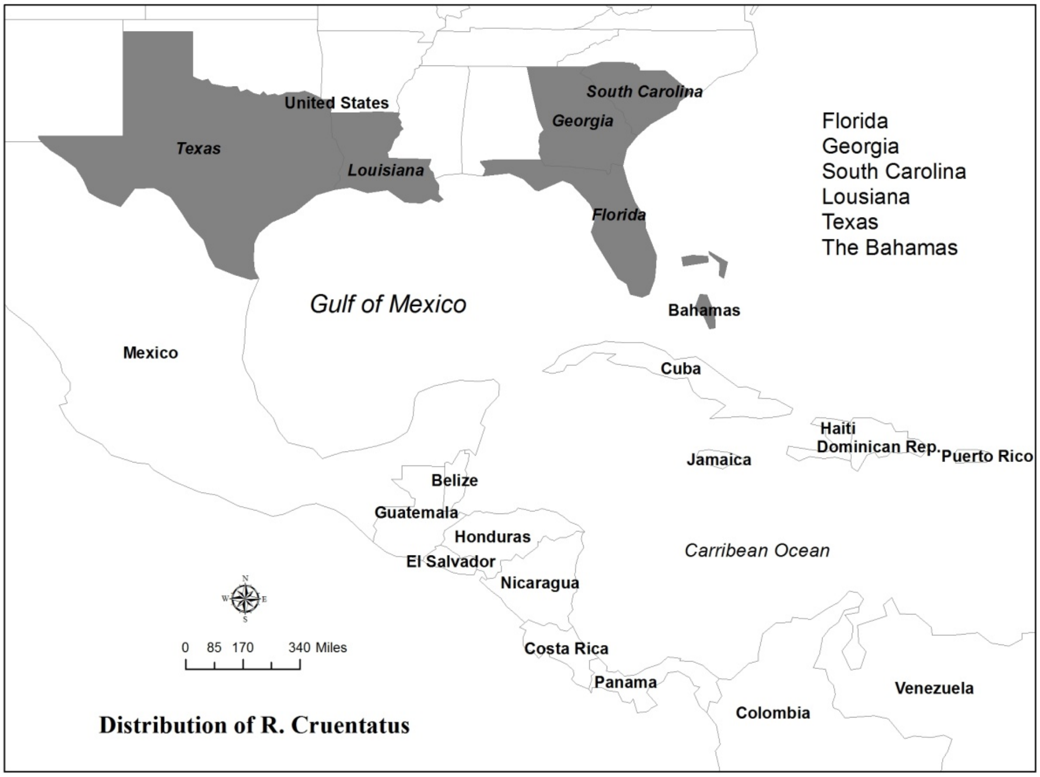
Palms in their various guises are a central feature of the landscape in most countries in the Caribbean basin where they play a multifunctional role. For many people, the archetype of the Caribbean as a tourist destination is beautiful landscapes of palms, sand, and water. There are many species of palms in the Caribbean, but perhaps the most obvious are coconut palms. Not surprisingly, palms are an important feature in most tourist amenity and residential areas. The importance of coconut palms (Arecaceae: *Cocos nucifera* L.) has increased considerably in recent times. An article in Fortune magazine (June 14, 2010) stated that during the previous two years, sales of coconut water had more than doubled to US$60 million. While there has been no comprehensive assessment of the economic impact of palms, it is clear that this is highly significant. In recent years, palms have been facing several new pest/disease threats such as lethal yellowing (causal agent: mycoplasma-like organism), red palm mite (*Raoiella indica* Hirst), and spiraling whitefly (*Aleurodicus dispersus* [Russell]), among others. The most recent threat, however, is posed by red palm weevil (RPW), *Rhyncophorus ferrugineus*, an Asian species that was first reported in the Western Hemisphere in Curacao about two years ago. The genus *Rhyncophorus* is comprised of at least ten types of fairly large weevils, two of which are native to the neotropics; *R. cruentatus and R. palmarum.*

Distribution and Pest Status of Neotropical *Rynchoporus*

Rhyncophorus cruentatus

The distribution of *R. cruentatus* includes parts of the southern United States and the Bahamas. Its native host is *Sabal palmetto*, but it seems to attack mainly wounded or dying palms. Occasionally, this species can be a severe nursery pest of *Phoenix canariensis* in Florida (Hunsberger et al. 2000). Other recorded hosts include *Bismarckia nobilis, Washingtonia sp., Serrenoa repens, P. dactylifera, Pritchardia* sp., *Roystonea* sp., *Cocos nucifera, Latania sp., Caryota* sp., and *Thrinax radiate.*

