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Global Threat to Date Palm Plantations: Red Palm Weevil-Distribution, Biology, and Management Tactics: A Review

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ABSTRACT

Date palm, Phoenix dactylifera (Arecaceae or Palmae) is a perennial and dioecious plant mostly cultivated in the arid regions of the world. Date palm plantations across the globe are threatened by Red palm weevil, Rhynchophorus ferrugineus Oliver (Coleoptera: Curculionidae). Relatively little is known about RPW biology, behavior, and resistance to chemical pesticides. Arthropod fauna recently listed for date palm includes 112 species of insects and mites and about 22 species associated with stored dates worldwide. Effective management options have been considered by researchers, extension scientists, and the farming community to mitigate the effect of this voracious herbivore. Some of the intervention options include early detection methods (including acoustic sensors, visual and thermal imaging detection methods), the use of pheromones, monitoring and mass trapping of weevil, the sterile insect technique for reproductive control, insecticides, etc. This review covers different management strategies to protect date palm plantations against the weevil. Collaborative and organized pursuit of innovative research strategies, effective monitoring systems, and integrated tactics for RPW is the need of the hour. A joint venture of national and international organizations in the form of funding, research programs, and result-oriented implementation can bring effective control over RPW.

Keywords: *Phoenix dactylifera; Rhynchophorus ferrugineus; host range; detection methods*

INTRODUCTION

Date palm (*Phoenix dactylifera* Linnaeus) has been cultivated in Middle East and North Africa for over 5000 years, genus *Phoenix* has fourteen species and *P. dactylifera* is claimed to have over 5000 cultivars [1-3] .Various types of the insect pests can attack on date palm [4]. The red palm weevil, *Rhynchophorus ferrugineus* (Olivier; Coleoptera: Curculionidae) is a highly destructive coleopterous insect that damages 29 different palm species particularly date palms which are economically important plants of Middle East, Africa, and South East Asia [5] . It has also invaded many palm-habitable continents except North and South America and is now present in Curacao and Aruba [6]. Owing to its similarity with one of the closely related species *R. cruentatus* (Fabricius) which is native to Florida, its spread to North and South America is not beyond expectation [35].

Another related species, *R palmarum* (L.) being

South American in origin was detected in the southwestern States of USA [7]. Another similar but difficult to distinguish *R. vulneratus* (Panzer) which is the third similar species difficult to distinguish from *R. ferrugineus*, was discovered in California and eradicated [8]. This pest has been found in 50 % of date-growing and 15% of coconut-producing countries in the world [9] including Pakistan, Taiwan and the Philippines [10]. In Pakistan, it was the first time reported in the Khairpur district [Sindh] [11].

Concealed feeding habit of RPW makes it difficult to monitor and manage [12-15], Though adult beetles can be monitored using pheromones yet, the larvae feeding internally, tunneling into the vegetative apex, and injured sections of the trunk are not possible to detect until the tree is damaged beyond recovery [16] or fallen to the ground. The management practices for this pest can be categorized into phytosanitation, use of pheromone traps [17] biotechnological or sterile insect technique (SIT) [18], biological control [19-20], fumigating, hole injecting, spraying and root-irrigation [21-22]. Synthetic insecticides are most commonly used for the control of this pest but comes with their caveats including the development of resistance, environmental consequences, and public health risks. In addition, bio-control has been widely studied using the natural enemies of this voracious pest. Nevertheless, these biocontrol agents are of low specificity as they are known to attack other organisms in the share ecological niches; therefore, the specificity of the purported biological agents should be thoroughly investigated to avoid non-target effects after the release [23].

