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ECOLOGY AND DETECTION OF THE RED PALM WEEVIL, *RHYNCHOPHORUS FERRUGINEUS* (COLEOPTERA: CURCULIONIDAE), AND RELATED WEEVILS FOR THE PROTECTION OF PALM TREE SPECIES IN THE UNITED STATES

N. J. HERRICK (1), R. W. MANKIN (2), O. G. DOSUNMU (1), AND M. T. K. KAIRO (1)

(1) Center for Biological Control, Florida A&M University, Tallahassee, FL USA,
nathan.herrick@famu.edu
(2) U.S. Department of Agriculture, Agricultural Research Service, Center for Medical, Agricultural, and Veterinary Entomology, Gainesville, Florida USA,
richard.mankin@ars.usda.gov

SUMMARY

The red palm weevil (RPW), *Rhynchophorus ferrugineus*, native to Asia, the neotropical *R. palmarum*, and the subneotropical *R. cruentatus* are international threats to palm industries. We evaluated the status of these species on Aruba over concerns that the former two species may cause significant damage if they enter the United States. Yearly trap captures of RPW remained the same from 17-Sep-2009 to 12-Aug-2010 when compared with trap captures made from 8-Sep-2011 to 9-Aug-2012. Trapping indicated that *R. cruentatus* and *R. palmarum* are not present on Aruba. Acoustical technology was capable of detecting infestations of early instar RPW. Comparisons of movement and feeding impulses produced by RPW and *R. cruentatus* were made. Aerial imagery may be useful for development of trapping protocols; however, an eradication program will only be feasible if phytosanitary laws are implemented on Aruba and adjacent islands.

Key words: *Rhynchophorus ferrugineus*, palm weevil, insect trapping, insect acoustics, eradication.

RÉSUMÉ

ECOLOGIE ET DETECTION DU CHARANÇON ROUGE DES PALMIERS, *RHYNCHOPHORUS FERRUGINEUS* (COLEOPTERA: CURCULIONIDAE) ET D'AUTRES ESPECES CONCERNEES POUR LA PROTECTION DES PALMIERS AUX ETATS-UNIS

Le charançon rouge des palmiers (CRP), *Rhynchophorus ferrugineus*, originaire d'Asie, *R. palmarum* de la région néotropicale et *R. cruentatus* de la région subnéotropicale sont des dangers internationaux pour la filière des palmiers. Nous avons évalué l'état actuel de ces espèces à Aruba, car les deux premières pourraient causer des dommages significatifs s'ils s'établissaient aux Etats-Unis. Les captures annuelles des CRP sont restées les mêmes du 17 septembre 2009 au 12 août 2010, comparées à celle enregistrées du 8 septembre 2011 au 9 août 2012. Les résultats des piégeages indiquent que *R. cruentatus* et *R. palmarum* ne sont pas présents à Aruba. Les technologies acoustiques ont permis de détecter les premiers stades d'infestation du CRP. Des comparaisons des vibrations produites par le CRP et *R. cruentatus* lors de leur alimentation ont été effectuées. L'imagerie aérienne peut être utile pour développer un programme de piégeages. Cependant, une éradication ne pourra être possible que si des mesures réglementaires sont imposées á Aruba et aux îles voisines.

Mots-clés : *Rhynchophorus ferrugineus,* charançon des palmiers, piégeages d'insectes, détection acoustique, éradication.

INTRODUCTION

Invasive species often cause environmental stress and economic burdens to the countries where they are introduced. Estimates for the cost for management of invasive species in the United States (U.S.) alone are as high as $120 billion per year (Pimentel et al. 2005). Offshore mitigation is a management tool that can be used to prevent the entry of high risk organisms from entering nations that are potentially vulnerable. Offshore mitigation involves several tactics from diagnosis of the presence/absence of a pest threat in adjacent countries and/or territories to eradication.

There are several *Rhynchophorus* species from various parts of the world that are threats to the international ornamental and date palm industries. *Rhynchophorus ferrugineus* (Olivier) (Coleoptera : Curculionidae), *R. palmarum* (L.), and *R. cruentatus* (Fab.) are of particular importance. *Rhynchophorus cruentatus* is native to the southeastern U.S. and there is little information addressing the potential damage it may cause if it was distributed to other parts of the world. *Rhynchophorus ferrugineus* is native to Asia and *R. palmarum* is native to Central and South America. The latter two species are not present in the U.S., but are especially important to the U.S. over concerns that either may enter the U.S. and cause devastating damage to palms.

