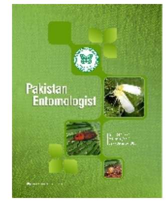
Pakistan Entomologist

Journal homepage: www.pakentomol.com



EVALUATION OF THREE TRAPPING STRATEGIES FOR THE PALM WEEVIL, *RHYNCHOPHORUS VULNERATUS* (COLEOPTERA: CURCULIONIDAE), IN SUMATRA INDONESIA

Christina D. Hoddle[1] and Mark S. Hoddle[1,2]

[1]Department of Entomology, University of California, Riverside, CA 92521, USA
[2]Center for Invasive Species Research, University of California, Riverside CA 92521, USA

ARTICLE INFORMATION

Received: December 01, 2015
Received in revised form: December 25, 2015
Accepted: December 27, 2015

***Corresponding Author**:
Mark Hoddle

E-mail: mark.hoddle@ucr.edu

ABSTRACT

Three different trapping protocols were assessed for attractiveness to the palm weevil, *Rhynchophorus vulneratus*, in a commercial oil palm plantation in Sumatra Indonesia. The three treatment types tested were: (A) a bucket trap loaded with aggregation pheromone, ethyl acetate synergist, and fermenting oil palm hearts; (B) consisted of Treatment A coupled with sections of cut coconut palm trunks, and (C) was comprised of sections of cut coconut palm trunks only. Treatments were replicated within and across three widely separated sites and traps were checked twice daily, in the morning (7:30am) and afternoon (3:00pm), for captured adult weevils. Results indicated that Treatment A and B caught significantly more weevils than Treatment C. Time of day did not significantly affect the mean total number of weevils captured. The results of this study are discussed in the context of eradication efforts targeting *R. vulneratus* in Laguna Beach California, USA.

Keywords: Aggregation pheromone, Bucket traps, Eradication, Flight periodicity, Laguna Beach

INTRODUCTION

Rhynchophorus spp. weevils (Coleoptera: Curculionidae) are destructive palm pests in their native and introduced ranges (Giblin-Davis *et al*., 2013). The palm weevil, *R. vulneratus* (Panzer), is native to southern Thailand-northern Malaysia on the Thai-Malay Peninsula, Singapore, and Indonesia (Wattanapongsiri 1966, Rugman-Jones *et al*., 2013). In Aug. and Sep. 2010, larval and adult *R. vulneratus* were recovered from badly damaged Canary Islands date palms, *Phoenix canariensis* Chabaud (Arecales: Arecaceae), in Laguna Beach California USA (Hoddle, 2010a). In response to this find, a delineation, containment, and eradication program targeting *R. vulneratus* was initiated by the United States Department of Agriculture (USDA) and the California Department of Food and Agriculture (CDFA). A core component to this program was the deployment of 3.78 liter bucket traps loaded with commercially-available aggregation pheromone, a synergist (i.e. ethyl acetate) and baited with fermenting fruit (e.g. apples). Approximately 1 liter of 50:50 mixture of water and propylene glycol was added to bucket traps to drown and preserve weevils (Hoddle, 2010b). The area infested with *R. vulneratus* was estimated to be ~ 1 km^2, or about 4% of the land area of the City of Laguna Beach.

A total of 150 pheromone traps were deployed over a 15.6 km^2 survey area which was ~ 68% of the total land area of Laguna Beach. Despite the deployment of a relatively large number of traps in areas with palm trees with confirmed *R. vulneratus* infestations, only 1 adult weevil was captured over a 3 yr period (Hoddle *et al*., 2015). The very low capture rates of *R. vulneratus* in pheromone traps in areas with apparent or suspected weevil infestations caused serious concern because it suggested that the pheromone traps might not be very attractive to *R. vulneratus*. If this was the case, then the lack of a sensitive and species-specific monitoring tool could significantly impair efforts to contain and eradicate *R. vulneratus* in California.

To determine whether or not the commercially-available aggregation pheromone used for monitoring *R. vulneratus* in California was attractive to this palm pest, and if volatiles from cut palm logs act synergistically with aggregation pheromone to increase attraction (Hallett *et al*., 1993), field trials evaluating the pheromone alone and in combination with logs of cut coconut palm trunk (*Cocos nucifera* L.