Date palm, past and present

The Date palm (*P. dactylifera*) is diploid, perennial, and monocotyledonous plant [24] and is most suitable for small and large farming system in dry and semi-arid regions [25]. *Phoenix dactylifera* is derived from ancient Greek word "*Phoenix*" which means purple or red and "*dactylifera*" denotes the finger like appearance of the fruit bunch. Spanish firstly introduced this fruit crop in the arid region of the Arabian Peninsula, North Africa and the Middle East [26]. It is a perennial and dioecious plant with the female as fruit bearing and the male as pollen-bearing plants growing separately. Known history of cultivated date palms as about 6000 years ago in the Mesopotamian region (present-day Iraq) [27-28]. Of the 100 million date palms present in the world, around 60 % are found in North Africa and the Middle East as an important component of people's culture and life in these regions [29]. The date fruit contains a higher amount of carbohydrates (44-88%), fats (0.2-0.5%), protein (2.3-5.6%), pectin (0.53.9%), dietary fiber (6.4-11.5%), fifteen different types of salts, minerals and almost six vitamins [30] Moreover, some cultivars are rich sources of potassium [31]. The date flesh contains 0.2-0.5% oil, while the seed contains 7.7-9.7% [32]. Moreover, dates contain various polyphenols, carotenoids, sterols, procyanidins, and flavonoids, which are required for general body fitness [33]. The trunk of the palm tree is used for making packaging materials for fruits and vegetables [34]. The tree parts are used in household goods, and building materials as well as for the preparation of animal feeds [35]. Similarly, the wood is used to prepare animal shelters, and their fruit used as food sources [36].

Economic importance

Date Palm has a major socio-economic importance not only for its fruit but also as an ornamental plant. Dates are a staple food and the main source of income for date-growing regions and have great importance for the local economy, society, and environment [37]. This voracious pest is damaging the share of date palm in the economy of several countries.

In the Middle East and North Africa, and from the last few decades even to Australia, India, Mexico, Southern Africa, South America, Pakistan, and the USA. The global production of thedates has steadily increased over the last several decades with an annual production of 1.8 million tons in 1962 to 7.0 million tons in 2016; while in Pakistan a total of 0.494 million tons of dates was produced from an area of 95,802 hectares [38], In United states of America total production was 0.03804 million tons annually in 2016 [39]. Pakistan is the sixth leading date-producing country [40], while Egypt is the top dates producing and exporting country in the world [41]. In Pakistan, about 300 date varieties cultivars have been documented including Aseel, Muzawati, Hillawi, Begum Jhangi, Rabai, and Dhakki. Developing countries are facing problems of low nutrition availability per capita that can be addressed by increasing the cultivation area under date palms and adopting better management practices to control emerging pests and diseases.

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Table1: Top Dates producing countries with total production, average yield, and area (FAOSTAT 2016. http://www.fao.org/faostat/en/#data/QC

Country	Production (tonnes)	Yield (hg/ha)	Harvested Area/ha
Egypt	1,694,813	351,965	48,153
Iran (Islamic Republic)	1,065,704	55,113	193,368
Algeria	1,029,596	61,550	167,279
Saudi Arabia	964,536	66,284	145,516
United Arab Emirates	671,891	71,813	93,561
Iraq	615,211	19,830	310,243
Pakistan	494,601	51,628	95,802
Sudan	439,120	118,005	37,212
Oman	348,642	144,545	24,120
Tunisia	241,000	39,353	61,240
Total	7,565,114	980,086	1,176,494

Emerging Threat to Date Palm Plantations - Red Palm Weevil

Date palm trees can be impacted by several pests and diseases, among those red palm weevil (*R. ferrugineus*) is the most severe threat to the health of date palm orchids across the globe.

Distribution of Red Palm Weevil

R. ferrugineus is the most voracious feeder among palm tree pests [42-44]. It belongs to Curculionidae family under Coleoptera order [45-46]. In today's world, the major proportion of total date palm production belongs to the Middle East and North Africa, however, during the last three decades, there has been a notable spread of date palms to Australia, India, Mexico, Southern Africa, South America, Pakistan and the USA. It was first reported in 1891 in India [47] and Pakistan, (Multan, Muzaffargarh, and Dera Ghazi Khan) [48]. In Pakistan, it was first time reported in Khairpur district [Sindh] [49].This pest is now present on all continents of the world, except Antarctica. Since then it has been reported in many countries across the globe (Table 2).

