Fecundity, Fertility and Survival of Red Palm Weevil (Rhynchophorus ferrugineus) Larvae Reared on Sago Palm

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Fecundity, Fertility and Survival of Red Palm Weevil (*Rhynchophorus ferrugineus*) Larvae Reared on Sago Palm

(Pembiakan, Kesuburan dan Kelangsungan Hidup Larva Kumbang Palma Merah (*Rhynchophorus ferrugineus*) yang Dipelihara dengan Sagu Sawit)

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ABSTRACT

Red palm weevil (RPW), Rhynchophorus ferrugineus *has been reported as a serious pest of coconut, sago palm and date palm in many parts of the world. In Malaysia, RPW is a lethal pest of coconut in Terengganu and sago palm in Sarawak. However, very limited information about the reproductive performance of RPW is available, specifically in Malaysia. In the present study, the reproductive performance of RPW reared on sago palm (*Metroxylon sagu*) were studied using nine pairs of virgin RPW under laboratory conditions. The number of eggs laid and eggs viability were recorded daily until females could not produce eggs. The total numbers of eggs laid were 3081 and the average number of eggs deposited by a female was 342.3±0.97 eggs (ranged from 270 to 396). The percentage of hatchability was 52.4% and out of the total 1614 hatched eggs, only 118 individuals (7.3%) were survived until late instar. However, no significant differences in fecundity, hatchability and total survived larvae in different RPW pairs were observed. Females longevity was found to be strongly influenced by the number of eggs laid; the higher number of eggs laid, the shorter is the life span of the female. This study is important to understand the biological aspects of RPW, as a first step to develop effective control strategy of the pest.*

Keywords: Coconut pest; fecundity; fertility; red palm weevil; Rhynchophorus ferrugineus

ABSTRAK

Kumbang palma merah (RPW), Rhynchophorus ferrugineus *telah dilaporkan sebagai perosak yang serius untuk kelapa, sagu dan kurma di merata tempat di dunia. Di Malaysia, RPW merupakan perosak pembunuh untuk kelapa di Terengganu dan sagu di Sarawak. Walau bagaimanapun, tidak banyak maklumat tentang prestasi pembiakan RPW, terutamanya di Malaysia. Kajian ini bertujuan untuk mengkaji prestasi pembiakan RPW dengan menggunakan sembilan pasang kumbang dewasa dara dalam keadaan makmal dengan dibekalkan makanan sagu (Metroxylon sagu). Bilangan telur direkodkan setiap hari sehingga kumbang betina tidak dapat menghasilkan telur. Jumlah bilangan telur yang dihasilkan ialah 3081 dan purata bilangan telur yang dihasilkan oleh setiap kumbang betina adalah 342.3±0.97 telur (antara 270 hingga 396). Peratus telur yang menetas adalah 52.4% dan daripada 1614 telur yang menetas, hanya 118 ekor larva yang hidup sehingga instar terakhir. Walau bagaimanapun, tiada perbezaan yang signifikan antara pembiakan, kesuburan dan larva yang hidup untuk setiap pasangan kumbang yang diuji. Jangka hayat betina didapati sangat dipengaruhi dengan bilangan telur yang dihasilkan; semakin banyak telur yang dihasilkan, semakin pendek jangka hayat kumbang betina. Kajian ini sangat penting untuk memahami aspek biologi RPW kerana ia merupakan langkah pertama untuk membangunkan strategi kawalan perosak yang berkesan terhadap perosak kumbang ini.*

Kata kunci: Kesuburan; kumbang palma merah; *pembiakan; perosak kelapa;* Rhynchophorus ferrugineus

INTRODUCTION

The red palm weevil (RPW), *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Curculionidae), is an economically important invasive tissue-boring pest of various palm species in many parts of the world. At the moment, RPW is described as a pest of 26 palm species belonging to 16 different genera (Malumphy & Moran 2009). The RPW has spread from its native Southeast Asia, to Asia (including China & India), Northern Africa, the Middle East, Europe, Oceania (Australia & Papua New Guinea), Caribbean (Aruba & Curacao) in 2008 and California in 2010 (EPPO 2010).