Generally, all of the *Rhynchophorus* species are attracted to stressed or damaged palms. After oviposition, typically at the base of the palm frond, larvae hatch where they bore and feed within the trunk. Detection of infested palms early in the development of the weevil is difficult and can go unnoticed until larvae are later in development; by this time the palm is often killed or of no value. *Rhynchophorus ferrugineus* (RPW) is known to cause the entire top of the palm canopy to fall off. El-Sabea et al. (2009) estimated the economic loss due to management and eradication of RPW in a date plantation in the Gulf region of the Middle-East to be as much as $25,920,000 at only 5% infestation. *Rhynchophorus palmarum* vectors the lethal nematode *Bursaphelenchus cocophilus* (Cobb) Baujard (Aphelenchida : Parasitaphelenchidae) which causes red-ring disease, an additional mechanism by which tree mortality can occur. *Rhynchophorus cruentatus* is most commonly associated as a pest of *Sabal palmetto* (Walt.) Lodd., but is occasionally a severe nursery pest of *Phoenix canariensis* Chabaud (Hunsberger et al. 2000).

Recently, *R. ferrugineus* was identified in the Caribbean on the islands of Curaçao and Aruba (Thomas 2010). Its arrival on Curaçao is suspected to be from *Phoenix* spp. imported to the island from Egypt (Roda et al. 2011). Shipments of palm from Curaçao to Aruba, and the lack of phytosanitary regulations, have resulted in the most recent establishment of RPW on Aruba. Detection of early instar RPW, and if present, *R. palmarum* and *R. cruentatus*, would significantly aid the treatment and managment of infested palms.

Studies have been conducted previously to detect RPW by pheromone trapping and acoustic methods (Fiaboe et al. 2011). These studies recently have been expanded by setting up additional pheromone traps to determine if *R. palmarum* and *R. cruentatus* are present or absent on Aruba and if they should be included in management strategies with RPW. Studies were also conducted to determine if global positioning technology and Google Earth satellite imagery can be used to locate palm species on Aruba to aid in future trap placement and eradication protocols. Finally, presentations and meetings were made with public, private, and governmental sectors to produce awareness of the RPW threat to palms and to discuss the potential implementation of phytosanitary laws in Aruba.

MATERIALS AND METHODS

Rhynchophorus ferrugineus trapping

From 17-Sep-2009 through 9-Aug-2012, 32 traps were set across Aruba (similar to the placement indicated in Fig. 1) to understand the seasonal activity of RPW on the island. Traps were designed from 15 L plastic buckets and contained the pheromone ferrugineol [(4S,5S)-5-methyl-4-octanol] (Giblin-Davis et al. 1995), ethyl acetate, and a food attractant. The pheromone was replaced tri-monthly. The food attractant was made from 200 ml of molasses, 2.5 L of ethylene glycol, and 17.3 L of tap water. Traps were hung on or adjacent to areas were palm trees were present. Traps also had 4 opposing 3 cm diam. holes to allow for the entry of weevils. Traps were inspected bi-weekly and the number of weevils captured was recorded. Yearly RPW trap capture estimates were made by averaging the number of weevils caught per month from 17-Sep-2009 to 12-Aug-2010 and comparing them to those captured from 8-Sep-2011 to 9-Aug-2012 using the Student's standardized *t*-test. These dates were chosen so estimates would encompass a complete year when trapping began and a complete year when trapping ended, have equal frequencies and similar dates of trap inspections, and allowed us to determine if the population changed or remained the same between the two-year intervals.

Rhynchophorus palmarum and *R. cruentatus* trapping

From 15-Feb-2012 to 6-May-2012, 32 traps were set across Aruba (Fig. 1) in areas where palms are commonly present, except in two locations on the north side of the island where palms were absent. Traps were designed by Fantastic Gardens, Aruba from 1 L plastic buckets, wrapped with burlap, and lids were opened to a fixed 45 degree angle to allow for entry of any weevils. These traps are regularly for sale to the local public and are successful in catching RPW. Half of the traps were baited with the pheromone cruentol [(4S,5S)-4-methyl-5-nonanol] (Mori and Morata 1995) and the other half were baited with rhynchophorol [(4S,2E)-6-methyl-2-hepten-4-ol] (Oehlschlager et al. 1993), to monitor for the presence or absence of *R. cruentatus* and *R. palmarum*, respectively. Each site had two traps that were placed approximately 5 m apart for monitoring each of the weevil species. Approximately 0.05 L of molasses was placed into a 0.2 L plastic vial that was fixed to the inside of the trap with tape. The molasses served as a food attractant. Unscented soap (15 ml) was mixed with 0.25 L water and acted as a killing agent. Traps were inspected weekly to determine if any weevils were captured and to replace the killing agent and/or refill the molasses. The trap design used for this portion of the experiments was different from the design used for the '*Rhynchophorus ferrugineus* trapping' because the materials for latter were not available.