Host range

The RPW has been reported to invade 29 palm tree species especially date palms in South East part of the Asia, Africa, and the Middle East [50-56] oil palm *Elaeis guineensis* Jaquin [57], Canary Island date palm *P. canariensis* Chabaud, [58]. Less than twenty-year old age palm trees were badly affected by this weevil [59-60]. Almost all known species of palm are more or less susceptible to the weevil [61-63].

The host status of two native European palm species *Chamaerops humilis* and *Phoenix theophrasti* Greuter has not been clearly understood.Chamaerops humilis is a native European species initially thought to exhibit resistance against *R. ferrugineus* [64] whereas the genus *Washingtonia* has been included in the vulnerable plants list [65]. However, experimental evidence indicates that *R. ferrugineus* never infest *Washingtonia filifera* (Lindl.) Wendl, while *W. robusta* is susceptible against this pest [66].

Biology and life cycle

Egg: The female of the *R.ferrugineus* makes a hole by its snout in which eggs are laid. Creamy white eggs with shiny surface, elongated shape and about 2.62×1.12 mm in size [67]. Before hatching, the mouthparts of the larvae can easily be seen into the egg shell. Depending on the temperature, eggs are hatched between three to several days [68].

Larvae: The creamy white color with a brownish head, legless larvae may appear with 13 segmented body, approximately 50 mm in length and 20 mm wide. The number of larval instars and development depends upon favorable temperature and diet, under favorable conditions, developmental rate may be approximately 24 to 128 days [69-70]. [71] observed 17 instars, while [72] observed 3 instars when meridic diet provided to adult. Although, [73] detected 13 larval instars of the insect infesting *P. canariensis* palms. The newly larva make galleries/tunnels into the stem by boring with snout, where they live and feed on the soft tissues. At maturity, larvae spin their cocoons and pupate at the leaf base [74]. Before pupation, they transition through pre-pupa stage which may last for approximately for 3 days [75].

Pupae: After pre-pupal stage they are converted into pupae that is approximately 80 × 35 mm in size [76]. In the early stage, pupae are creamy color but at later stage they turn brown with a shiny surface and are reticulated. The development rate of pupal stage lasts for approximately 11 to 45 days [77-79].

Adult: Emerging adults live on their host and complete their life cycle [80]. The color of RPW adults are rusty red with average size (35 mm in length and 12 mm of width) and have a long-curved rostrum. Males have short brownish setae on the anterior dorsal half of the

Table 2: Distribution pattern of *Rhychophorus* spp. (Modified from El-Mergawy and Al-Ajlan, 2011)

