

Laboratory Study of life table and demographic parameters of Red Palm Weevil (*Rhynchophorus ferrugineus*, Coleoptera: Dryophthoridae) on sugarcane slices

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Abstract

Red Palm Weevil (RPW), *Rhynchophorus ferrugineus*, is a serious pest of palms throughout South and Southeast Asia which are the native habitat of this pest. The aim of this study was to assess survival and fertility characteristics of the Red Palm Weevil (RPW), *R. ferrugineus* in the laboratory. Life tables and population parameters of the RPW were constructed on sugarcane slices as a course food for RPW under laboratory conditions. The results showed that the highest mortality occurred in 12th instar. The life table analysis showed that the population density of RPW decreased gradually. The survival ratio of male to female was 0.396:0.604. The females lived for a maximum of 196 days. The highest number of eggs produced per female per day was 5. The intrinsic rate of increase (r_m) in egg production per female per day was 0.17 and the daily finite of increase (λ) was 1.19 females per female per day, with a mean generation time (T) of 25.15 days. The net reproductive rate (R_o) of the population was 70.18. The population doubling time (DT) was 4.8 days.

Keywords: Red Palm Weevil, Life table, Population parameters

Introduction

Red Palm Weevil (RPW), *R. ferrugineus*, is a serious pest of palms throughout South and Southeast Asia which which are the native habitat of this pest Sadakathulla (1991). The invasion of *R. ferrugineus* spread rapidly in the Middle East, Europe, USA and South America Wattanapongsiri (1966); Marante (2003); Zhang et al. (2008); Jones et al. (2013). This

pest feeds primarily on Arecaceae such as dates palms, coconut tree, sago palm as well as oil palm. Besides, it has also been recorded on Agavaceae (century plant), and Poaceae (sugarcane) Malumphy and Moran (2009). Infestation with RPW starts with gravid females attracted to palm volatiles for laying eggs which hatch into damage inflicting larvae.

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Infestation date palms exhibit several symptoms depending on the stage of attack, e.g. oozing of brownish fluid mixed with palm tissue exerted by feeding larvae that has a typical fermented odor, tunneling of palm tissue by larval, presence of adults and pupae at the base of fronds, drying of infested offshoots, fallen pupae around an infested palm, drying of outer leaves and fruit bunches and topping of trunk in case of sever and extensive tissue damage Abraham *etal*(1998).

In Egypt, the beginning of the invasion was caused by an importation of offshoots from the United Arab Emirates. At the beginning, the extension of this pest into Egypt was restricted to a limited number of locations in two northeastern provinces. In 1995, three years after its first discovery in Egypt, an Egyptian agriculture official considered that the red palm weevil had been eradicated Ferry (1996).

Unfortunately, this announcement was erroneous. In the two provinces where the pest was first recorded, the red palm weevil continues to infect and kill new date palms year after year, despite all the efforts developed to combat it Gomez and Ferry (1998).

It was reported to infest 40 palm species worldwide Anonymous (2013) Laboratory rearing of insects is very important to maintain purity, age and sex-based selection for carrying out lab and field test for improving the control strategies.

The knowledge of insect biology, behavior, population dynamics and availability of various stages in bulk amount facilitates in keeping many factors unbiased Shahina *et al.* (2009). The construction of life tables is an important tool for understanding the population dynamics of an insect. Age-specific life tables serve as a framework for organizing data on mortality and natality. Additionally, it provides a detailed transparent description of the actual properties of the cohorts. It generates simple summary statistics including life expectancy and natality rate. It also has a basic form that can be expanded, condensed, or modified for analyzing different types of data such as mortality by various factors Carey (2001). Analysis of life tables is the most suitable method to evaluate natality and reproduction of a population Southwood (1978); Begon and Mortimer (1981); Price (1997). Deevey (1947) reported that a life table is a concise summary statement for every interval of age, the number of deaths (dX), the number of survivors at the beginning of the age class X (lX), the rate of mortality (qX), and the expectation of life remaining for individuals of age X (eX).