Acoustical measurements of *R. ferrugineus* and *R. cruentatus* early-instar activity

To obtain neonates, 4 male and 4 female field-collected RPW or *R. cruentatus* were placed in a plastic container (20 X 18 X 14 cm) with an 8-cm-diam. hole cut into the lid that was covered with mesh screen. Paper towels were placed in the bottom of the container and moistened with a 20% sugar solution to provide moisture and an oviposition substrate. The paper towels were replaced and inspected daily for eggs. Eggs were gently brushed onto moistened filter paper, housed in Petri dishes, and inspected daily for eclosion. Experiments conducted with RPW were carried out in Aruba and the *R. cruentatus* experiments were conducted in the U.S.

Six uninfested *P. canariensis* fronds (12 X 6 cm at base of frond), collected in Aruba (near N 12.53942 W 070.04067, elev. 21 m), were prepared for inoculation by drilling three holes approximately 2.54 cm apart into the base of each frond. The holes (3 mm diam.) were drilled approximately 5 cm deep. The *P. canariensis* fronds were inoculated with neonates of RPW. Ten uninfested *S. palmetto* fronds (6 X 3 cm at base of frond), collected in Tallahassee, FL (near N 30.42264 W 084.28458, elev. 84 m) were inoculated with neonates of *R. cruentatus*. The *S. palmetto* fronds were prepared similarly to the *P. canariensis* fronds except the inoculation holes were approximately 1 cm apart. Neonates were placed gently into each hole using the soft-tipped end of a paintbrush. Holes were plugged with a small piece of paper towel to prevent escape of larvae. Fronds were placed in a plastic bag with 2.54 cm water that was replaced daily to prevent them from drying out. Adults, eggs, and fronds were held under local ambient conditions.

To consider the acoustic detectability of early-instar RPW and *R. cruentatus* in enclosed and open environments, acoustic recordings were compared in enclosed and open environments beginning ca. 24 h after fronds were inoculated with neonates. A 3- X 6-m room with a 2.5-m ceiling, isolated inside a building was set up as an inexpensive sound-reducing enclosure to partial shielding against wind, road noise, bird calls, and other external background sounds. Doors and windows were closed, and circuit breakers and water supplies were shut off to reduce background noise levels.

Two sets of five (2-min) recordings were made of sounds produced by early instar RPW or *R. cruentatus* in the six or ten inoculated fronds (replicates), respectively. The first set of recordings with both species was made under enclosed conditions, while the second set was made outdoors, where extrinsic environmental conditions were not controlled, and frequent periods of vehicular noise, wind, and bird calls occurred. The recordings were made between 13:00 and 18:00 h.

The experiments were conducted using an AED-2000 amplifier (Acoustic Emission Consulting [AEC], Sacramento, CA) with a Model SP-1L sensor-preamplifier module (AEC, Sacramento, CA) which had a magnetic attachment at its base, enabling connection to a screw (13 X 1 cm) inserted into the frond between the second and third inoculation site and approximately 4 cm from the first inoculation site. The AED-2000 was connected to a digital (44.1 kHz sampling rate) audio recorder (model HD-P2, Tascam, Montebello, CA) with headphones that enabled immediate listener assessment of larval signals as they were being recorded. The AED-2000 amplifier filters out signals below 1 kHz where much of the traffic and wind noise occurs (Mankin et al. 2011).

Computer assessments were performed to compare the detectability of early instar RPW or *R. cruentatus* in enclosed and open environments. The procedure for conducting assessments was based on methods described previously in Mankin et al. (2008a, 2011). Such procedures have been used successfully in several previous studies to detect RPW (Mankin et al. 2011, Fiaboe et al. 2011, Mankin et al. 2008a) and other insects (Mankin et al. 2008b) in wood when background noise was of low to moderate intensity.

In the initial stage of the insect sound assessment procedure, recordings were screened using the Raven sound analysis program (Charif et al. 2008) and intervals were selected that separately contained insect or background sounds unambiguously identifiable to listener with previous field-recording experience. Mean spectral profiles of the insect sound impulses and background noise impulses in the selections were constructed using the DAVIS insect signal analysis program (Mankin et al. 2000). Relatively noise-free segments of 40 s or longer were analyzed from enclosed- and open-environment recordings in DAVIS to distinguish whether spectra of individual impulses closely matched insect sound profiles, bird or vehicle noise sound profiles, or as otherwise unknown background noise (Mankin et al. 2011). Impulses that closely matched the insect sound profiles were classified by automated DAVIS subroutines as larval impulses and all other impulses were classified as background noise impulses, (Mankin et al. 2000). For this study, an example profile of RPW early-instar sound impulses was constructed from a 180-s period which contained 178 impulses (see Results). Two profiles were constructed for *R. cruentatus* early instar sounds because impulses of relatively high frequency were interspersed with impulses of lower frequency. A high-frequency profile was constructed from a 120-s period containing 1322 impulses. A low-frequency profile for *R. cruentatus* early instars was constructed from a 120-s period containing 252 impulses. A 15-s segment of an outdoor recording containing a period with bird calls of several species at the recording site in Tallahassee was used to construct a bird noise profile as an average of spectra from 138 impulses. The vehicular noise profile was calculated as a 5-s mean of 50 consecutive 512-sample spectra of vehicle-produced impulses recorded under open conditions during a period of loud traffic in Aruba (Herrick and Mankin in press).