Figure 1. Distribution of *Rhynchophorus cruentatus* (after Hunsberger et al., 2000)



Rhynchophorus palmarum

Rynchophorus palmarum has been reported as a pest on palms and sugarcane (EPPO 2005). The species is a vector of the nematode, *Bursaphelenchus cocophilus,* which causes red-ring disease of palms. The species has a wide host range which includes 35 plant species in 12 different families. It is, however, found predominantly on Arecaceae. Among the key hosts are *Cocos nucifera, Elaeis guineensis, Euterpe edulis, Metroxylon sagu, Phoenix canariensis, Phoenix dactylifera, Saccharum offi cinarum. Rhyncophorus palmarum* is widely distributed in the neotropics

Red Palm Weevil (RPW) *Rhynchophorus ferrugineus*

Distribution and appearance of RPW in the Western Hemisphere

RPW probably arrived in the Dutch Antilles in 2008, but the earliest documented reports go back to the beginning of 2009 (EPPO 2009). It appears likely that the weevil was brought in on mature palms imported from Egypt by the landscaping industry. RPW is native to tropical Asia but over the last two to three decades, the pest has spread to the Middle East, Africa, and the Mediterranean, including the Canary Islands (EPPO 2008, 2009). RPW has a long history, and research and management efforts have been ongoing for the last century. Most of the earlier work was recently reviewed by Faleiro (2006) and USDA/APHIS (2010), and the account summarized below is largely derived from these publications unless stated otherwise. The specific focus of this summary is information that is of relevance to the Caribbean.

Figure 2. Distribution of *Rhynchophorus palmarum* (after EPPO, 2005)

Host plants

According to Esteban-Duran et al. (1998), RPW has been recorded on at least 17 palm species including: *Areca catechu*, *Arenga pinnata, Borassus flabellifer, Caryota maxima, C. cumingii, Cocos nucifera, Corypha gebanga, C. umbraculifera, C. elata, Elaeis guineensis, Metroxylon sagu, Oreodoxa regia, Phoenix canariensis, P. dactylifera, P. sylvestris, Sabal umbraculifera, Washingtonia sp.* In the Caribbean, the pest has been reported on at least seven palm species but the most seriously affected are *Phoenix canariensis* and *P. dactylifera* (Table 1).

Table 1. Host plant list of the red palm weevil in the Caribbean.

