Key Factors in Red Palm Weevil Biology (*Rhynchophorus ferrugineus*) (*Curculionoidea*)

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Abstract

A tentative life-table study of the Red Palm Weevil (RPW) is presented in order to emphasize the control key factors in the pest biology, behaviour and ecology. Important characteristics of the relationship between *R. ferrugineus* and the infested plants are its short duration and the weevil association with fermentation microorganisms. These characteristics contribute to the fast host plant death. One of the serious consequences of this unbalanced coexistence is that natural enemies have neither time nor a suitable niche to control the pest. The weevil reproductive r/selection strategy is based on its high reproduction rate and accordingly, on the large scale spreading-related adult mortality. A further population control factor could be represented by cannibalism or food competition with young larvae. However, this hypothesis is difficult to demonstrate. One more important feature in *R. ferrugineus* success is its chemical communication model based on palm wound and tissue fermentation chemical cues. At present, the attractiveness of newly infested/damaged plants is a well-known issue in palm pest management. Further characteristics in *R. ferrugineus* fitness are its polyandrous mating and egg laying strategies that make the weevil a pest even at a very low population level. Planting host palm species in orchards with a density higher than the natural one made RPW shift from endemic to epidemic and therefore, become a destructive palm pest.

INTRODUCTION

Despite the *Rhynchophorus ferrugineus* (Olivier, 1790) is a pest of cultivated palms from a relatively long time (Milne, 1918; Simmonds, 1925; Faleiro, 2006) and effective control strategies have yet to be developed. There are no successful control measures available for the growers (Leefmans, 1920).

Moreover, the RPW host plant also moved from coconut to alternative host date palm and Canary palm thereby causing severe damages by killing tens of thousands *Phoenix dactylifera* L. and *canariensis* in the Mediterranean area.

The recent introduction of *R. ferrugineus* in the Caribbean Islands and USA substantiates the quick dispersal ability and severe damages caused by this devastating pest species (Nisson et al., 2010).

The present study discusses several topics related to the interaction between RPW and its host plant and focuses on the most successful strategies to control *R. ferrugineus*.

MATERIALS AND METHODS

This study is based on direct observations carried out on palms infested by RPW and other palm weevil species in several countries in Europe, Africa, Near East and Central America.

During the collection trip in Costa Rica (1995), observations were carried out in the rain forest on unidentified palms infested by a *Rhynchophorus* sp. near La Selva OTS

Biological Station (Heredia) and on weevil-infested *Elaeis guineensis* Jacq. (oil palm) near the "Manglar de Sierpe" on the Snake River (Rio Sierpe) bank.

A plot was established at the Mediterranean Agronomic Institute of Bari (CIHEAM-MAIB, Italy) in 2007 to study RPW behaviour. A similar semi-field trial was also conducted in Malta starting from 2008. Further observations on date and Canary palms were also carried out in Lebanon (Beirut), Morocco (Tangeri), Spain (Alicante and Elche), and Saudi Arabia (Eastern Province). Finally, more than 300 *P. canariensis* naturally infested by *R. ferrugineus* in Apulia (Italy) were also studied. Adults from infested palms were collected and observed in controlled conditions and then discarded after use. It is strongly suspected that RPW can easily adapt to experimental conditions.

RESULTS AND DISCUSSION

Commercial palms are monocotyledonous plants devoid of secondary meristems and, thus, unable to recover from damages inflicted to their stipe. The stipe shows a complex system of intermingled vessels to build an internally interconnected "pillar" filled with starchy parenchyma. Moreover, with the exception of date palm (*Phoenix dactylifera* L.), they have just one sprout: a single vegetative apex concealed into the plant top (Tomlinson, 1961; Zimmermann and Tomlinson, 1965). Due to special anatomical character of palm trees, it is difficult or even impossible for them to survive or recover once infested.

The duration of infestation plays an important role in the biology of RPW (Fig. 1). Unlike other insect pests, the weevil infests and kills the host palm quickly. Even in the natural ecosystem, the time-span of RPW palm infestation is yet to be known. Infested coconut and date palm may be reinfested repeatedly and lose their sprouts due to the recurrent grubs feeding. Canary palm is infested just once; it is killed because of the massive plant parenchyma infection by RPW-associated bacteria and yeasts (Fig. 2). During the process of egg-laying, bacterial infection occurred on eggs and egg-chamber. The microorganisms enhance RPW larvae fitness by turning plant tissues into an alcohol-acid and warm environment (up to 48°C) which is highly favourable to grub development.