In the field, the male of RPW produces a pheromone which causes the weevils to aggregate on damage trees (Gunawardena & Bandarage 1995). The larvae can only feed on soft tissue, tree crown, upper part of the trunk and at the base of petioles. At the same time, they not only bore into the decaying tissue of dying palm, but can also attack healthy palm. Tunneling and feeding by the larvae enervate the infected trees, which die as a consequence of the build up numerous generations attained by the insects (Ferry & Gomez 2002). Infestations are problematic because RPW is very difficult to be detected until the crown of the coconut collapse. The infected trees can die in a few months.

RPW infestation was first detected by the Department of Agriculture (DOA) in 2007, which caused the death of coconut palms (*Cocos nucifera*) in 58 localities in all seven districts of Terengganu, east coast of Peninsular Malaysia. RPW was also found to attack other palm trees such as nibong (*Oncosperma* sp.), nipah (*Nypa fruticans*), sago palm (*Metroxylon sagu*) and the Royal palms (*Roystonea* sp.) (Zazali Chik 2012). The infestation of RPW on coconut palms in Terengganu have increased drastically in 2011 (858 localities) and the damage level is expected to increase in the future (DOA 2011; Wahizatul et al. 2013). However, until now little study on the biology and life history of the RPW is recorded in Malaysia. This invasive weevil has the potential to become one of the aggressive coconut pests which will threaten the coconut industry and the survival of other palm trees, specifically the oil palm plantations which is the key economic growth driver in Malaysia.

In this current study, *R. ferrugineus* was used to determine the reproductive parameters such as fecundity, fertility and total survived larvae of this invasive pest reared on sago palm (*Metroxylon sagu*) under laboratory conditions. As there is very few information about RPW available especially in tropical climate of Malaysia, understanding the reproductive performance could be the first step in the development of better techniques for their control.

Materials and Methods

INSECTS COLLECTION

Cocoons of RPW were originally obtained from infected coconut palm trees in infested coconut palm which were located at Setiu Agriculture Department, Rhu Tapai (5°31'53"N 102°44'2"E) and Marang Agriculture Department (5°12'0"N 103°13'11"E), Terengganu, Malaysia. The cocoons were incubated in the General Biology Laboratory, Universiti Malaysia Terengganu under laboratory conditions (25±2°C, 70±5% RH, photoperiod of 12: 12 (L: D) h). Upon emergence, the adults were fed with sago stem and later allowed to mate. The adults were sexed according to gender-specific based on external characteristics of the rostrum (Wattanapongsiri 1966).

MATING EXPERIMENT

Nine pairs of virgin adult weevils which represent nine replicates were placed in separate containers labeled as pairs A, B, C, D, E, F G, H and I for the mating experiment. Each pair was allowed to mate for only one time per day (approximately 30 min - 1 h). The mating experiments were conducted for 81 days and were continued for another study (i.e. life cycle and adult longevity) which took about 7 months of total study period. Male A was put into container of female A for mating**.** After finished copulating (approximately 1.5 h), the male was taken out and transferred back into its individual container. The females were separated from males after the copulation has ended. Each female was placed in a rearing container provided with sago stem to feed and laying egg. Similar mating procedures were done for pairs B, C, D, E, F, G, H and I. Sago were renewed every day for adults. Rearing containers were emptied daily and the sago stems were examined for eggs.

REPRODUCTIVE PERFORMANCE

Parameters measured for the reproductive performance of each RPW pair were fecundity (total number of eggs laid per female), hatchability (total number of hatched eggs), survived larvae until 7th instar and adult longevity (life span of adults). Fecundity, hatchability and total survived larvae were studied for 60 days, whereas adult longevity were determined after 7 months of study period (October 2011 until April 2012). Five to six of deposited eggs were placed and reared on a sago stem. Small holes were made on the lid of the containers and wet tissues were used to maintain high humidity of the sago stem. After 4-5 days, the newly hatched eggs were carefully removed using soft forceps and placed individually in small rearing containers provided with sago stem for feeding. The sago stem was replaced after 3 days.