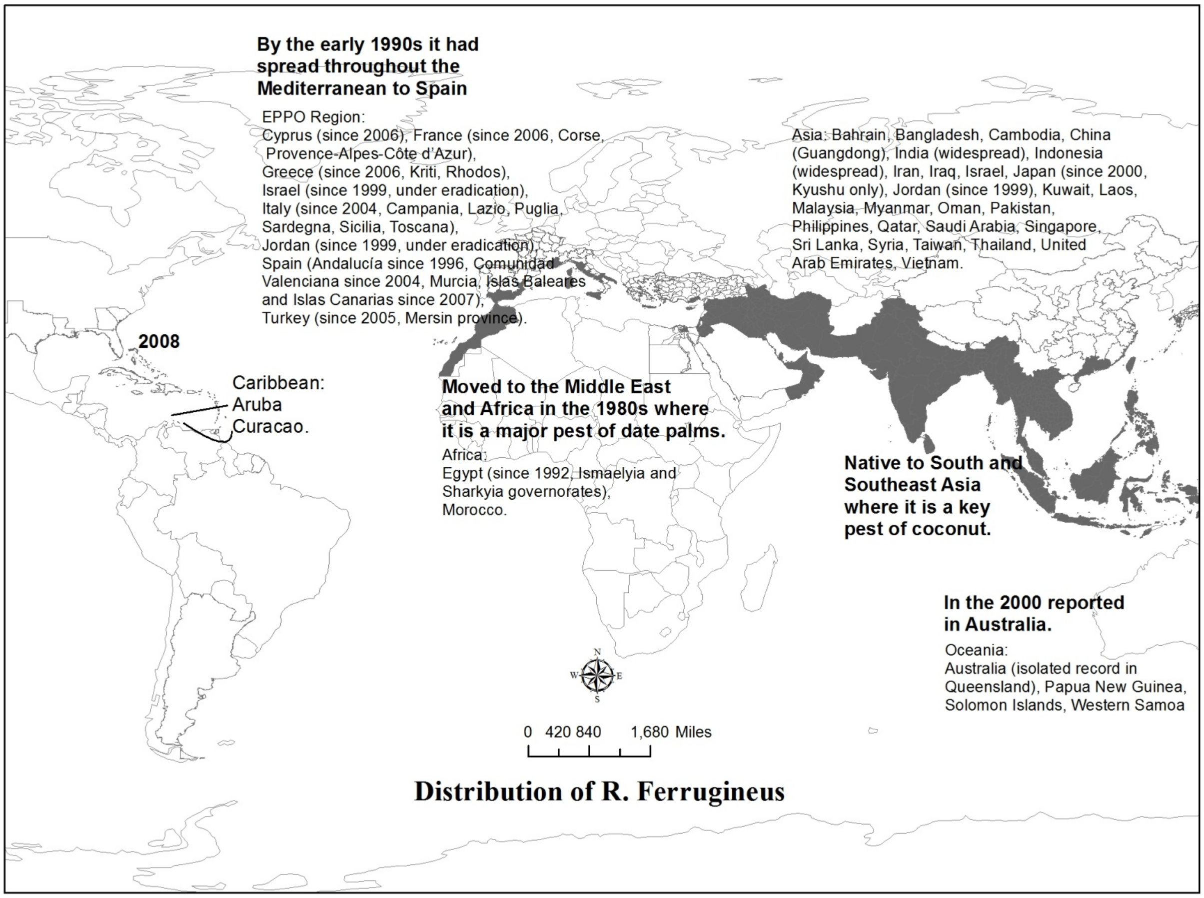
Host Plant Species	Status
Phoenix dactylifera	Highly attacked
Phoenix sylvestris	Highly attacked
Cocos nucifera	Reported

Note: Weevil larvae have been found in *Bismarckia nobilis, Washingtonia robusta, Pritchardia pacifica, Dictyosperma album*, but these have not been identified to species.

Developmental and reproductive biology

Faleiro (2006) reviewed a range of previous studies which are used as the basis for the summary below, but more recent studies have also been conducted in Spain (Dembilio and Jacas 2011). Females lay 58–531 eggs which undergo a 1–6 days incubation period. Larval and pupal development ranges from 25–105 and 11–45 days, respectively. The overall lifecycle may last from 45–139 days while adults can live for 2–3 months. The number of reported generations per year varies considerably, with reports ranging 3–21 per year.

Figure 3. Distribution of *Rhynchophorus ferrugineus* (after EPPO, 2008, 2009).



Dispersal and spread

Long-distance spread of RPW is mainly through the palm trade. The introduction of the pest to the Netherlands Antilles is strongly linked to the importation of mature palms from Egypt. Based on this information, it is imperative that care is taken when importing material from regions where the pest is present. Adult weevils are also attracted to ripening fruits, which raises the possibility of them hitch-hiking. This can be important in situations where there is high boat traffic involving inter-island or island/continent fruit and vegetable traders. Such trade is for instance common between Curacao and Venezuela. At the local level, adults can fly up to 1 km per day.

Options for control

As a pest that has become established in areas outside its native range, classical biological control would seem like a logical solution. However, to-date, no studies have shown promise using this approach (USDA/APHIS 2010; Faleiro 2006). Thus efforts have been focused on development and implementation of Integrated Pest Management (IPM). For instance, in India, RPW has been successfully managed on coconut using IPM since the mid-1970s. More recently, successful IPM programs have been implemented in the Middle East for date palms. In Spain

(Canary Islands), recent years have shown good promise with eradication, although these efforts are ongoing (Jacas personal communications). The essential components of IPM include early detection of infestations, and use of a variety of approaches such as, trapping, sanitation, chemical control, biological control, and education and outreach.

Detection of early infestations: The ability to detect early stage infestations of RPW is critical for the effective implementation of IPM. As an internal feeder, symptoms of RPW may not be immediately obvious and by the time they become apparent, it may be too late to take remedial action. Among the damage symptoms to look out for are gnawing sound due to larvae feeding, notched and deformed fronds, oozing out of thick brown fluid from the tunnels, appearance of frass with a typical fermented odor, drooping fronds/yellowing, pupal cases and dead adults, and in advanced infestations the trunk may break and the crown may topple. It is noteworthy that in contrast to what commonly happens in the Middle East where infestations commonly occur on the trunk near the ground, in the Caribbean RPW infestation are most commonly found attacking the crown. Infestations have been noticed on the trunk near the ground but these are relatively rare and are associated with very humid conditions (irrigation).