The bacterial fermentation and higher temperature inside the trunk suppress the development of any natural enemy of RPW. Therefore, in natural ecosystem beneficials are not available or they hardly survive.

RPW consumes and destroys the palm tree in less than one year, then the adults are forced to abandon it and start to lay their eggs into a new palm. During this large-scale spread, they are able to explore more than thirty thousand hectares (Fig. 3). Spreading-related adult mortality (Fig. 4) is likely to be the main mortality factor for RPW (Murphy and Briscoe, 1999).

The RPW courtship, mating and egg laying is a key point to understand pest population dynamic. Egg laying behaviour details were rather unknown until a recent study (Ince, 2010). Polygamous and polyandrous RPW females mate as they emerge from the pupal cell; moreover, they mate many times before and/or during egg-laying that occurs day and night, indifferently (Fig. 5). Ovipositing is fast and takes less than four minutes per egg. Few eggs are laid, one at time, during a session but a series of maximum eight eggs were observed in the present study. Very often the female lays eggs alone, without mating in between, even if a male is adjacent. Repeated mating and egg laying were rarely observed (Fig. 6).

CONCLUSIONS

RPW infestation is a lethal and fast event based on the pest biological r/strategy. The pest with its host plant forms a temporary environment that does not permit any kind of ecological equilibrium, thus hampering the presence of any weevil antagonist. Moreover, the niche modification, triggered by RPW-associated microorganisms, excludes pathogens of the weevil from infested plant tissues.

Plant secondary metabolites as wound kairomones or bacterial fermentation products help the pest to reach suitable host plants so that the attractiveness of newly

infested and/or damaged plants is a well-known issue in RPW management.

Moreover, high-density planting in orchards or in urban areas minimizes the dispersion-related adult mortality of *R. ferrugineus*.

The ability of RPW to spread and the interaction mode between the pest and its host plant turns the weevil into a serious pest for economically-relevant palms even at very low population density.

The pest density is less than 0,01 RPW/ha and strongly suggests that the use of preventive and protective pest control measures could reduce its population successfully.

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Figures

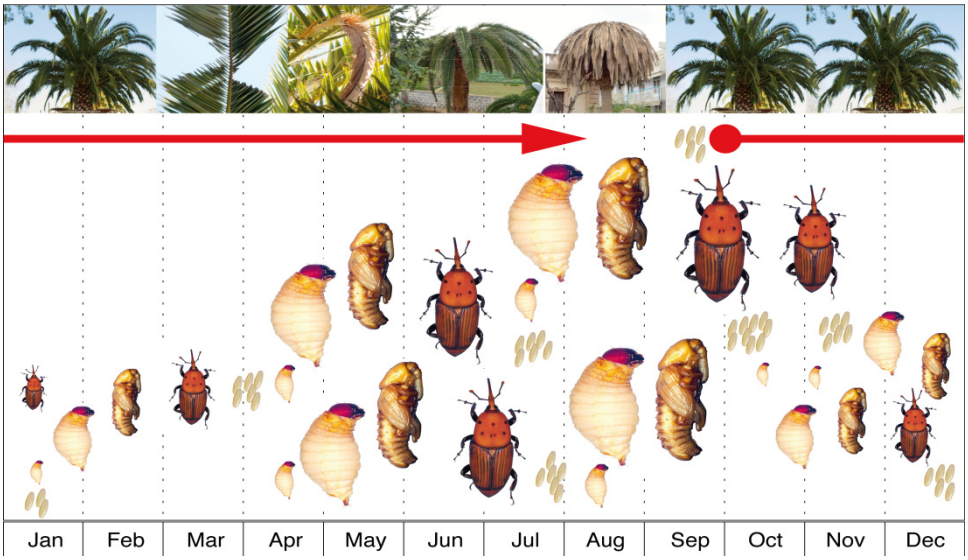

Fig. 1. The interaction between the pest and its host plant is short and lethal to host plant. A consequence of this unbalanced symbiosis is that natural enemies have neither time nor a suitable niche to control the pest.