DATA ANALYSIS

Analysis of variance (ANOVA) was used to evaluate differences in each reproductive parameter such as fecundity, hatchability and survived larvae between RPW pairs. Data were $\log(x+1)$ transformed to ensure normality in calculations of means and ANOVAs. Where there were significant differences, least significance difference (LSD) tests were employed to describe which means were most alike (or different) and to test the equality of means for each pair of variables. Spearman correlation analysis was done to determine the relationship of female longevity with total number of eggs laid. All statistic analyses were conducted with SPSS 19.0 statistical software.

Results and Discussion

The adult fecundity experiments were done for 81 days for each pair of RPW except pairs B and G. This was due to the short life span of female B (31 days) and female G (35 days) compared with other females. The nine tested females deposited a total number of 3081 eggs and the average number of eggs deposited per female was 342.3±0.97 eggs (ranged from 270 to 396). Pairs G, E and F recorded the highest number of eggs laid (396, 392 and 386 eggs, respectively), followed by pairs H (361 eggs), I (352 eggs), A (320 eggs) and B (316 eggs). Pairs C and D recorded the lowest number of eggs laid (270 and 288 eggs, respectively) (Figure 1). However, no significant difference in the total number of eggs laid per female were found (F= 0.969, $p > 0.05$). The number of eggs laid for each pair of RPW was decreasing day by day over a period of approximately 11 weeks (81 days) until the females could

not lay eggs again (Figure 2). In general, egg production can be costly because it makes high energy demands on available resources and leads to a decrease of insect's life span (Chapman et al. 1998; Yanagi & Miyatake 2003).

The average fecundity in the present study was lower than the previous studies. For instance, previous studies reported that RPW could lay eggs up to 531 eggs (Wattanapongsiri 1966) and 55-412 eggs (Aldhafer et al. 1988). Each tested female could lay 270-396 eggs and the period of oviposition took only 9-10 weeks. A review study by Blumberg (2008) reported that the female could lay 300–500 eggs over a period of 8-10 weeks. After that, the female could not lay eggs until death although the male still mate with the female.

In the present study, the eggs took 4-5 days to become new hatching larvae. Some researchers measured the egg incubation of RPW in other host plants. The incubation period was from 4 to 6 days when RPW reared on semi-artificial diet (Sharaby & Al-Dhafar 2013). Urbano (2008) found that egg hatches need 2 to 5 days to become whitish or yellowish legless larvae which bore into the interior of the date palm and feeding on soft succulent tissues. Thus, it can be concluded that the current study achieved similar results on incubation period of RPW.

In this study, only 1614 eggs (52.4%) were successfully hatched from a total number of 3081 eggs deposited by all tested females. The highest percentage of fertility was contributed from pair C, (75.9%), followed by pairs D, (69.1%), A (64.1%), I (50.3%), B (47.8%), H (44.6%), G (44.2%), E (44.1%) and F (43.5%) (Figure 1). There was no significant difference for fertility between different pairs of RPW (F= 0.510, p>0.05).

In contrast, some studies found that the percentage of egg fertility were higher compared with the present