Considerable effort has been made to develop tools to assist in the detection of early infestations. Such tools have typically been based on the detection of sound made by feeding larvae or on olfactory detection of infestations using sniffer dogs (Mankin et al. 2011; Siriwardena et al. 2010; Faleiro 2006).

Trapping: Trapping is used for monitoring infestations and control through adult trapping. RPW trapping is based on the use of pheromone-based lures (comprised of a male aggregation pheromone made up of two molecules, 4-methyl-5-nonanol and 4-methyl-5-nonanone) and host-based lures (ethyl acetate and/or food baits such as sugarcane, apples, palm pieces, or dates).

Sanitation: Sanitation is a crucial component of any management program. When palms are severely infested, the solution is often to cut down the plants. Because weevils will continue to emerge from infested palms even after they are cut down, it is important that such material is disposed of properly so that they do not remain a source of infestation. This can be done by burning, chipping the material into small bits, or deep burial of the material. When chipping the material, this should be done to a size that is smaller than the typical pupa.

Chemical control: Insecticides are a critical component of IPM programs and these may be used for preventative or curative treatments (USDA/APHIS 2010; Faleiro 2006). Both contact and systemic pesticides are used. The latter are particularly critical in order to target the internally feeding larvae. Careful considerations should be made where material may be harvested for human consumption. Depending on the product, several application methods have been used, including sprays, ground drenches, and tree injections.

Biological control: Recent efforts have examined the use of biopesticides based on the nematode *S. carpocapsae* (Llacer et al. 2009; Dembilio et al. 2009). A product, Biorend^{R}, which is comprised of the nematode+ Chitosan (N-acetyl-glucosamine), has been registered. The literature also includes fungal-based biopesticides although it is unclear how effective these are. In the Netherlands Antilles, some fungal-based products were being recommended for application by injection.

Public awareness: In the Caribbean, RPW is mainly a pest of amenity and is often found in residential areas where palms are grown as ornamentals. Education and outreach components are therefore vital to the success of any management program. The audiences are typically, government officials, hotels, commercial nurseries, and homeowners. The purpose of such campaigns is typically to increase awareness of the serious economic impact of RPW by providing information on the necessary actions to mitigate the risks of re-importing or spreading the pest and on preventative and/or management actions, including proper use of pesticides.

Current status in Curacao and Aruba

Our ongoing work in Curacao and Aruba has been focused on the following elements: assessing the current distribution and impact of RPW, implementing a pilot monitoring/surveillance program, conducting critical applied research to validate relevant technologies, developing new pest response guidelines, and providing assistance in the development and implementation of a long-term management response.

CONCLUSIONS

RPW is a serious threat to the Caribbean, so it is imperative that a cooperative regional effort is developed to address the problem. There is a strong need for increased public awareness across the region and preparation of detailed contingency plans for the management of the pest should it spread beyond its current distribution. Part of the problem is that some of the countries in the region have inadequate, or lack appropriate, legislation to allow implementation of appropriate phytosanitary measures. It will therefore be important for policy makers to address this challenge in order to effectively deal with invasive species in general. Given the results that are being achieved in the Canary Islands, it seems reasonable to consider the possibility of eradicating RPW in the affected Caribbean islands. Such a program would be beneficial to the rest of the region as it would minimize the risk of spread. However, to ensure success, the program would need to be carefully planned and adequately resourced.

ACKNOWLEDGMENTS

We thank our collaborators from USDA/APHIS/PPQ/CPHST; USDA/APHIS/GCSI; USDA/APHIS/IS; USDA/ARS/CMAVE; Curacao DLVV; Aruba DLVV; and to members of AHATA, CHATA, Fantastic Gardens, and Professional Pest Control for providing critical information The work is being funded through a cooperative agreement between FAMU and USDA/APHIS and through U.S. Farm Bill Section 10201 funding.