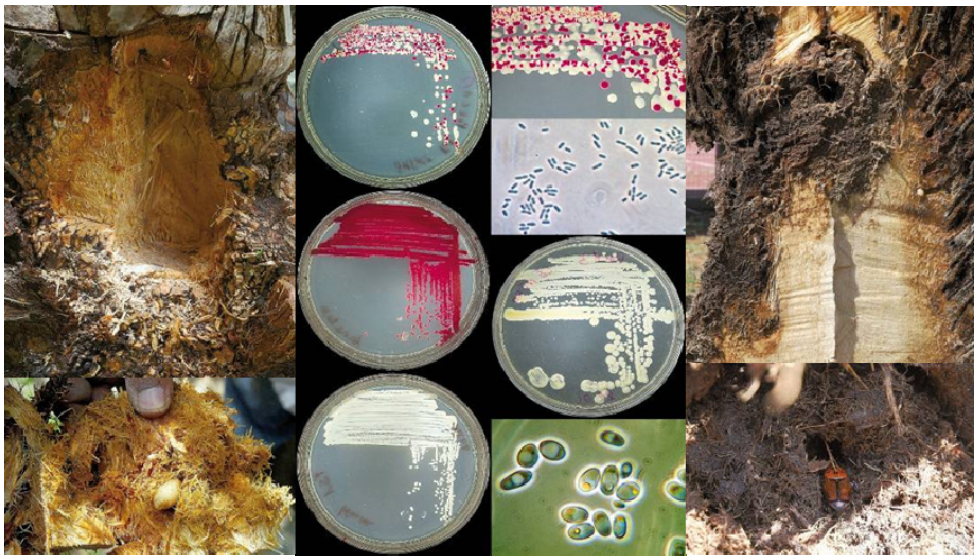

Fig. 2. The host plant shift drives biological changes enhancing the pest fecundity, the micro organic symbiosis and, thus, the weevil fitness. Infested coconuts exhibit small foci each harbouring few (1-20) juveniles (left column) while hundreds RPW to more than one thousand infest a single Canary palm (right column). Bacteria and yeasts found associated with Red Palm Weevil eggs and egg chamber (centre column) trigger the plant rotting that blackens *P. canariensis* tissue.