The rates of occurrences of larval impulses (Mankin et al. 2008b) were counted, as well as rates of occurrences of background noise impulses. Finally the larval-sound-impulse rates detected in enclosed and open conditions were compared statistically using two-tailed, paired Student's *t*-tests. In addition, two-tailed, paired Student's *t*-tests were performed in comparing background noise trains in enclosed and open environments, as well as rates of background noise impulses in enclosed and open environments. Because the studies on the RPW larvae are being described in more detail in Herrick and Mankin (in press), we will describe in this report primarily the results from the *R. cruentatus* experiments.

Aerial imagery for identifying the distribution of palms

Global positioning satellite coordinates of palms were taken at two sites on Aruba to map locations where palms are known to occur and determine if these site locations match the locations on Google Earth's satellite imagery free software. Coordinates of palms were taken at open canopy sites where they were intended to be easily visible on Google Earth's satellite imagery and at sites with overstory or dense vegetation were palms may be less discernable from backround vegetation.

RESULTS

Rhynchophorus ferrugineus trapping

From 17-Sep-2009 through 9-Aug-2012, the average number of RPW captured per month varied seasonally. The data show a peak in adults from November through January with lesser, but maintained adult activity, from February through September (Fig. 2). Captures of RPW remained the same from the year trapping began (*i.e.* 17-Sep-2009 to 12-Aug-2010) (10.4 ± 3.3 adults/month, mean ± se) when compared with the year trapping ended (*i.e.* 8-Sep-2011 to 9-Aug-2012) (9.7 ± 1.6 adults/month, $t = 2.2$, $P > 0.05$).

Rhynchophorus palmarum and *R. cruentatus* trapping

While *R. palmarum* and *R. cruentatus* are active from 15-Feb-2012 to 6-May-2012 in their native range (Camino et al. 2000, Weissling et al. 1994), neither species was captured on Aruba when our sampling took place.

Acoustical measurements of early-instar *R. ferrugineus* and *R. cruentatus*

Early instar RPW produced impulses with a wide range of amplitudes and spectral features, exemplified in the oscillogram and spectrogram of Fig. 3A-B. As expected, early instar *R. cruentatus* produced impulses of the same order of magnitude (Fig. 3C-D). Because the sensor was ca 50% closer to the *R. cruentatus* larvae than to the *R. ferrugineus* larvae (see Methods above), the amplitudes of the *R. cruentatus* signals in the example were slightly larger than those observed from RPW. Possibly because RPW early instar larvae are larger than *R. cruentatus*, the mean spectra (profiles) of their impulses (Fig. 4a) often peak at lower frequencies than *R. cruentatus* (Fig. 4b,c), all of which were recorded in enclosed conditions.

The shielding of the enclosed room reduced the sound pressure level of external background noise by ca. 10 dB. For example, in a 50-s period recorded from a palm frond outdoors, 54 impulses classified as background sounds had a mean SPL[> 1kHz] of 62.17 ± 0.34 dB, while 33 background sound impulses had a mean SPL[> 1kHz] of 51.06 ± 0.64 dB when the frond was transferred to the enclosure (Herrick and Mankin in press). However, averaged over five palm fronds, the mean SPL[> 1kHz] in the outside environment in Tallahassee was

56.20 ± 3.18 dB, compared to 52.09 ± 2.54 dB in the enclosed room. In this case, the overall level of background noise was lower at the Tallahassee recording site than in Aruba.

A preliminary assessment of the detectability of sounds produced by early instar *R. cruentatus* in enclosed and open environments was performed for five of the 10 inoculated *S. palmetto* fronds using the DAVIS signal analysis program. The results in Table 1 were inconclusive due to the high variability of the sound production rates and the background noise in both environments. Assessment of the complete set of recordings may be necessary to establish whether the use of an enclosed room in the Tallahassee study provided sufficient shielding to improve the detectability of *R. cruentatus* larvae. However, as in the example of Fig. 3, both RPW and *R. cruentatus* early instars produce sounds sufficiently energetic enough to be detected in both shielded and open environmental conditions with moderate noise background.