Therefore, the aim of this study was to construct life tables of (RPW) fed on sugarcane plants for demographic analysis and to determine the survival rate.

Materials and Methods

To study the number of insect generation per year as well as certain biological aspects of this

species of curculionid weevils, adult insects were obtained from cocoons collected from infested date palm trees in Qena district. For this purpose, a huge number of cocoons were brought and put in an oblongate opaque-white plastic boxes (21×10.5 ×7 cm.in length, width, and height,respectively) with press-on tight – fitting lids and perforated covers. These cocoons were kept in wet toweling till adult emergence. The newly emerged adult was sexually differentiated in view of the fact that male dorsal apical half of the snout is covered with a pad of short hairs whereas, female snout is smooth and devoid of hairs Rahalkar et al.(1985). Group of 20 pairs of newly emerged males and female weevils were confined, each pair in a rearing opaque white plastic boxes (32×23×16 cm. in length, width, and height, respectively) and tightly covered with a perforated cover. The insect pairs were left for one week to mate and the boxes were provided with rasped shreds of sugarcane stems as adult food and oviposition substrate. The food was changed every three days by new fresh one. Afterwards the deposited eggs were removed Thus, many newly laid eggs almost of the same age (0.0 – 24 hours) were available.

1.1.Numbers and durations of larval instars:

To study the number and duration of larval instars of this curculionid great numbers of newly deposited eggs of the same age (0.0-24 hours.) were obtained from adults emerged from field cocoons. These eggs were placed on Petri dishes or small plastic boxes (10 ×7cm)

provided with rasped sugarcane and Sprayed daily or we can use a wet ball of cotton to allow a relative humidity of about 90% in order to obtain high percentage of egg hatchability. These dishes were put on the bench and daily inspected to observe egg hatching. Thus, newly hatched larvae of almost the same age (0.0- 24 hours.) were available to the experimental work. To study the number of larval instars, as well as, the duration of each instar about 320 newly hatched larvae were used by putting it on sugarcane slices by using a soft hairbrush. These slices were introduced in a plastic box and tightly covered with a perforated cover. These boxes were placed on a bench in the laboratory. Larvae were inspected daily to record the date of molting by observing exuviae.

1.2. Pre- pupal period:

At the end of last larval instar, and beginning of pre-pupal period, the remaining food was removed from rearing boxes. Each box was provided by a sugarcane stems to use it as a cocoons (7cm). These stems were kept in wet toweling till adult emergence.

1.3. Pupal and adult stage:

After two days from adult Emergence in stems, 5 pairs of adults were taken and put in a plastic box and tightly covered (one pair/ each box). These boxes were provided with Longitudinal halves of sugarcane stems and inspected daily to record the date of laying of the first egg as well as the daily number of eggs deposited till

the end of female life in order to determine female pre- oviposition, oviposition and post – oviposition periods, female fecundity of eggs, male and female longevity and generation interval .When the first newly emerged began to lay eggs, the second generation was initiated on this date, and so on.

The records of temperature and atmospheric relative humidity were used to show the effect of each factor on the insect different biological aspects. The values of simple correlation and simple regression were calculated according to Fisher (1950).

Data analysis was carried out following the single-sex method Birch (1948); Southwood (1978). Life table was constructed using the following column of parameters:

X: the pivotal age for the age class in units of time (days)

IX: the number of surviving individuals at the beginning of age class X

LX: the number of living individuals between the ages X and X+1

dX: the number of dying individuals during the age interval X

100qX: percent apparent mortality

SX: survival rate during a stage

TX: total number of age X units beyond the age X

eX: life expectancy for individuals of age X

mX: age-specific fertility, the number of living females born per female in each interval class