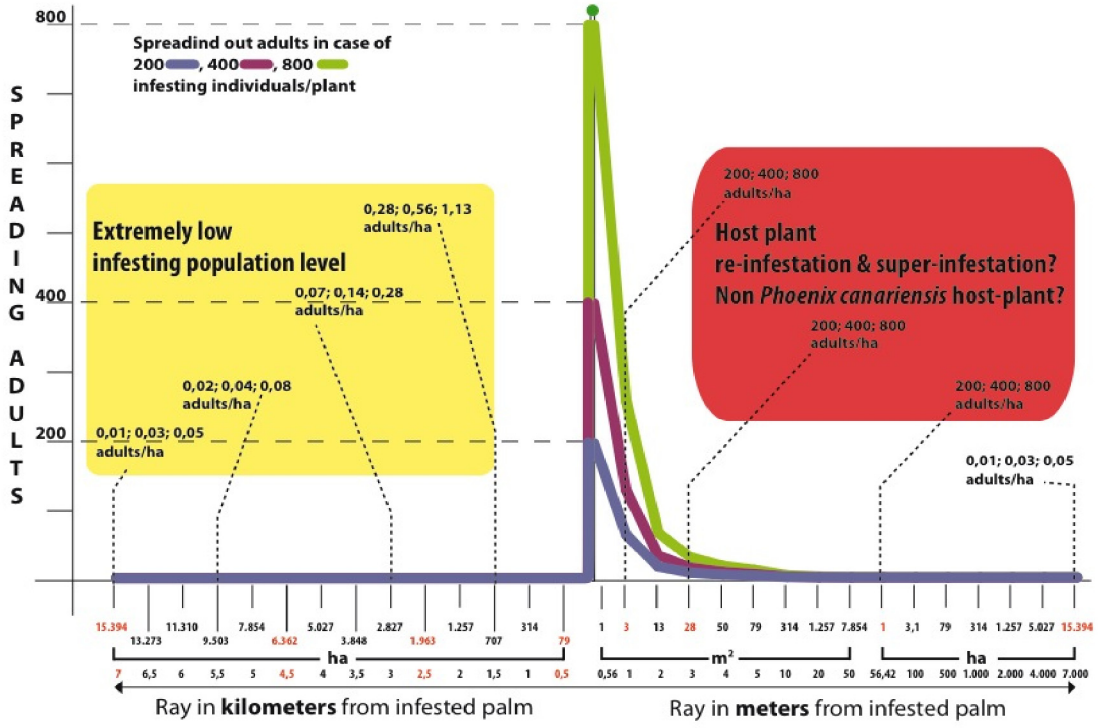

Fig. 3. RPW spreads and adults population density.

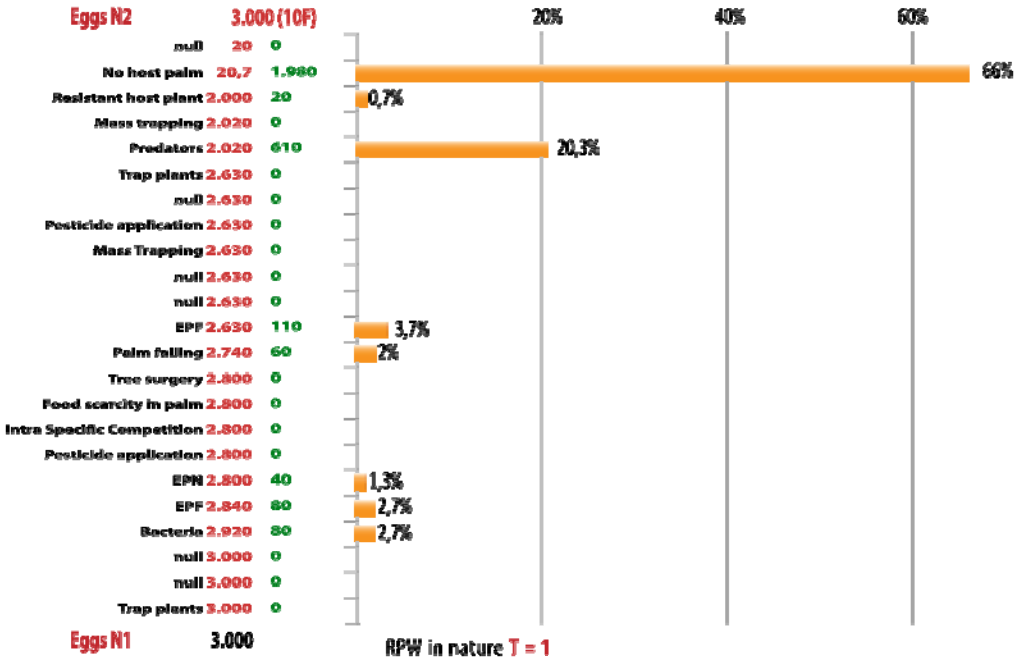

Fig. 4. RPW r/selection strategy is based on high reproduction rate and dispersion-related adult mortality as calculated in this simplified life table for a natural population.