REFERENCES

Dembilio, Ó. and J. Jacas. 2011. Basic bio-ecological parameters of the invasive Red Palm Weevil,*Rhynchophorus ferrugineus* (Coleoptera: Curculionidae), in *Phoenix canariensis* under Mediterranean climate. *Bulletin of Entomological Research* 101: 153-163

Dembilio, O., E. Llacere, M. Martinez De Altube, and J. Jacas, 2009. Field efficacy of imidacloprid and *Steinernema carpocapsae* in a chitosan formulation against the red palm weevil *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae) in *Phoenix canariensis*. *Pest Management Science* 66: 365-370.

EPPO. 2008. Data sheets on quarantine pests—*Rhynchophorus ferrugineus*. *OEPP/EPPO Bulletin* 38: 55-59.

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

EPPO. 2009. First record of *Rhynchophorus ferrugineus* in Curaçao, Netherlands Antilles. Pests & Diseases 2009/02. EPPO Reporting Service, Paris, France. http://archives.eppo.org/EPPOReporting/2009/Rse-0901.pdf.

Esteban-Duran, J., J. Yela, C. Beitia, and A. Jimenez. 1998. Biology of red palm weevil, *Rhynchophorus ferrugineus* (Olivier) Coleoptera: Curculionidae: Rhynchophorinae. *Boletin de Sanidad Vegetal Plagas* 24: 737-748.

Faleiro, J. 2006. A review of the issues and management of the red palm weevil *Rhynchophorus ferrugineus* (Coleoptera: Rhynchophoridae) in coconut and date palm during the last one hundred years *International Journal of Tropical Insect Science* 26(3): 135, 154.

Hunsberger, A., R. Giblin-Davis, and T. Weissling. 2000. Symptoms and population dynamics of *Rhynchophorus cruentatus* (Coleoptera: Curculionidae) infestation in Canary Island date palms. *Florida Entomologist* 83(3): 290-303.

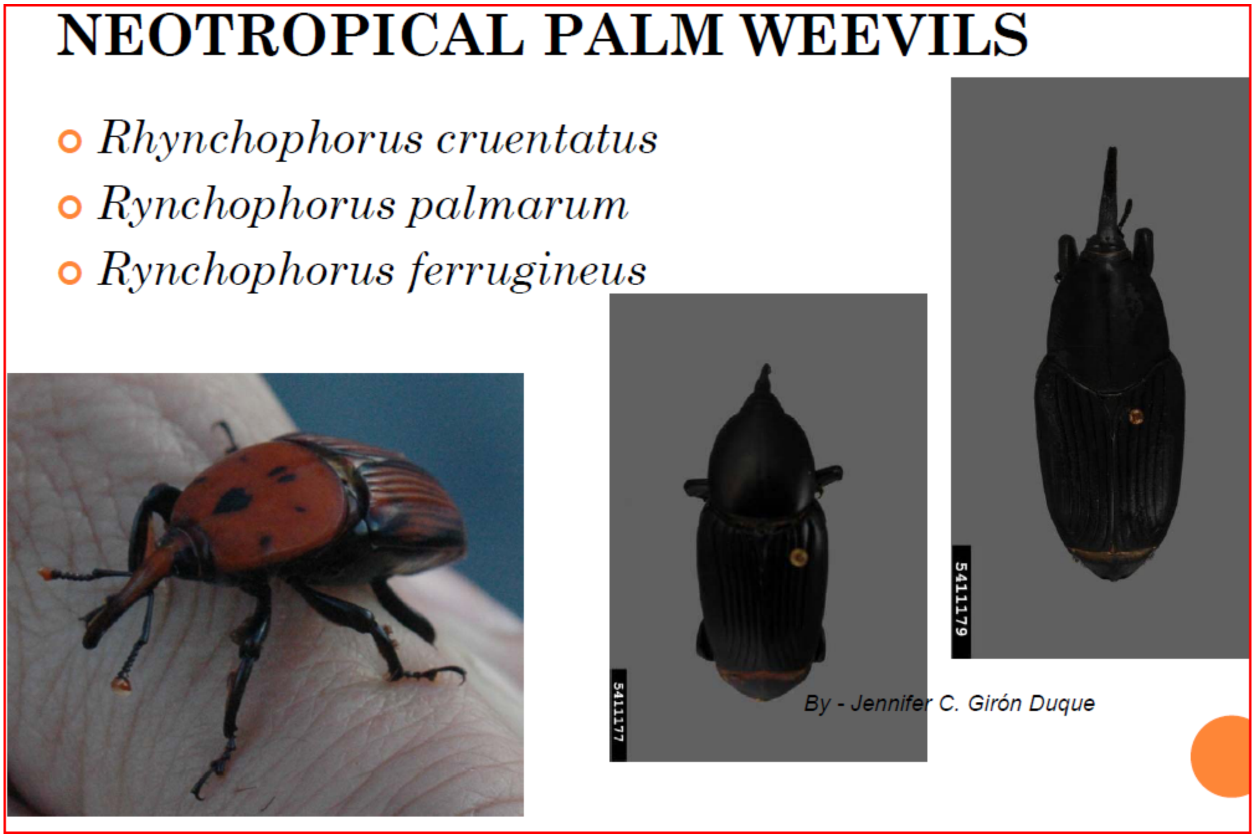
Llacer, E., O. Dembilio, and J. Jacas. 2010. Evaluation of the efficacy of an insecticidal paint based on chlorpyrifos and pyriproxyfen in a micro-encapsulated formulation against the red palm weevil, *Rhynchophorus ferrugineus*. *Journal of Economic Entomology* 103: 402-408.