Continent	**Country**	**Location of record**	**Year of first recorded**	**Host plant**	**Reference**
Asia	India	Northern India	1891	*Cocos nucifera*	Lefroy, 1906
	areas under Pakistan	Punjab (Multan, Muzaffargarh and Dera Ghazi Khan)	1891	*P. dactylifera*	Milne 1918
	Qatar	Doha	1985	*P. dactylifera*	Zaid *et al.,* 2002
	UAE	Rass El Khaima	1985	*P. dactylifera*	Zaid *et al.,* 2002
	Oman	Northern Oman,	1985	*P. dactylifera*	Azam *et al.,* 2001
	Saudi Arabia	El Qatif district)	1987	*P. dactylifera*	Ferry & Gomez 2002; Zaid *et al.,* 2002
	Iran	Saravan, Sistan	1990	*P. dactylifera*	Faghih, 1996
	China	Fujian	1990	*P. canariensis*	Yuezhong *et al.,* 2009
	Pakistan	Sindh (Khairpur)	1992	*P. dactylifera*	Baloach *et al.,* 1992
	Israel	Yafit and Yitav	1994	*P. dactylifera*	Kehat, 1999;
	Palestine	Jericho Palestinian Territories	1999	*P. dactylifera*	Kehat, 1999;
	Jordan	Shunnae (on the Jordanian side of the Jordan Valley)	1999	*P. dactylifera*	Kehat, 1999;
	Japan	Makurazaki-city	2000	*P. canariensis*	Aman *et al.,*2000
Africa	Egypt	Al Salihyah and, Al Qassasin	1992	*P. dactylifera*	Cox, 1993
	Morocco	Tangier	2008	*P. canariensis*	EPPO, 2009
	Libya	North East of Libya (Tobruk)	2009	*P. dactylifera*	EPPO, 2009
Europe	Spain	Granada, Spain	1995	*P. dactylifera*	Barranco *et al.,* 1996
	Italy	Marsala, Ragusa Catania,	2004	*P. canariensis*	Longo and Tamburino, 2005
	Turkey	Canary Islands	2005	*P. dactylifera*	Karut and kazak, 2005
	Syria	Lattakia city	2005	*P. dactylifera*	Karut and kazak, 2005; Sacchetti *et al.,*2005; Kontodimas *et al.,* 2006;
	Greece	Hersonissos	2005	*P. dactylifera* and *P. canariensis*	EPPO, 2008; EPPO, 2009
	Cyprus	Limassol district	2006	*P. canariensis*	Kontodimas et al., 2006 EPPO, 2008
	France	Sanary	2006	*P. canariensis*	EPPO, 2006
	Portugal	Algarve	2007	*P. canariensis*	EPPO, 2008
	Albania	Albania Territory	2009	*P. dactylifera*	EPPO, 2009
North America	USA	Laguna Beach, Orange County, California,	2010	*P. canariensis*	(NAPPO 2010)
		Texas	2012	*P. canariensis*	(NAPPO 2012)
		Yuma, Arizona	2015	*P. canariensis*	(NAPPO 2015)

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rostrum. Female rostrum is different from the male due to lack of hair and relatively thin, curved and longer. The young adults from cocoon lay their eggs for 3 weeks inside the abrasion parts of leaves and trunk, cracks, or on offshoots [81]. Adult weevils are active during day and night but crawling and flying is limited during the day time. In their total life span, males and female mate many time, and mating can take place at any time. Three generations have been reported in their total life cycle in Egypt [82] with the shortest generation period of 100.5 days and the longest period of 127.8 days.

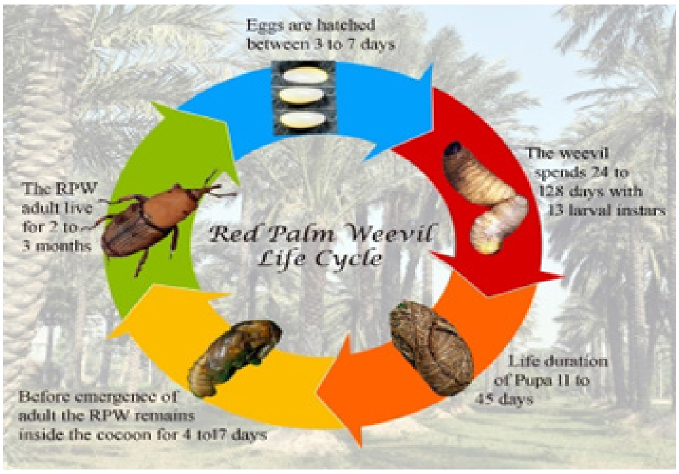

Fig 1. Life cycle of *R. ferrugineus* (By M.A. Saleem)

The adults have the strong flying ability with well-development wings [83], and can easily cover 500–800 m long distances [84]. Flight mill studies classified the adult weevil flyers into three categories including short, medium and long distances to evaluate the flying ability. It has been recorded that 54% of an adult are short flyers and cover <100 m distance, while 36% are medium flyer and cover 100-5000m but the rest 10% are long flyers covering about >5000 m distance; indicating a diverse range of flight habits [85]. Much of the RPW population is short-distance flyer [86-87], which can be a helpful feature playing a vital role in pest aggregation.