Aerial imagery for identifying the distribution of palms on Aruba

The Google Earth's free imaging software likely is not of sufficient resolution for an observer to identify a palm tree without having visited Aruba and having knowledge of the island and knowing the exact location of palms, either in open canopy or in locations with understory and/or overstory vegetation (Fig. 5A-B and Fig. 6A-B). Our familiarity with the island allowed us to visually identify locations of palms in open canopy areas using Google Earth's free imaging software, but not in areas with vegetation.

Figure 1 : Locations (16 sites) of 32 traps used to catch *R. cruentatus* (16 traps) and *R. palmarum* (16 traps) on the island of Aruba from 15-Feb-2012 through the 6-May-2012.

Localisation des 32 pièges (16 sites) utilisés pour piéger *R. cruentatus* (16 pièges) et *R. palmarum* (16 pièges) sur l'ile d'Aruba du 15 février au 6 mai 2012.

Figure 2 : Average monthly trap captures (mean ± SE) of adult *R. ferrugineus* on the island of Aruba from 17-Sep-2009 through 9-Aug-2012.

Captures moyennes mensuelles d'adultes (moyenne + erreur standard) de *R. ferrugineus* à Aruba du 17 septembre 2009 au 9 août 2012.

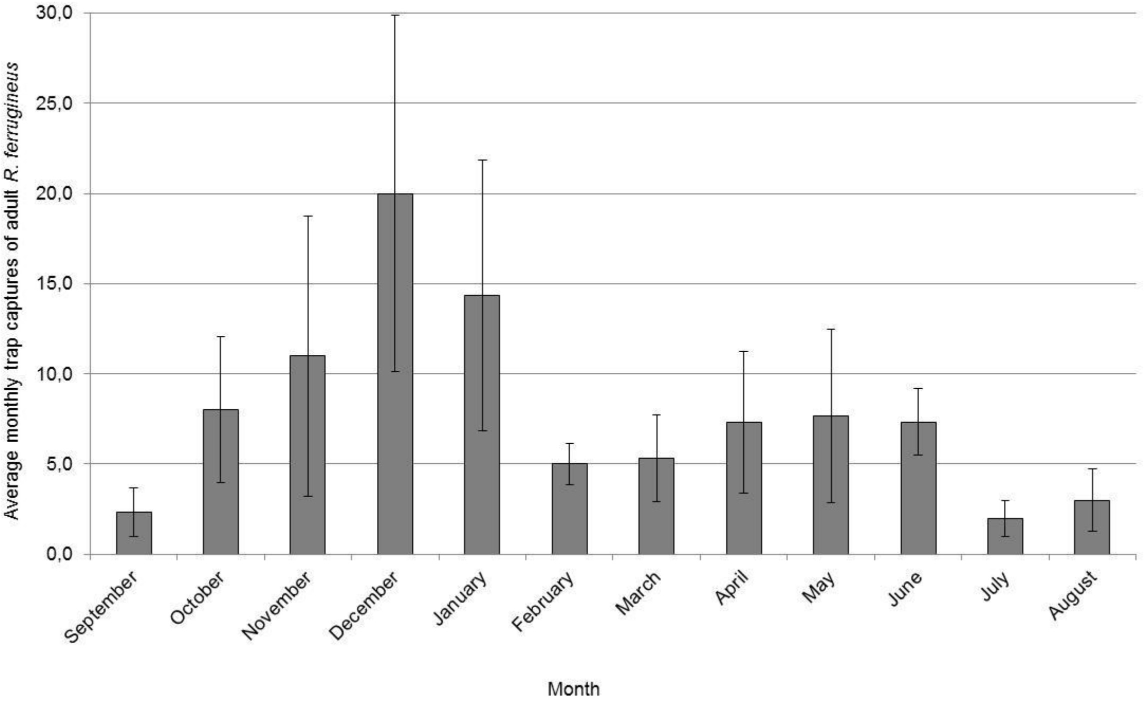

Figure 3 : Oscillogram (A) and spectrogram (B) of sound impulses produced by early-instar *R. ferrugineus* compared with oscillogram (C) and spectrogram (D) of impulses produced by early instar *R. cruentatus*. In spectrograms B and D, the darker shading indicates frequencies and times of greatest energy.

Oscillogramme (A) et spectrogamme (B) d'ondes sonores produites par un stade larvaire précoce de *R. ferrugineus* comparés à l'oscillogramme (C) et au spectrogramme (D) d'ondes émises par des stades larvaires précoces de *R. cruentatus*. Sur les spectrogrammes B et D, l'ombre plus sombre indique des fréquences et des durées de plus forte énergie.