Ro: net reproductive rate, equal to the sum of the IXmX products as in the following equation:

$$R_o = \sum IXmX$$

Tc: cohort generation time (in days), approximated by the following formula:

$$T_c = \frac{\sum Xl_x m_x}{\sum l_x m_x}$$

rc: innate capacity for increase, calculated by:

$$r_c = \ln R_o / T_c$$

rm: the maximum population growth, the intrinsic rate of natural increase or the innate capacity for increase as calculated by iteration of Euler's equation:

$$\sum e^{-rm} \cdot XlXmX = 1$$

Results

Data in Table (1) and Fig. (1) Showed that the life table of the red palm weevil, *R. ferrugineus* Olivier and mortality. The results showed that this insect had from 9 to 12 larval instar since at the end of 9 larval instar: some larvae molted the 10 molts to become pupae. The hatchability percentage of eggs was (87.68%). As shown in Table (1) and Fig. (1) high mortality was recorded in 12th instar (71.43%).

As shown in Table (2) and Fig. (2) The survivorship and fecundity of the red palm weevil, *R. ferrugineus* Olivier. Results show that the first adult female emerged on week 18(126 days). The pre pupal from 3 to 4 weeks. Egg laying was recorded just after 3 days of female emergence) and egg laying almost continued till the death. The last female died on week 32. The mean number of eggs per female laid was 177.

Table (1): Age-Specific Life Table of the red palm weevil, *Rhynchophorus ferrugineus* Olivier.

X	Lx	LX	Dx	100qx	Sx	Tx	Ex
Egg	203	190.5	25	12.32	87.68	1700	8.37
instar1	178	174	8	4.49	95.51	1509	8.48
instar2	170	156.5	27	15.88	84.12	1335	7.85
instar3	143	141	4	2.79	97.21	1179	8.24
instar4	139	136	6	4.32	95.68	1038	7.46
instar5	133	132.5	1	0.75	99.25	901.5	6.78
instar6	132	129	6	4.55	95.45	769	5.83
instar7	126	124.5	3	2.38	97.62	640	5.08
instar8	123	122.5	1	0.81	99.19	515.5	4.19
instar9	122	112.5	19	15.57	84.43	403	3.3
instar10	103	89.5	7	6.79	93.21	290.5	2.82
instar11	76	55.5	6	7.89	92.11	201	2.64
instar12	35	50	25	71.43	28.57	145.5	4.16
Pupae	65	59	12	18.46	81.54	59	0.91
Adult	53	26.5	150				

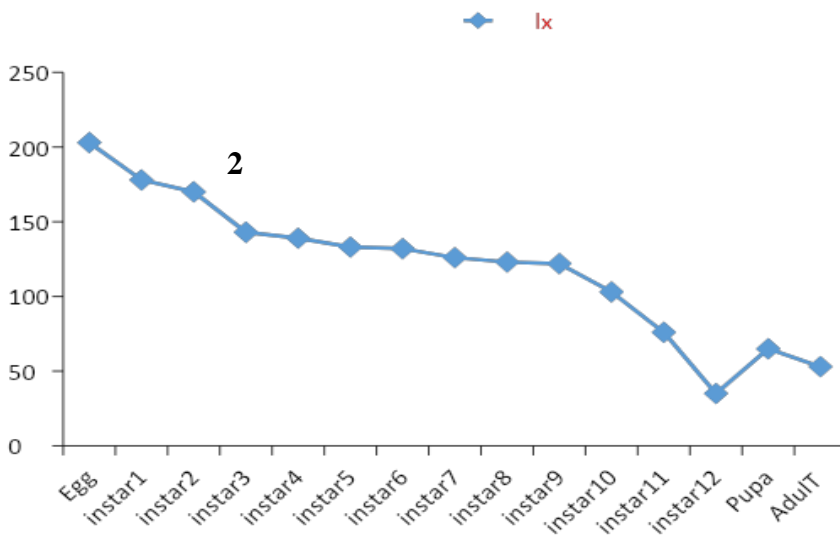


Table 2: life and Age-Specific Fertility table of the red palm weevil, *Rhynchophorus ferrugineus* Olivier