Detection methods for *Rhynchophorus ferrugineus*

One of the major constraints with the RPW is early detection before the palm orchids are ruined. With the concealed feeding habit, this insect provides no sign of infestation apparently until the damage to the plant is beyond the threshold of recovery. Only the later stages of damage are conspicuous however, efforts to develop better early detection methods are underway. Once palms are infested by RPW, they are very difficult to treat, especially *P. canariensis* which often dies from extensive damage before detection [88]. Different techniques have been used for the detection and management *R. ferrugineus* infestation; detection and control techniques are being overviewed as under:

Acoustic sensors for early detection

The RPW is intrinsically a hidden pest, posing a magnum challenge for early detection of this pest, by the time damage is visible and detectable, the host plant is seriously damaged. Infested palm plant could be destroyed and eradicated at the first sign of damage symptoms to avoid pest propagation [89]. Infestation level of *R. ferrugineus* can monitored using different detection techniques. One of the promising methods is the use of acoustic sensors in early detection [90-92]. Though acoustic method show promise for the early detection of *R. ferrugineus* [93]; however, distinguishing the RPW larvae from other insects can be difficult due to the production of short, high-frequency sound impulses by larvae which can be similar sounds of other insects or small animals, or by wind-induced tapping noises [94]. This technique has been successfully applied to detect RPW in Saudi Arabian date palm orchards, in the presence of background noises of birds, machinery, winds and other non-target insects [95]. The spectral features extracted from the acoustic movement of the RPW larvae can be helpful in early detection and protect the palm tree from further infestation [96]. Late instars larvae can easily be detected by acoustic detection systems [97-99]. Neonate RPW is large enough to be detected over distances of 0.5–1 m with sensitive equipment [100]. Inspecting the infested date palm tree and early detection by acoustic sensors is helpful in the successful control of *R. ferrugineus*-Integrated Pest Management program.

Visual detection

A practically important method to detect damage symptoms of *R. ferrugineus* is the visual observation of palm trees. The technique is applicable for determining the level of RPW infestation in a broad range of host species including date palms. The visual symptoms of *R. ferrugineus* activity depend on the infestation stage; tunnels formed on the trunk and at frond's petiole bases, thick brown liquid ooze out, chewed plant tissue frass with fermenting smell odor, adult weevil and their cocoon remains around the tree, and in severe cases trunk break down or topping [101]. However, palms may have broken down or dead at the later stage of infestation.

In a study conducted in Saudi Arabia, appropriately trained personnel were used to determine the health of date palm plantations and visual observation was used to detect *R. ferrugineus* damage. It was found that monthly inspection of the date palms could maintain a healthy orchid [102]. The period between the egg laying stage to the emergence of an adult is 45 days and appropriately trained personnel can detect infestation before the emergence of adults. Therefore, regular inspection of the date palm is the most important component of management practices to keep the pest population under control. However, visual detection of date palm infestation is exhausting and time-consuming practice, not suitable on large scale plantations. Alternately, the combined use of pheromone and trapping technique provide a viable basis to control *R. ferrugineus*. In addition, Geographical Information System (GIS) technique along with pheromone traps have been documented successfully chronicle the activity of the weevils on large scale plantations [103].