Cite this article as: Cite: Hoddle, C.D. and M.S. Hoddle, 2015. Evaluation of three trapping strategies for the palm weevil, *Rhynchophorus vulneratus* (Coleoptera: Curculionidae), in Sumatra Indonesia. Pak. Entomol., 37(2):73-77.

[Arecales: Arecaceae]) for attractiveness to *R. vulneratus* in part of its home range, Sumatra Indonesia, were conducted. The results of these field studies are presented here.

MATERIALS AND METHODS

Field trials were conducted in a commercial oil palm (*Elaeis guineensis* Jacq. [Arecales: Arecaceae]) plantation in Bandar, Simalungun Regency, North Sumatra, Indonesia over 16-23 Feb. 2012. Three treatments were set up and replicated across three different sectors of the plantation. These study sites were separated by 2-4 km and each of the treatments within a study site was separated by at least 100 m. Sector one and three had each of the three treatments replicated twice, and sector two had one replicate of each of the three treatments for a total of 15 replicated treatments deployed across three different study sites.

Experimental treatments

Treatment A consisted of a 20 l plastic bucket (~ 40 cm tall and ~ 30 cm diameter) loaded with commercially-available aggregation pheromone (i.e., Ferrolure™ 700 mg, manufactured by ChemTica International S.A., Costa Rica; this product consists of one of the two *R. vulneratus* aggregation pheromones, 4-methyl-5-nonanol [ferrugineol]), weevil magnet (an ethyl acetate synergist contained in a slow release pouch [P080-lure manufactured by ChemTica International S.A., Costa Rica), and bait which consisted of ~ 1 kg of fresh apical sections of oil palm. Two sheet metal panels, approximately the same width and height of the bucket trap attached to wooden supports, were each cut to their respective mid-points and the two metal sheets were interlocked via these cuts. The joined metal sheets formed a 4 panel interception barrier that was attached to the top of the bucket trap (Fig. 1). Bucket traps were attached to posts and suspended ~ 1 m above the ground to deter interference from animals.

Treatment B consisted of stacks of 6-8 freshly cut coconut palm trunks ~ 1m in length. Each log was notched four times to provide deep crevices for *R. vulneratus* that were attracted to this treatment to hide in. A bucket trap loaded with aggregation pheromone, ethyl acetate synergist, and bait (i.e., freshly cut pieces of apical sections of oil palm) was placed on top of this log stack (Fig. 2). Treatment C consisted only of a stack of cut coconut palm trunks that had been notched to provide hiding places for *R. vulneratus* adults that were attracted to cut logs (Fig. 3).

Data collection and analyses

Experimental treatments at each study site were checked twice daily at 7:30am and 3:00pm. The number of adult *R. vulneratus* (Fig. 4) captured in each treatment was recorded by site for each time period and weevils were removed. Captured adult weevils were examined for the presence of phoretic mites and the number of infested weevils was recorded for each treatment type by inspection time and location. A mixed linear repeated measures model was used to test if the mean total numbers of weevils captured were different across treatments and time of capture (i.e., morning and afternoon). In the model, the site was treated as a random effect while treatment, time, and their interaction were treated as fixed effects. Weevil counts were log transformed (y=log[x+1]) before fitting the model. Tukey-Kramer least squares means separation test adjusted for multiple comparisons at the 0.05 level of significance was used to determine if significant differences between mean number total number of weevils captured by treatment and time existed. All analyses were conducted in SAS (SAS, 2008).

RESULTS AND DISCUSSION

A total of 107 *R. vulneratus* were captured across all treatments and experimental sites. Of these captured weevils, 46 (43%) were males and 61 (57%) were females. Of these 107 captured weevils, 65 (61%) were infested with phoretic mites, of these 65 weevils 40 (62%) were female and 25 (38%) were males. The identity and ecological role of these phoretic mites was not determined, but it is possible they exploit habitat within infested palms created by *R. vulneratus* infestations and adult weevils move mites phoretically between palms (Porcelli *et al*., 2009). Phoretic mites associated with adult *Rhynchophorus* spp. do not appear to function as natural enemies of these palm pests (Porcelli *et al*., 2009).