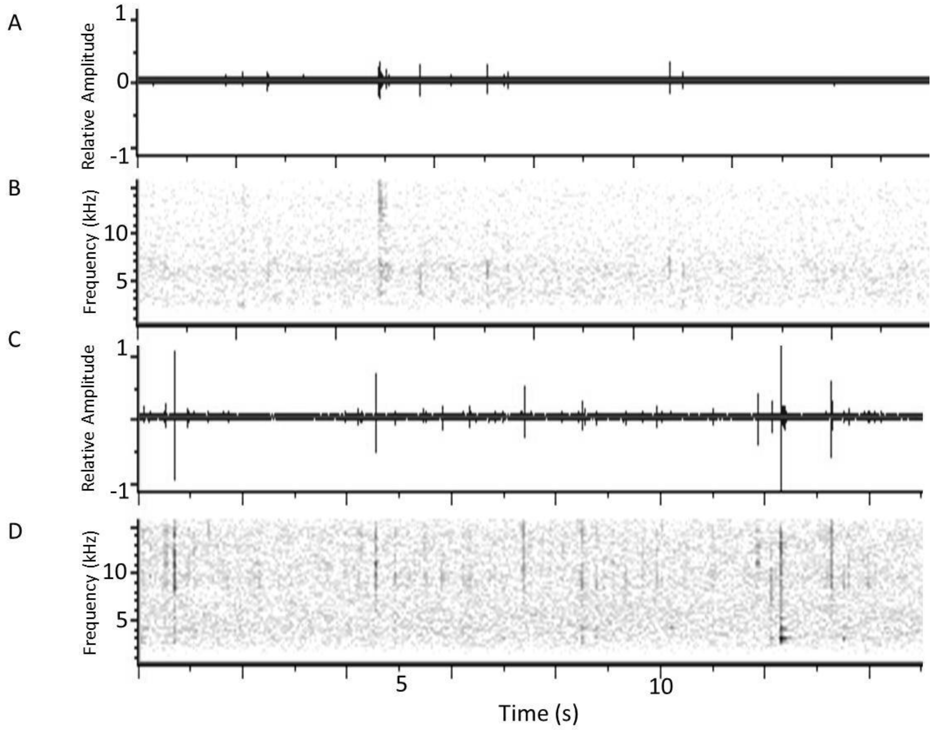

Figure 4: Comparison of profiles for a) RPW early instar sounds (solid line), b) *R. cruentatus* (RC) early instar low-frequency sounds (dashed line), and c) *R. cruentatus* (RC) early instar high-frequency sounds (dotted line) obtained from three separate recordings. The peak relative spectrum levels tended to occur at lower frequencies for RPW than for *R. cruentatus*.

Comparaison de profils pour des a) sons émis par un stade larvaire précoce de CRP (ligne continue), b) des sons basse fréquence émis par un stade larvaire précoce de *R. cruentatus* (RC) (tirets), et c) sons haute fréquence émis par les stades larvaires précoces de *R. cruentatus* (RC) (pointillés). On observe une tendance à l'émission de sons qui prédominent à des fréquences plus basse pour le CRP que pour *R. cruentatus*.

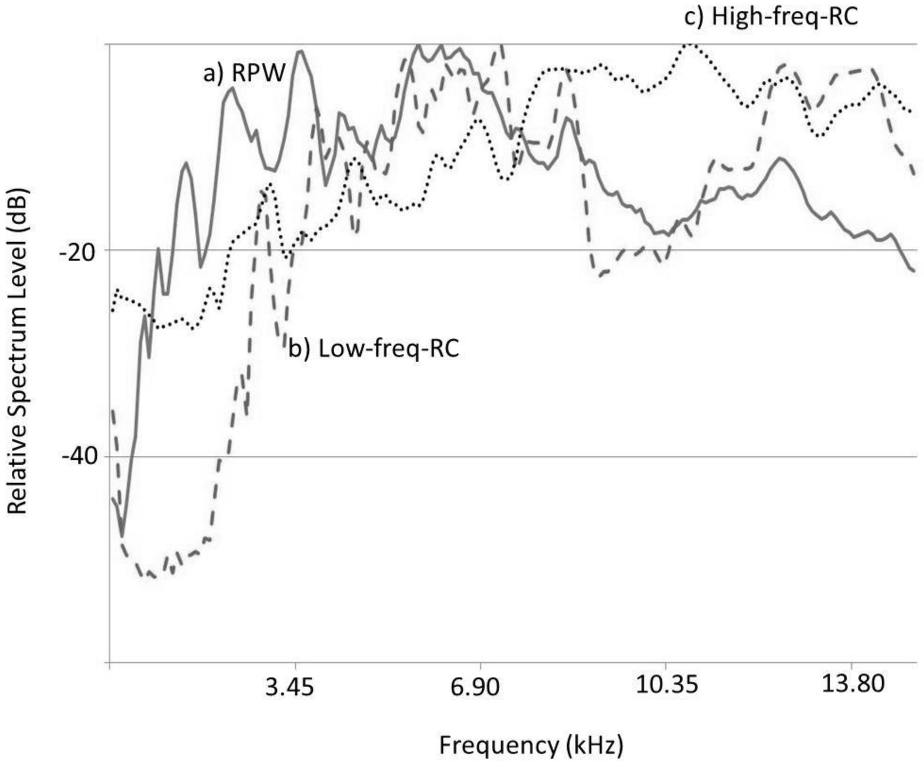
c) High-freq-RC
a) RPW
b) Low-freq-RC
Relative Spectrum Level (dB)
-20
-40
3.45
6.90
10.35
13.80
Frequency (kHz)