Chemical detection

The date palm plantations infested with *R. ferrugineus* are known for releasing characteristic odorous chemicals and detection of such chemicals is a valuable early detection strategy. In the past, various dog breeds including Rottweilers, Beagles, Labradors and Golden Retriever were employed for sniffing based detection. The ability of Golden Retriever dogs to successfully sniff and detect the oozing secretion from *R. ferrugineus* infested palm trees under laboratory conditions [104]. However, the ability of trained dogs to reliably detect infested palm in field has not been proven [105]. In summer, under elevated temperatures, their ability could be negligible or limited [106]. Olfactory sensors present new prospects for chemical olfactory recognition in the industry on large-scale quality control applications, monitoring for health and security purposes [107]. In agriculture, electronic gas sensors have been used to detect volatile organic compounds emitted by plants infested by insects [108]. Unfortunately, these sensors are also highly sensitive to the presence of other different compounds such as alcohols, ketones, fatty acids and esters [109] and more studies need to be carried out to develop sensors that can accurately detect chemical signatures of R. ferrugineus infested palms.

Thermal imaging detection

The RPW larval feeding activity produces heat, resulting in increased temperature inside the infested trunk above the ambient temperature (30°C to 45°C) that can be recorded using infra-red cameras [110-111]. Aerial thermal imaging is a promising method for date palm trees, to map water status and health of commercial scale plantations [112]. Semi-automated procedures could be developed to process thermal images of palm trees in homogeneous plantations on a large scale to map infestation and detected canopy temperature [113]. Potamitis *et al.,* evaluated thermal system on field scale to detect infected trees [114]. By measurements, imaging and analyzing of infected and uninfected trees over multi-year experiments in quarantine and commercial orchards, thermal imaging was able to detect RPW induced water stress and differential canopy temperatures. In a recent study, baseline information on temperature profiles of *R. ferrugineus* infested trees was provided [115]. This is a nondestructive method promising early detection in this serious pest. However, powerful devices are required to detect infested plantations. Additional work is needed for use of this techniques to detect the initial *R. ferrugineus* infestation level.

Semiochemicals

More than a hundred years ago, semiochemicals were introduced for the management of different insect pest. In the past 50 years, the advancement of sensitive analytical techniques, has made it possible to detect the chemical signals associated with a broad range of insect species. Species of both sexes can be attracted by aggregation pheromone [116]. It has been observed that the pheromone attraction (specifically aggregation pheromones) is synergized by the volatiles emerging from the plants. The combinatorial effects of these plant volatiles and the pheromones, are more potent attractant for conspecifics compared to their impact. In some cases, the repellent volatile effects have also been reported [117]. Semiochemicals are important components of effective management tactics, particularly, for cryptic species [118].

The integrated pest management (IPM) strategy has been extensively used to restrain the *R. ferrugineus* population in date palm plantations [119]. In the context of problems associated with the practices of traditional insecticides, the semiochemicals have prospects for behavioral manipulation to reduce the resistance development risks in target pests [120]. Synthesis, formulation, and use of aggregation pheromone produced by male Ferrugineol is an effective control method [121]. Pheromone traps are

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a valuable strategy for monitoring the adults in palm tree plantations where pheromone traps are installed [122]. Pheromone traps are useful monitoring and management strategy in commercial palm plantations as well as in zones with highly valuable historic palms like Elche-Alicante, Spain. [123-124] checked pheromone-trapping efficiency with a Sensitive olfactometer against RPW in field and laboratory conditions and reported that aggregation pheromone (ferrugineol) are more effective for attracting virgin male and female than the mated or old age weevil population. The semiochemicals play important role in IPM programs for the control of *R. ferrugineus*. Use of α-pinene, individually and or combine with repellent, methyl salicylate was found effective in the control of *R. ferrugineus* [125]. Nevertheless, the integration of further precautionary measures in IMP programs is needed for the effective protection of the palm plantation. For instance, the oviposition rate and egg-hatching ability of *R. ferrugineus* depend on area temperature; considerations of these factors in the implementation of baiting /trapping IMP program can be advantageous.