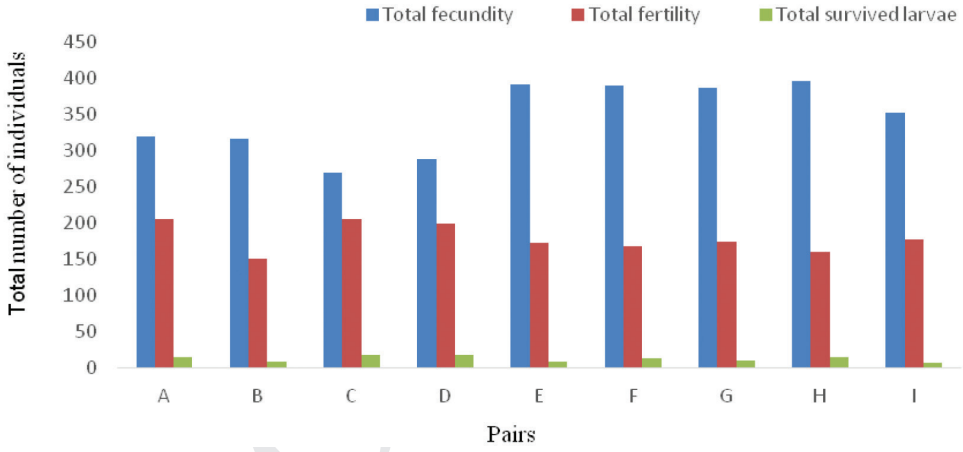

FIGURE 1. Total number of fecundity, fertility and total survived larvae for each pair of RPW

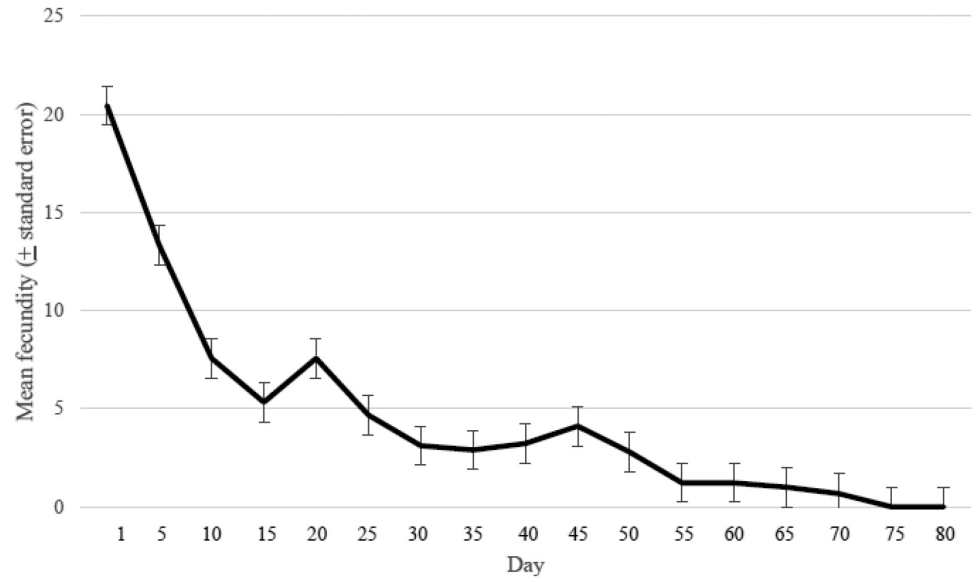

FIGURE 2. Mean fecundity rate vs. days for all 9 pairs of RPW adult for 81 days. Note that fecundity data for female of pair B and pair G were only recorded for 31 days and 35 days compared with other females

study. For example, the paper of Leefmans (1920) cited by Dembilio and Jacas (2012) mentioned that 87% of hatchability was reported when females reared on sago pump lumps and 65-95% of hatchability was obtained when females reared on sugarcane (Aldhafer et al. 1998). Li et al. (2010) reported that the temperatures from 28 to 32°C were the most suitable temperatures for the development time, survival and reproduction of RPW reared on sugarcane. In the present study, the laboratory temperature conditions was 25±2°C, which may suggest that the temparature condition might be affecting the fecundity and fertility rate for this experiment. This assumption was also supported by Kaakeh (2005) who reported that suboptimal conditions (host plant type, temperature, and rearing procedure) could affect the number of eggs deposited by the females and the rate of fertility.