The mean total number of *R. vulneratus* captured across treatments differed significantly (F = 23.78. df = 2, P < 0.0001) (Fig. 5A). Treatment A (i.e. a bucket trap loaded with aggregation pheromone, ethyl acetate synergist, and bait [apical pieces of oil palm trunk]) and Treatment B (i.e., Treatment A combined with sections of cut coconut palm trunk) caught significantly more *R. vulneratus* than Treatment C (i.e. sections of cut coconut palm trunk) (Fig. 5A). Although not significantly different, Treatment B, on average, resulted in the capture of more *R. vulneratus* than Treatment A and C (Fig 5A) and a higher percentage of adult weevils were caught in Treatment B (Fig. 5B). This result indicates that combining sections of cut coconut palm trunks with bucket traps loaded with aggregation pheromone, synergist, and bait resulted in the capture of more weevils than loaded bucket traps alone. A similar result was observed for *R. ferrugineus* captures in the Philippines (Hoddle and Hoddle, 2011). When taken together, capture rates for *Rhynchophorus* spp. appear to increase when pheromone traps loaded with aggregation pheromone, synergist, and fermenting bait are set up with sections of cut palm trunk. Hallett *et al*. (1993) suggested that volatiles released from cut palm logs act synergistically with aggregation pheromone to increase trap attractiveness to weevils.

Time of day had no significant effect on the mean total number of weevils captures (F = 0.49, df = 1, P = 0.49) (Fig. 6A) and there was no significant treatment by time interaction effect either (F = 0.24, df = 2, P = 0.79). Although not significant, on average more weevils and a higher percentage (Fig. 6B) of weevils were recovered from traps when they were checked in the morning (7:30am), and fewer weevils were captured in traps in the afternoon (traps were checked at 3:00pm) (Fig. 6A and B). There are two possible interpretations for this result. First, more weevils were captured in traps when they were checked in the morning because weevils had longer to find these traps. This occurred because trap checking was completed by about 5:00pm in the afternoon, so from 5:00pm to 7:30am, weevils had approximately 14.5 hr to accumulate in traps before they were checked the following morning. In contrast, traps checked in the afternoon only had approximately 5.5 hr to capture weevils (morning trap inspections were completed by 9:30am). Second, it is possible that *R. vulneratus* is more active at night and has a greater propensity to fly at this time. Periodicity of flight by *R. ferrugineus* in Saudi Arabia has been investigated using electronic "smart traps" to determine the times male and female weevils arrive at traps in commercial date palm plantations (Aldryhim and Al Ayedh, 2015). Similar studies in Greece using "smart traps" with optical sensors that count weevils entering traps have been used to record weevils arriving in traps in real time. Capture data from traps with optical sensors are wirelessly transmitted to smart phones, tablets, or internet addresses (Potamitis and Rigakis, 2015). Similar studies using smart traps to monitor *R. vulneratus* in Indonesia would help resolve uncertainties over flight arrival times to pheromone traps.

The results of this study were used to design trapping programs to monitor incipient populations of *R. vulneratus* in Laguna Beach. Densities of this pest weevil were very low when trapping programs were underway and trap efficacy needed to be optimized to maximize the likelihood of weevil captures. Consequently two "enhanced" trapping programs were conducted in Laguna Beach using bucket traps loaded with aggregation pheromone, ethyl acetate synergist, and fermenting fruit (bait). These traps were deployed with sections of cut date palm trunk around *R. vulneratus* find sites. Enhanced trapping programs failed to capture *R. vulneratus* and helped provide additional evidence that populations of this pest were either too low to trap or weevils had gone extinct because of eradication efforts (Hoddle *et al*., 2015). In January 2015, *R. vulneratus* was officially declared eradicated from Laguna Beach by the USDA after three consecutive years of no trap captures (El Lissy, 2015). Enhanced trapping programs using data from this study contributed, in part, to the conclusion that *R. vulneratus* had been successfully eradicated from California.