Figure 5 : Examples of palm tree locations without (A) and with (B) gps coordinates in an open canopy at the Aruba international airport.

Exemples de localisation de palmiers sans (A) et avec coordonnées GPS (B) dans un espace ouvert à l'aéroport international d'Aruba.

Figure 6 : Examples of palm tree locations without (A) and with (B) gps coordinates in an area with vegetation on Aruba.

Exemples de localisation de palmiers sans GPS (A) et avec coordonnées GPS (B) dans un espace végétalisé à Aruba

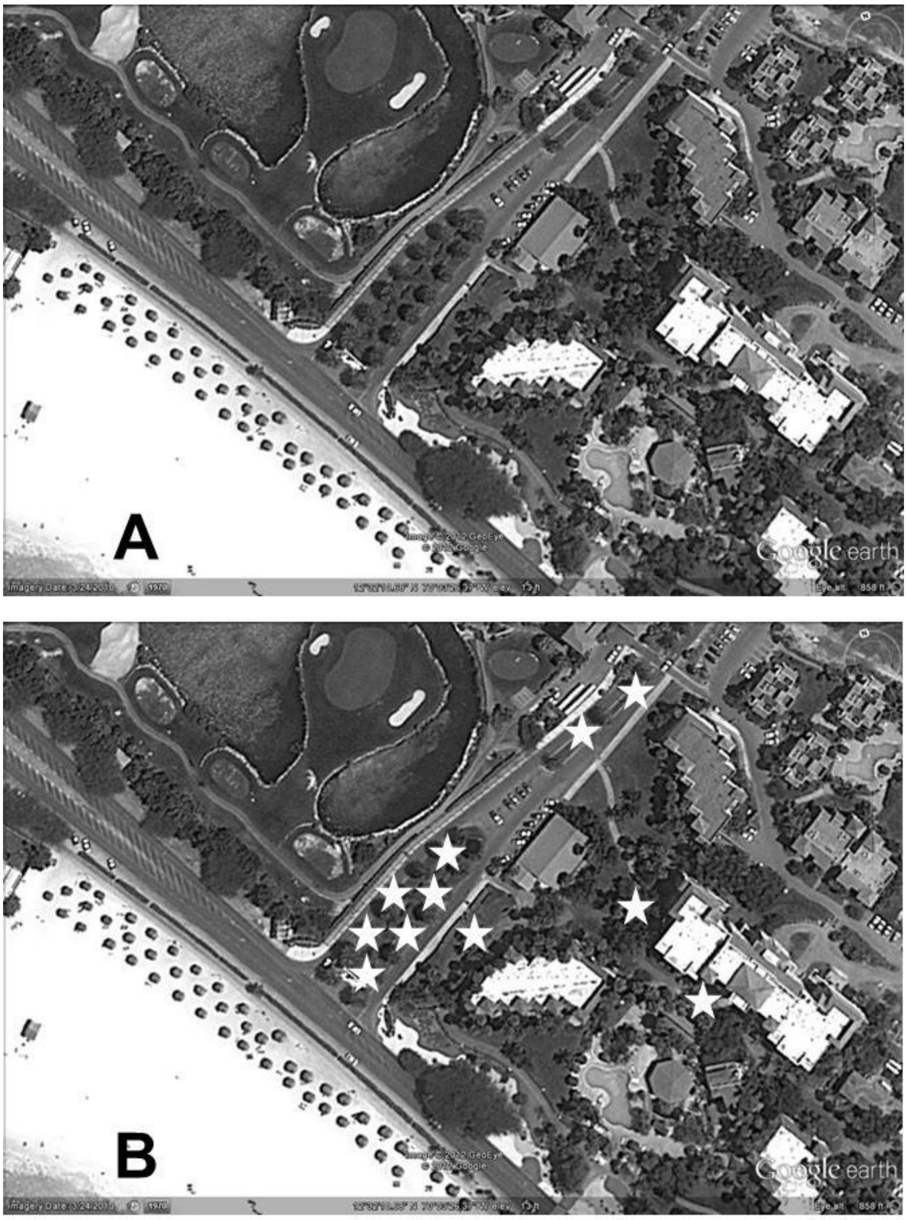

Table 1. Comparisons among rates of early-instar *R. cruentatus* sound impulses[1] and background noise[2] impulses recorded in five palm fronds in enclosed (shielded) and open (exposed) conditions

Tableau 1. Comparaison des taux d'impulsion sonores (1) de larves des premiers stades de *R. cruentatus* et le bruit de fond enregistré dans cinq frondes dans un espace couvert (Int) et en conditions extérieures (Ext)

Frond/ Fronde	Larval profile[1] impulse rate (No. / s) Nb. d'impulsions larvaires par seconde		Noise profile[2] impulse rate (No. / s) Nb. d'impulsions dues au bruit par seconde	
No.	Shielded/Int	Exposed/Ext	Shielded/Int	Exposed/Ext
1	14.71	0.35	1.35	11.18
2	13.51	3.38	10.43	2.39
3	12.21	6.13	9.47	17.55
4	13.63	9.68	2.28	0.33
5	11.02	43.18	4.56	0.19
M	13.02	12.54	5.62	6.33
± SE	0.64	7.81	1.85	3.45

M : Mean/ Moyenne ; SE : standard error /erreur standard.

[1] In each recording in shielded or exposed conditions, counts of impulses were summed per origin : / Pour chaque enregistrement, réalisé à couvert ou en extérieur, les impulsions ont été comptées selon leur origine :

[1] impulses that matched larval profiles b) or c) in Fig. 4 / impulsions correspondant aux profils b) ou c) de la Fig. 4.

[2] and impulses that matched vehicle or bird noise profiles (see Methods). / impulsions correspondant à des sons causés par des véhicules ou des oiseaux (Voir Méthodes).

DISCUSSION

Our results showing peak activity in Aruba from November to January differ from reports of RPW seasonal activity in other geographic areas, but it is known that the seasonal activity of RPW is variable across its distribution (Faleiro 2006). In areas of Saudi Arabia peak activity is during April – May (Vidyasagar et al. 2000), in Egypt activity spikes in April – June (El-Garhy 1996), with similar activity in Israel as that reported in Egypt (Soroker et al. 2005) Therefore, trapping efforts should be robust