The total survived larvae were 118 individuals (7.3%) until late instar (7th instar). The survived larvae from pair D was the highest (19 individuals), followed by pairs C (18 individuals), H (16 individuals), A (15 individuals), F (14 individuals), G (10 individuals), B and E (9 individuals each) and I (8 individuals) (Figure 1). At the end of the larval instar, the larvae would compact most of the available medium to form a pupal cell (cocoon). There was no significant difference for survived larvae between different pairs of RPW (F= 1.579, p>0.05).

The longest life span for the female was female D (162 days), followed by females C, B, A, I, H, F and E (120 to 70 days). Unexpectedly, the shortest life span was female G which only survived for 35 days. Female G contributed the highest number of eggs laid (396 eggs) compared with other females. There was a negative correlation between the longevity of females and total number of eggs produced. The female longevity decreased significantly with increasing total number of eggs laid (p<0.05). Probably, Female G had to lose lots of energy to reproduce eggs due to its high fecundity and as a concequence, less potential to survive as long as other females. In general, egg production can be costly because it makes high energy demands on available resources and leads to a decrease of insect's life span (Yanagi & Miyatake 2003).

In the present study, the reproductive performance of RPW is considered low as compared with previous studies. However, the previous studies conducted on the reproductive aspects of RPW have been inconclusive and contradictory. Some studies reported overlapping generations which comprised of different stages of the weevils. For example, RPW could lay eggs up to 531 eggs (Wattanapongsiri 1966), 55-412 eggs (Aldhafer et al. 1988) and 250 eggs (Murphy & Briscoe 1999). Larval development has been reported 25-105 days (Abraham et al. 1998; Avand Faghih 1996) and 128 days (Salama et al. 2009), depending on feeding substrate and temperature.

So far, there is limited study on reproductive performance of RPW on sago palm reported in the literature. Sago palm is classified as one of important crops in East Malaysia, Sarawak and played an important role in socio-economic, cultural aspect and food source for indigenous people. The only reports on growth performance of *Rhynchophorus* spp. in Malaysia were *R. schach* (*R. vulneratus*) on coconut palm in Perak (Sivapragrasm et al. 1990) and sago palm in Sarawak (Bong et al. 2008). Sivapragasm et al. (1990) only reported the life cycle of *R. vulneratus* in infested coconut palms and the conditions of each stage under laboratory conditions. Bong et al. (2008) studied on meridic diet of *R. schach* (*R. vulneratus*) and they found that sago flour diet was the most suitable diet compared with other diets. However, they did not mention the number of survived larvae until last instar in the larval stage development on meridic diet.

In this study, it is suggested that sago has limited nutrient as it contains only pure carbohydrate and little nutrients for the larval growth. Based on sago nutritional content analysis, sago contains 84.6% carbohydrate and 15.4 % of moisture, fibre, ash, protein and fat (Nurul Ain Aqilla 2013). Thus, further study will be conducted to compare the reproductive performance of RPW for different food diets such as coconut palm and oil palm which will be supported with nutritional content analysis data. The quality of host plant plays a significant effect on the survival and development of larvae, and also influence the weight, reproductive ability and longevity of adult insects (Al-Ayedh 2008; Calvo & Molina 2005).

Conclusion

In conclusion, the fecundity, fertility and total survived larvae (until 7th instar) of RPW reared on sago palm were lower compared with the previous studies. The number of fecundity until 7th instar were found to decrease gradually for each pair of RPW. This is probably due to lower fecundity of RPW females after certain period of time and it is suspected that egg production can be costly as it requires high energy demands on available resources for the insect. It is hoped that findings from this study will provide important information on the biological aspects of this invasive pest, specifically in Malaysia tropical climate. However, further study is needed to ensure this study is more accurate for the whole life cycle from eggs production until adult emergence. Further experiments will be conducted to determine whether the rearing environmental conditions and food types (coconut and oil palm) influence the individual's growth, survival and fecundity through their effects on pupal weight and adult body size.

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