ACKNOWLEDGEMENTS

We are indebted to Stephen Nelson, Ahmed Saleh, Lisanti Cahyasiwi, Adi Sumantri, Linda Purwaninigsih, and Prima Wijayanto, Sumatra Bioscience, Bah Lias Research Station (Lonsum) for their outstanding hospitality and generous assistance with pheromone field evaluations and aeration trials in Sumatra, Indonesia. Dr. Karen Xu, UC Riverside Statistics Department provided assistance with statistical analyses. Research in support of this project was supported, in part, by a CDFA Specialty Crops Grant, SCB11061, "Addressing Urgent Research Needs for Red Palm Weevil in California."

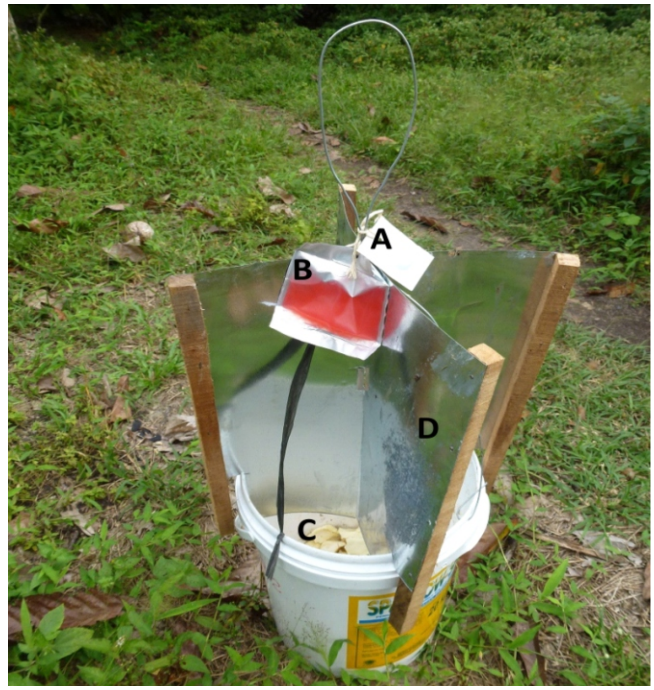


Fig. 1.

Treatment A consisted of a bucket trap loaded with the *Rhynchophorus vulneratus* aggregation pheromone (A), ethyl acetate synergist (B), and bait which consisted freshly cut oil palm heart (~ 1 kg) that was placed inside the bucket (C). Four sheet metal panels (D) intercepted flying weevils causing them to fall into the bucket where they fed and hid amongst pieces of cut oil palm. This trap was suspended ~ 1 m above the ground to deter interference from animals.

Fig. 2.

Treatment B consisted of a stack of cut coconut palm trunks that had been notched to provide hiding places for *Rhynchophorus vulneratus* and Treatment A (see Fig. 1) which consisted of a bucket trap loaded with aggregation pheromone, ethyl acetate synergist, and fresh apical pieces of oil palm that acted as bait.

Fig. 3.

Treatment C was comprised only of a stack of cut and notched coconut palm trunks. The notches provided hiding places for *Rhynchophorus vulneratus* attracted to cut logs.

Fig. 4.

An adult male *Rhynchophorus vulneratus* that was attracted to Treatment B and found resting on a cut section of coconut palm trunk.