during these months if mass trapping is implemented as a control method. In addition, the data indicate the seasonal activity of RPW on Aruba has stayed the same from the beginning of trapping to date. While environmental factors likely have influenced the lack of increase in RPW activity, collaborative efforts between the U.S. and Aruba and public awareness efforts also may have impeded RPW population growth because homeowners and hotel employee's are more likely to report the pest to pest managers. Furthermore, Roda et al. (2011) report a maximum trap catch in Aruba at 6 weevils per trap and higher populations of RPW on Curaçao than on Aruba. Implementation of an eradication program may be easiest on Aruba during the initial phases because the island and the RPW population are smaller. Complementary to our suggestions, Roda et al. (2011) presented several useful management recommendations for the potential eradication of RPW from Aruba and Curaçao.

R. palmarum and *R. cruentatus* were not found on Aruba. However, monitoring for these species should be maintained in case they are accidently introduced. In case of accidental introduction of these species they could be included in an eradication protocol with RPW since their behavior and life histories are similar.

High resolution aerial photography, such as the Google Earth satellite imagery but with greater resolution, would be an invaluable tool for determining palm locations, concentrations, and facilitate ideal trap placement in a mass trapping scheme. Aerial photography would also save practitioners valuable time, allowing them to avoid developing ‘blind’ trapping protocols. Quality high resolution imagery would allow scientists and managers to understand movement and concentration of RPW permitting better management of resources over the course of an eradication program.

CONCLUSION

Further studies would be beneficial to RPW eradication efforts; such as, comparisons of the most efficient trap design, trap efficacy (*i.e.* mark-release-recapture studies), and the most efficient pheromone blend (*i.e.* blend manufactured in Costa Rica versus blend manufactured in Germany). However, mitigation of RPW threats to the U.S. and outlying areas will likely not be successful without the implementation of phytosanitary regulations on Aruba and Curaçao and nearby islands due to the possibility of re-entry of the pest.

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