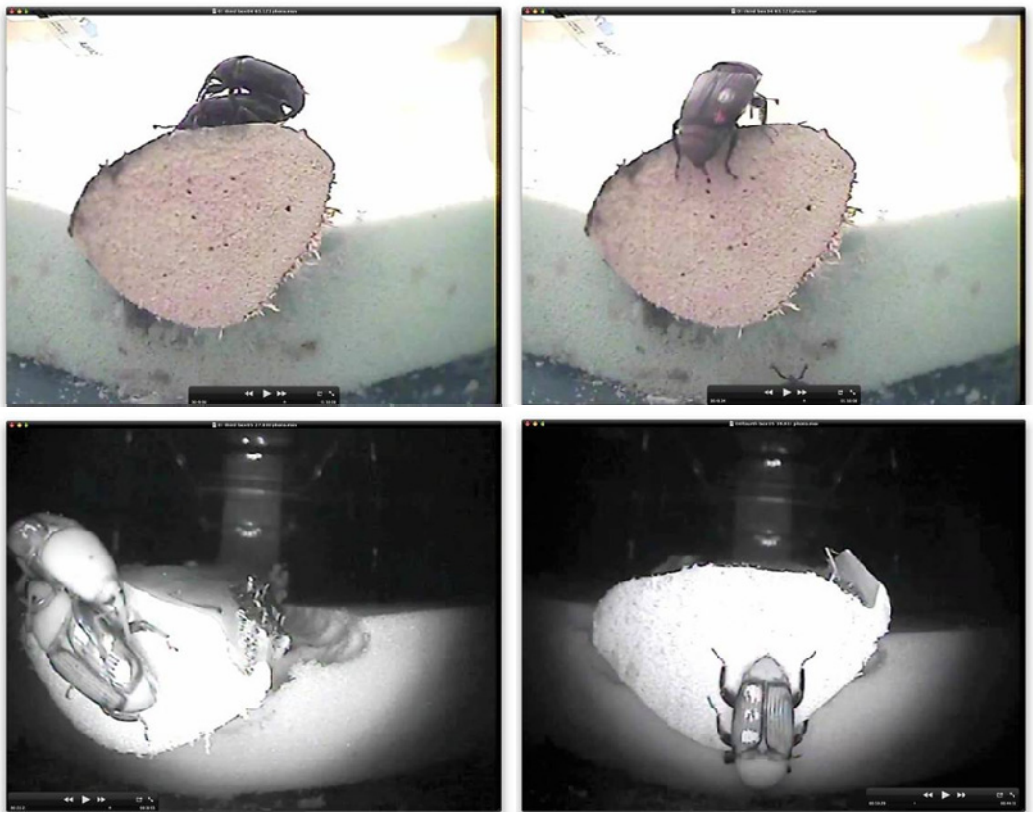

Fig. 5. *R. ferrugineus* mating, feeding and egg laying take few minutes on the host plant and occurs indifferently by day and by night.

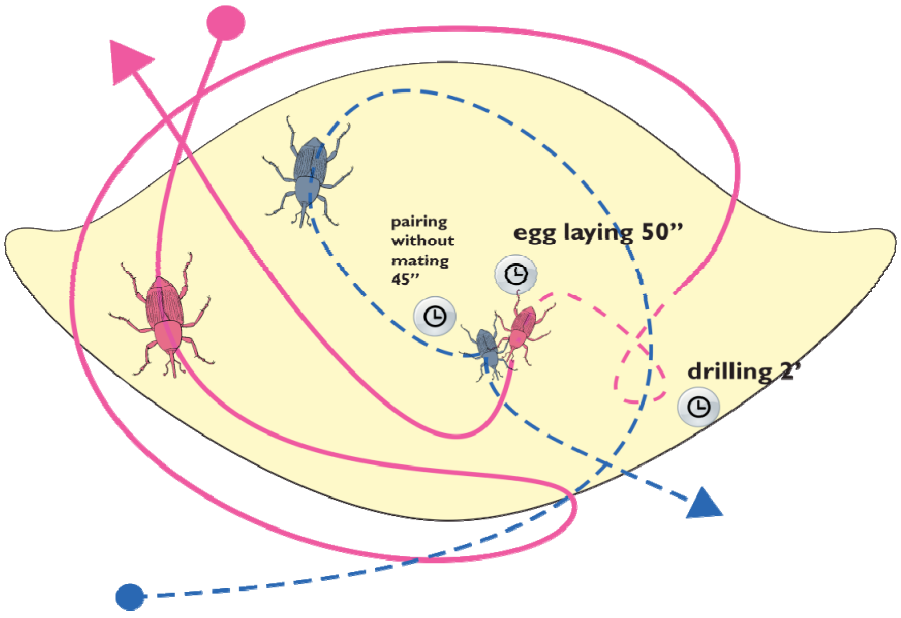

Fig. 6. Egg laying behaviour is fast and complex involving plant drilling even by males, host plant acceptance at egg release, feeding, mating and drilling without egg laying and direct egg laying by females alone.