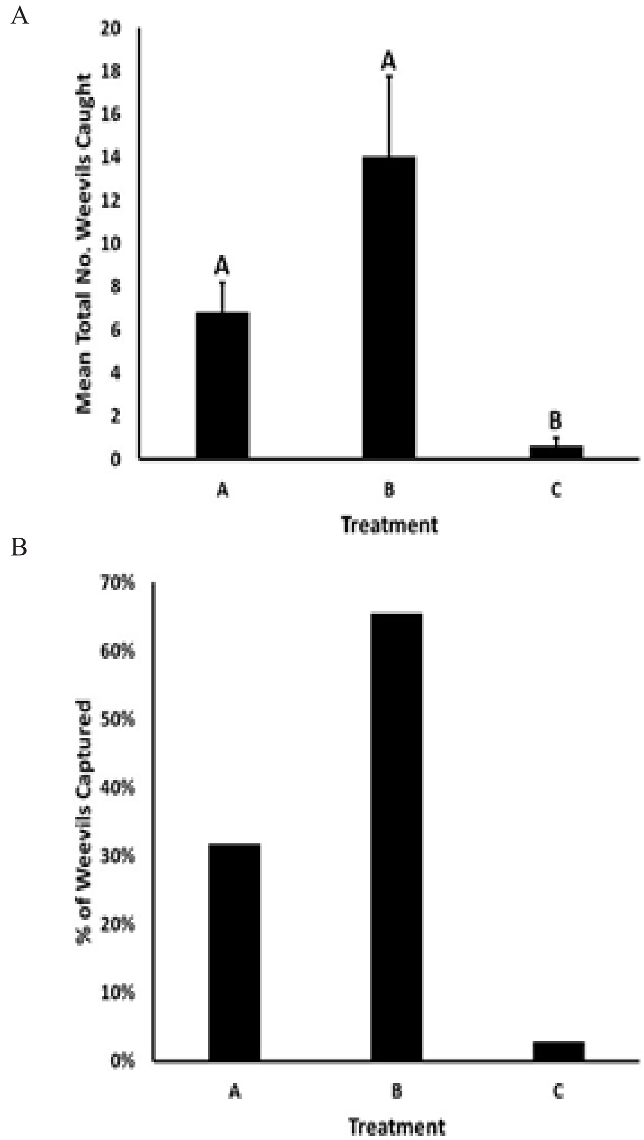
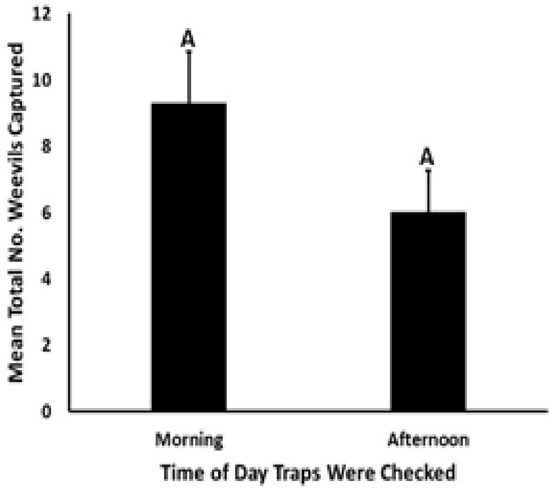


Fig. 5.

(A) Mean (± SE) total number of *Rhynchophorus vulneratus* combined across sites and time for each treatment. Means with the same letter are not significantly different at the 0.05 level of significance. (B) Percentage of *R. vulneratus* captured across the three different experimental treatments. Treatment A consisted of a bucket trap with aggregation pheromone, ethyl acetate synergist, and bait (apical pieces of oil palm trunk) (see Fig. 1). Treatment B consisted of Treatment A combined with sections of cut coconut palm logs (see Fig. 2). Treatment C consisted of cut coconut palm logs only (see Fig. 3).

A



B

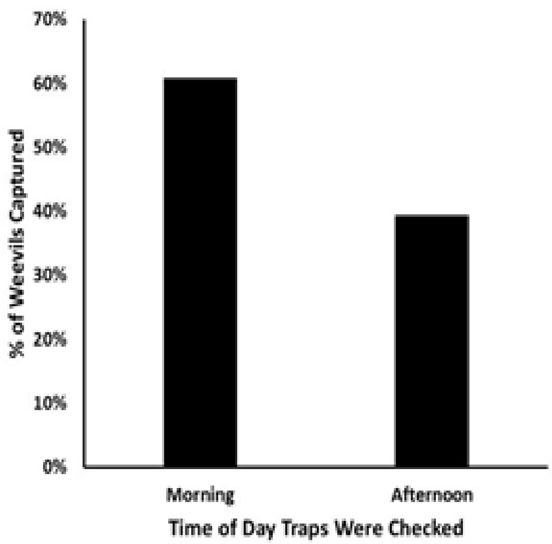


Fig. 6.