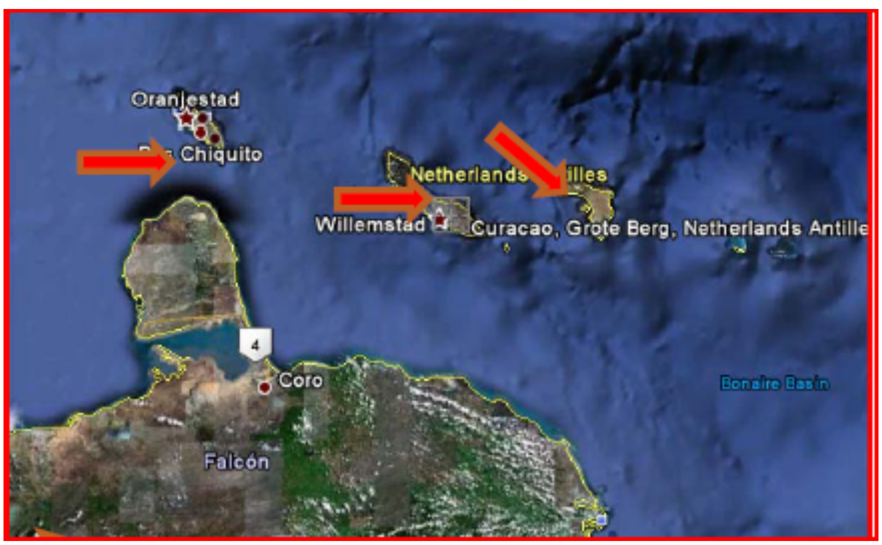
Llacer, E., M. Martinez De Altube, and J. Jacas. 2009. Evaluation of the efficacy of *Steinernema carpocapsae* in a chitosan formulation against the red palm weevil, *Rhynchophorus ferrugineus* in *Phoenix canariensis*. *BioControl* 54: 559-565.

Mankin, R., D. Hagstrum, M. Smith, A. Roda, and M. Kairo. 2011. Perspective and promise: a century of insect acoustic detection and monitoring. *American Entomologist* 57(1): 30-44.

Siriwardena K., L. Fernando, N. Nanayakkara, K. Perera, A. Kumara, and T. Nanayakkara. 2010. Portable acoustic device for detection of coconut palms infested by *Rynchophorus ferrugineus* (Coleoptera: Curculionidae). *Crop Protection* 29: 25–29

USDA/APHIS, 2010. New Pest Response Guidelines: Red Palm Weevil *Rhynchophorus ferrugineus.* United States Department of Agriculture, Animal and Plant Health Inspection Service, Washington, D.C.