X	LX	MX	LXMX	LXMXX
Week 0-17	Immature stages			
week18	pre ovipositionPeriods			
week 19	0.16	1.87	0.29	5.51
week 20	0.29	3.39	0.98	19.6
week 21	0.48	5.61	2.69	56.49
week 22	0.64	7.48	4.79	105.16
week 23	0.77	8.99	6.92	159.16
week 24	1	11.68	11.68	280.32
week 25	0.99	11.56	11.44	286
week 26	0.96	11.21	10.76	279.76
week 27	0.95	11.09	10.54	284.58
week 28	0.68	7.94	5.39	150.92
week 29	0.52	6.07	3.16	91.64
week 30	0.38	4.44	1.33	39.9
Week31	0.13	1.52	0.19	5.89

Also, the interaction between humic acid application and NK treatment had a significant effect on top length in the first season only. It was clear from the obtained results that the highest mean value of top length/plant (48.1 cm in the first season) was obtained from H₁F₉ (humic acid soil application and 90kg N +100kg K₂O/fed.). While, the lowest mean value in the respect (37.3cm) was obtained from H₀F₁ (without humic acid and 30kg N + 0kg K₂O/fed.).

3-Top fresh weight /plant (g):

Data recorded in Table 3 clear that top fresh weight/plant was significantly affected by humic acid application in the both seasons. The application of humic acid on soil did not differ significantly from the foliar spray of humic acid. The greatest value of top fresh weight/plant (814.44 and 485.78g in the first and second seasons, respectively) were derived from H₂ (foliar application) and H₁ (soil application). Humic substances such as humate, humic acid and fulvic acid, play avital role in soil fertility and plant nutrition. This tendency

was recorded by El-gamal *et al* (2016), (2018), Ozbay and Murat (2018) and Enan *et al* (2016), Nemeata Alla *et al* Thalooth *et al* (2019).

Table 3: Effects of humic acid, NK treatments and their interaction on top fresh weight/plant (g) of fodder beet in 2016-2017 and 2017-2018.

X	LX	MX	LXMX	LXMXX
Week 0-17	Immature stages			
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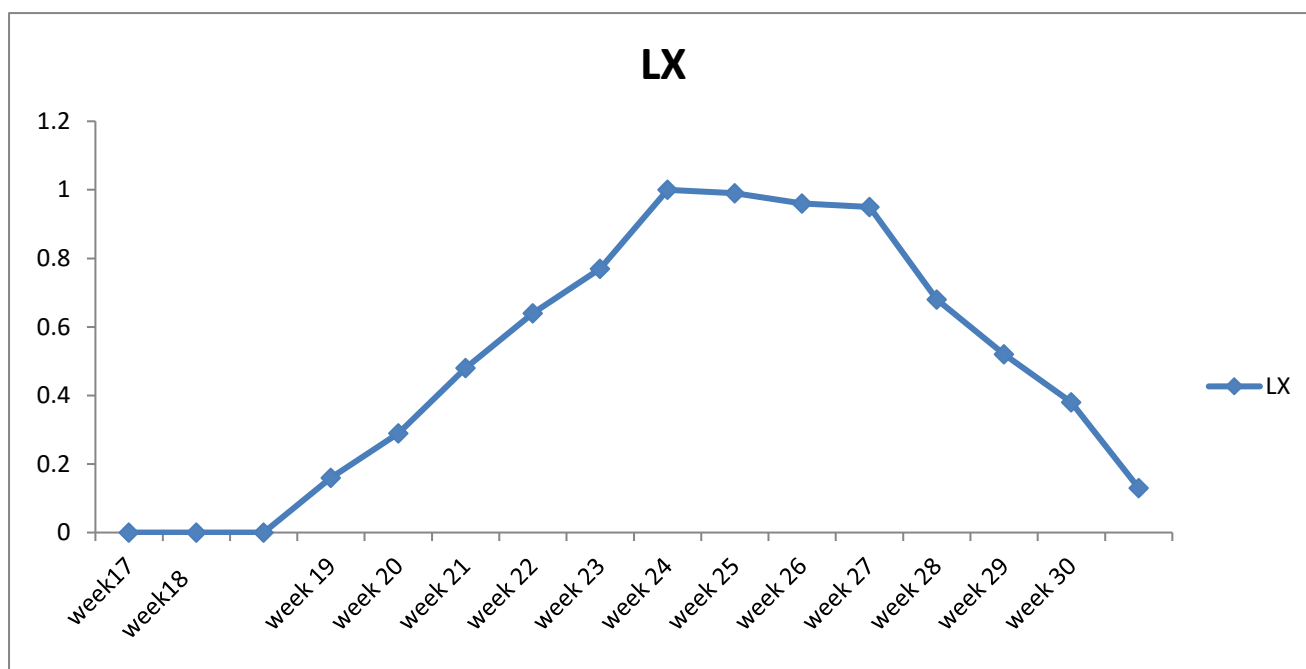