(A) Mean (± SE) total number of *Rhynchophorus vulneratus* found in treatments combined across sites and treatments for morning (7:30am) and afternoon (3:00pm) inspections. Means with the same letter are not significantly different at the 0.05 level of significance. (B) Percentage of *R. vulneratus* recovered from experimental treatments after inspection in morning (7:30am) or afternoon (3:00pm). Treatment A consisted of a bucket trap with aggregation pheromone, ethyl acetate synergist, and bait (apical pieces of oil palm trunk) (see Fig. 1). Treatment B consisted of Treatment A combined with sections of cut coconut palm logs (see Fig. 2). Treatment C consisted of cut coconut palm logs only (see Fig. 3).

REFERENCES

Aldryhim, Y. N., and H. Y. Al Ayedh, 2015. Diel flight activity patterns of the red palm weevil (Coleoptera: Dryophthoridae) as monitored by smart traps. Fla. Entomol., 98:1019-1024.

El-Lissy, O.A., 2015. Red palm weevil (*Rhynchophorus ferrugineus*) eradicated from California. http://content.govdelivery.com/accounts/USDAAPHIS/ bulletins/eb0f5e(last accessed 30 Nov. 2015).

Giblin-Davis, R., J.R. Faleiro, J.A. Jacas, J.E. Peña, and P.S.P. V. Vidyasagar, 2013. Biology and management of the red palm weevil, *Rhynchophorus ferrugineus*, pp. 1-34. *In* J. E. Peña (ed.), Potential invasive pests of agricultural crops. CABI Publishing, United Kingdom.

Hallett, R.H., G. Gries, R. Gries, and J.H. Borden, 1993. Aggregation pheromones of two Asian palm weevils, *Rhynchophorus ferrugineus* and *R. vulneratus*. Naturwissen 80: 328-331.

Hoddle M.S., 2010a. Confirmed: live red palm weevil found in US. (last accessed 30 Nov. 2015).

Hoddle, M.S. 2010b. Red palm weevil technical working group field trip to Laguna Beach. http://cisr.ucr.edu/blog/invasive-species/red-palm-weevil-technical-working-group-field-trip-to-laguna-beach/ (last accessed 30 Nov. 2015).

Hoddle, M.S. and C.D. Hoddle, 2011. Evaluation of three trapping strategies for red palm weevil, *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae) in the Philippines. Pak. Entomol. 33: 77-80.

Hoddle, M.S., M. Alzubaidy, J. Kabashima, J.N. Nisson, J. Millar and C.D. Hoddle, 2015. Successful eradication of the palm weevil, *Rhynchophorus vulneratus* (Coleoptera: Curculionidae), from Laguna Beach, California USA. Invas. Biol. (submitted Aug. 2015).

Porcelli, F., E. Ragusa, A.M. D'Onghia, S. Mizzi and D. Mifsud, 2009. Occurrence of *Centrouropoda almerodai* and *Uroobovella marginata* (Acari: Uropodina) phoretic on the red palm weevil in Malta. Bull. Entomol. Soc. Malta 2: 61-66.

Potamitis I. and I. Rigakis, 2015. Smart traps for automatic remote monitoring of *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae) PeerJ PrePrints 3:e1651 http://dx.doi.org/10.7287/peerj.preprints.1337v1

Rugman-Jones, P.F., C.D. Hoddle, M.S. Hoddle and R. Stouthamer, 2013. The lesser of two weevils: molecular genetics of pest palm weevil populations confirm *Rhynchophorus vulneratus* (Panzer 1798) as a valid species distinct from *R. ferrugineus* (Olivier 1790), and reveal the global extent of both. PLoS One 8(10): e78739.

SAS Institute, 2008. SAS/STAT User's Guide 9.2, second edition. SAS Institute, Cary, NC.

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