Baiting Trapping Capture Efficacy and Station Design

Aggregation pheromone, ferruginol is the most common pheromone of *R. ferrugineus* [126-127]. These traps are preferably for capturing the adult female weevil over the male in a ratio between 2:1 (female: male) [128-132] with 74% capture efficacy for adult female weevils (Jayanth *et al.* 2007); whereas 65% capture efficacy has been reported for 4-methyl-5-nonanone (ketone) [133].

Different food baits have been reported; however, the best food bait used for the adult weevil is 250g of dates in 1L of water [134]. In addition, the mixture of ethyl acetate in the insect trap have been reported to increase the capture efficacy for adult weevils [135].

Pheromone traps are installed at half buried in the ground or hanging on a palm tree and placed under the shady area [136]. A trap design consisting of 5 Litre bucket with four-window, fabricated with the outer rough surface has been used in Saudi Arabia [136]. In another study, a black dome-shaped trap was used in Spain, to capture *R. ferrugineus* adults [136].

Reproductive/ Biotechnological control (Sterile Insect Technique)

The sterile insect technique (SIT) is a valuable strategy for controlling of different insect pests. This technique has been applied in various countries to control the population of insects impacting humans, animals, and crops [137]. In the 1970s, SIT was adopted for the control of *R. ferrugineus* in India by releasing the mass population of sterile *R. ferrugineus* adult males; however, it failed to yield desirable results due to the collection of higher population of fertile females in field [137]. X-ray radiation is known to affect RPW adult males [138] whereas no effect had found on the F2 generation by the γ radiation [138]. The X-rays dose of 1.5 krad resulted in 90% sterility in adult male weevil without affecting their life span; whereas higher doses resulted in complete sterility and shortened life span [139]. Moreover, RPW mating behavior is not disturbed by γ radiation, and no effect is seen on weevil behavior [139]. The SIT technique can yield variable results due to the hidden behavior of RPW that impact the chances for the female to mate with normal males [140]. Some of the challenges in the application of SIT include difficulty in getting normal-sized RPW adults mass raised on an artificial diet, competition between normal and sterile adults, and difficulty in males separating from females, In addition, lack of knowledge of RPW subspecies in an area is a challenges group of subspecies may act barrier in mating between populations, In their life cycle RPW adults mate several times and only single copulation required for an adult female to producing fertile eggs [140]. Therefore, a population-based kinetic model is needed to determine the optimal ratio of sterile male adults to fertile females for the successful implementation of SIT technique.

CONCLUSION AND FUTURE PERSPECTIVE

The *R. ferrugineus*,RPW is a voracious pest of the different palm species in the world and are extensively spread in all the continents. In Pakistan, RPW has become the major pest of the date palm and destroy the dates, with 10–20% losses found in Pakistan [140, 141], 10-25% losses in coconut tree recorded in India. Based on the above information, concluded that RPW did not control 100% under field conditions. Better knowledge is required about the RPW biology, their reproductive and damaging behavior, host range specificity, early detection of RPW damage to reduce infestation level, trap and capturing with pheromone, chemicals control, the success of different IPM strategies and natural enemies of this pest implemented to curtail the effect of this pest and minimize pest population. However, adopting an early detection technique by using bioacoustics sensor could help manage RPW. Treatment with insecticides in early attacked of pest are helpful to recover the plant. Moreover, food baited pheromone, sex pheromone, and aggregation pheromone strategy could be implemented for the mass trapping or weevil. Biotechnological control strategy, SIT is very useful in several countries to eradicate pest populations. The release of Insects with Diseased Lethality can be another emerging tool to fight this insect pest with least harm to natural fauna and flora. Identifying lethal genes in the population or introducing the same from some foreign source to the wild population of RPW can keep this under control. Female-specific lethality that is already in practice for fruit flies, pink bollworm, and mosquitoes can be a good choice to target the females of RPW with good reproductive potential. This area of research is awaiting some share from researchers associated with RPW and close relatives of it. Further experiments will be necessary to improve the different management strategies of this pest and implement new methods which can be more effective against the RPW to reduce the population and palms safe from destruction.

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