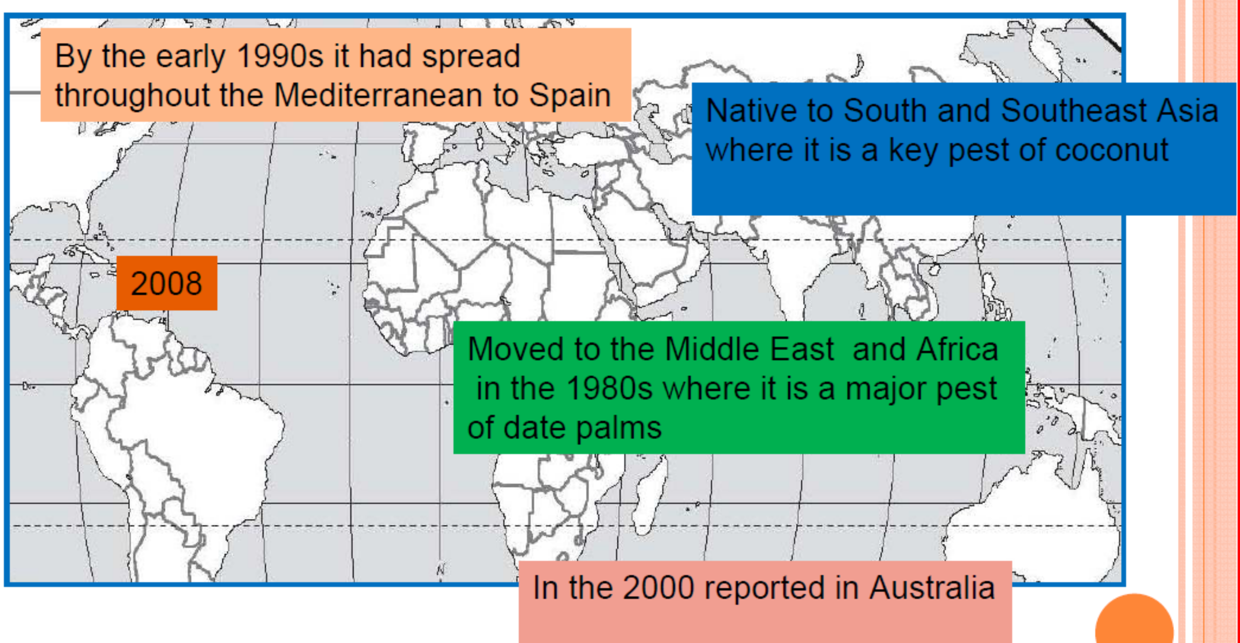




Netherlands Antilles infested with Red Palm Weevil.