Fig. (2): Daily age-specific survival (LX) and fecundity (mX) of the red palm weevil, *Rhynchophorus ferrugineus* Olivier female fed on sugarcane stems.

Data in Table (3) show the Population and reproductive parameters of *R. ferrugineus* Olivier reared on sugarcane under laboratory conditions. The intrinsic rate of natural increase (r_m) of *R. ferrugineus* Olivier was 0.17 per female per day and the daily finite rate of increase (λ) was 1.19 female off springs per female per day with mean generation time (T) of 25.15 days. The net reproductive rate (R_0) of population was 70.18 female off springs per one female which indicates the rate of multiplication in one generation. Doubling time was recorded only 4.08 days.

Discussion

These results in agreement with those These Kaakeh *et al.* (2001) who proved that the percentage of hatchability (viability of eggs) ranged from 74.3% to

93.3%. Hussein (1998) found that mortality in the five-last instar (from 9th to 13th instar) was higher than in the eight-former instar.

Kaakeh *et al.* (2001) reported that red palm weevil completed its larval period from 50 – 80 days. Rahalkar *et al.* (1985) mentioned that the pupal period ranged from 12 to 20 days and the entire life cycle from egg to adult requires about 80 days. Shahina *et al.* (2009) proved that egg production (2 – 3) days after mating female of RPW laid eggs. These results agreement with Rahalkar *et al.* (1985) mentioned that adult females survive for about 60 days and deposit 70 to 350 eggs. The intrinsic rate of natural increase was first applied by Birch (1948) as a Measuring the animal's growth rate and

has since been used on many insects Lee
et al. (2002).

Table (3): Population and reproductive parameters of *Rhynchophorus ferrugineus* Olivier reared on sugarcane under laboratory conditions.

No.	Parameters	Formula	Values
1	Net reproduction rate (Ro)	$\sum lXmX$	70.18
2	Corrected generation time (T), (days)	$\ln Ro/rm$	25.15
3	Intrinsic rate of natural increase (rm)	$\sum e^{-rm}lXmX = 1$	0.17
5	Finite rate of increase (λ)	e^r	1.19
6	Doubling time (DT), (days)	$\ln 2/r$	4.08
7	Gross reproduction rate	$\sum mx$	92.85

Conclusions

The survivorship curve indicated a modest rate of mortality during the early life stages and a gradual decrease as it approached adulthood. The pooled life table showed that the population changes according to death and birth rates. It showed that mortality of eggs of *R. ferrugineus* Olivier was 12.32% and the

mean net reproductive rate (Ro) was 70.18. The intrinsic rate of natural increase (rm) of *R. ferrugineus* Olivier was 0.17 per female per day and the daily finite rate of increase (λ) was 1.19 female offspring per female per day with a mean generation time (T) of 25.15.

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Conflict of interest

The authors hereby declare that no competing and conflict of interests exist

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