RED PALM WEEVIL
RHYNCHOPHORUS FERRUGINEUS

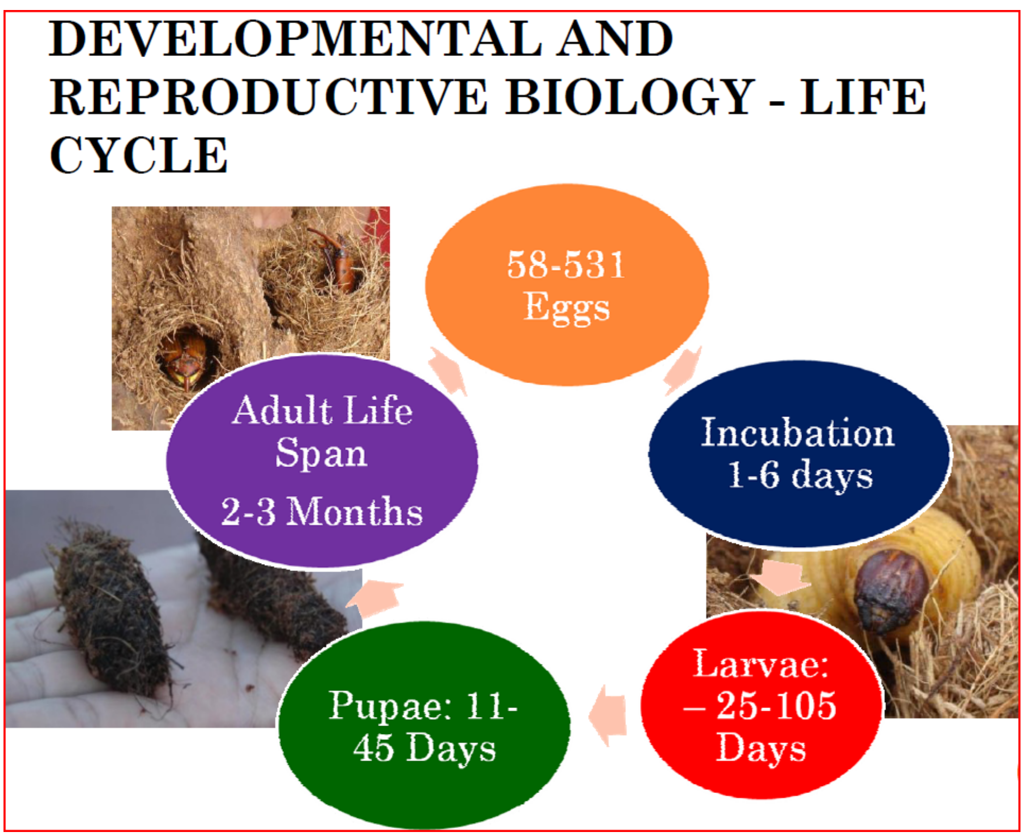
ORIGIN AND DISTRIBUTION



*OEPP/EPPO, 2008, Bulletin OEPP/EPPO Bulletin **38** , 55–59*

The inexeoable spread of the Red Palm Weevil.

Damage to valuable palms near resort hotels caused by the Red Palm Weevil in the Netherlands Antiles.



Proceedings of the Caribbean Food Crops Society. 46(1): 97-106. 2010

LAUREL WILT: A DANGEROUS NEW DISEASE OF AVOCADO IN THE WESTERN HEMISPHERE

Randy C. Ploetz[1], José M. Pérez-Martínez[1], Jason A. Smith[2], Marc Hughes[2], Tyler Dreaden[2], Robert Blanchette[3], Benjamin Held[3], and Sharon A. Inch[1]
[1]University of Florida, Department of Plant Pathology, Tropical Research & Education Center, 18905 SW 280th Street, Homestead, FL 33031-3314 USA; [2]University of Florida, School of Forest Resources and Conservation, 134 Newins-Ziegler Hall, P.O. Box 110410, Gainesville, FL USA 32611-0410; and [3]University of Minnesota, Department of Plant Pathology, 495 Borlaug Hall, 1991 Upper Buford Circle, St. Paul, MN 55108-6030 USA.
Direct correspondence to RCP: Phone: 305-246-7000; E-mail: kelly12@ufl.edu

ABSTRACT: Laurel wilt kills American members of the Lauraceae plant family, including avocado (*Persea americana*). The disease is caused by a recently described fungus, *Raffaelea lauricola*, and is vectored by an ambrosia beetle from Asia, *Xyleborus glabratus*. Responses to laurel wilt were determined for 22 cultivars of avocado that are grown in Florida. Those with a West Indian pedigree (they are most important in Florida and the Dominican Republic) were most susceptible. *In vitro* and *in planta* studies were conducted to identify effective fungicides. Several chemistries impacted the fungus *in vitro*, but only demethylation inhibitors and thiabendazole provided significant disease control in greenhouse trials. Field investigations are underway to achieve high xylem concentrations of an effective triazole, propiconazole. Although it will be difficult to control this disease by managing *X. glabratus*, insecticides and repellents are also being examined, as are attractants for attract and kill strategies.

Avocado responds to infection by *R. lauricola* by accumulating phenolic substances and producing tyloses in vessel elements, typical host defense responses. Diagnostic PCR primers for the small subunit (SSU) ribosomal DNA of *R. lauricola* were developed and used with traditional and realtime PCR; they have enabled the sensitive detection and localization of *R. lauricola* in artificially inoculated plants, and have been valuable tools in studies on host:pathogen interactions, fungicidal control, epidemiology, and resistance. A species-specific diagnostic tool, now under development, will play an important role in laurel wilt interdiction and laurel wilt management in avocado production areas via sanitation. Early detection of the pathogen and disease are needed for quarantine, eradication, and sanitation efforts.

Key Words: *Raffaelea lauricola, Xyleborus glabratus*, redbay ambrosia beetle, avocado, *Persea americana*, quarantine, detection, sanitation, eradication

INTRODUCTION

In May 2002, an exotic ambrosia beetle, *Xyleborus glabratus*, was trapped at Port Wentworth, a maritime port outside Savannah, Georgia, USA (Rabaglia et al. 2006). A native of Asia (Bangladesh, Burma, India, Japan, and Taiwan), the insect had not been reported previously in the Western Hemisphere. Little concern was attached to its appearance until it was associated with a new disease. Laurel wilt affected a native component of forests in the southeastern United States, redbay (*Persea borbonia* Lauraceae), and was shown to be vectored by *X. glabratus* and caused by a previously unknown fungus, *Raffaelea lauricola* (Fraedrich et al. 2008; Harrington et al. 2008; Mayfield et al. 2008b).