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SOME BIOLOGICAL ASPECTS OF THE RED PALM WEEVIL, *RHYNCHOPHORUS FERRUGINEUS* (OLIVIER) AS INFLUENCED BY REARING ON CERTAIN PALM VARIETIES, TEMPERATURE AND RELATIVE HUMIDITY

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ABSTRACT: Certain biological aspects of *Rhynchophorus ferrugineus* (Olivier) (larval and pupal periods, male and female longevity as well as female fecundity of eggs) were studied for two successive years from 22/6/2005 to 22/6/2007 on five varieties of palms (Hayani, Eglany, Amry, Zaghlool date palms and Pritchardia ornamental palm) under laboratory conditions. The obtained data revealed that the durations of larvae and pupae were high significantly affected by the tested varieties during the 1st and 2nd generations. Longevity of both males and females insignificantly and high significantly influenced with palm variety during the 1st generation, but during the 2nd one the opposite is true. The highest mean numbers of eggs/female (107.33 and 127.50) were deposited in case of Amry and Zaghlool date palm varieties in the 1st and 2nd generations, respectively. The fecundity of females resulted in case of Pritchardia ornamental palm variety was the least during the two aforementioned generations.

Duration of larvae significantly correlated with both temperature and relative humidity for all tested varieties during the three generations completed through the two successive years of the present investigation. Pupal duration showed significant correlations with both temperature and relative humidity during the 1st generation with the exception of those in respect to Zaghlool date palm (temperature) and Pritchardia ornamental palm (relative

humidity) that proved to be insignificantly correlated. The correlation between temperature as well relative humidity and longevity of both males and females differed according to the tested varieties. During the 2nd generation, mean number of eggs/female significantly correlated with temperature and relative humidity in case of Zaghlool date palm variety. Mean complete developmental period positively and high significantly correlated with temperature during the three generations with the exception of that concerning the first generation which showed a negative relationship. The correlation was highly significant with relative humidity during the three generations, except with Eglany and Amry date palm varieties during the 2nd generation that proved to be not significant.

Key words: Date palm, biological aspects, *Rhynchophorus ferrugineus*, susceptibility, temperature, relative humidity.

INTRODUCTION

Date palm, *Phoenix dactylifera* (L.) (Family: Palmaceae), cultivation goes back thousands of years in Egypt. The total number of date palm trees recorded in the ancient life reached about 109 million which yielded 4.2 million metric tons. Arab countries however, contain 78.3% of the total world date palm trees which demonstrate 75% of the world production (Abdel-Megeed *et al.*, 2004).

Unfortunately, during the last decade, a new most serious insect pest, namely the red palm weevil, *Rhynchophorus ferrugineus* (Olivier) (Family: Curculionidae, Order : Coleoptera) was first recorded in date palm plantations of Sharkia and Ismailia Governorates in Egypt by Saleh, Professor of Economic Entomology, Plant Protection Department, Faculty of Agriculture, Zagazig University on 10th of Sepember, 1992 and identified by British Museum as a first record in Egypt and Africa Continent under no. 10634, Africa and group no. 22563 (Saleh, 1992; and Saleh and Gouhar, 1993). The origin of this pest was South East of Asia, mainly in Pakistan, India, Burma, Pengaladish and Indonesia, as have been reported by International Institute of Entomology in London (Liver, 1969) and spreaded later in many other countries where date palms are grown such as Iran and Arabian countries; Iraq, Saudi Arabia, Emirates and recently in

Egypt. It is worthy to mention that the damage of all pests invading date palm trees together can not be comparable with that of the red palm weevil alone as the latter insect is considered a destructive pest. The red palm weevil is a serious pest of cultivated palm trees in India (Ghosh, 1912 and Nirula, 1956) Srilanka (Brand, 1917) and Indonesia (Leefmans, 1920). This weevil has been reported on 19 palm species belonging to 15 different genera (Barranco *et al.*, 2000; EPPO, 2008 and Dembilio *et al.*, 2009).

Now all efforts are undertaken to reduce the damage inflicted by this serious weevil by cultivating varieties which show certain level of resistance to infestation in order to avoid chemical control treatments as possible due to their harmful side effects on human, domestic animals and environment. The economic importance of evaluating the varietal resistance of palms against *R. ferrugineus* received attention of few workers such as Hussein (1998); Barranco *et al.* (2000); Farazmand (2001 and 2002); Abdel-Salam *et al.* (2008) and Dembilio *et al.* (2009).

Therefore, the present work aims to study the impact of some palm varieties, on certain biological aspects of the red palm weevil reared for three successive generations during two successive years under laboratory conditions of temperature and relative humidity.

MATERIALS AND METHODS

The experiments were conducted at Research Laboratory of Date Palm Pests, Plant Protection Department, Faculty of Agriculture, Zagazig University. Adult insects used for mass rearing were obtained from cocoons collected from infested date palm trees in Ismailia Governorate at Qasassin district. Thus, many newly laid eggs almost of the same age (0.0-24 hours old) were available to initiate the insect first generation. These eggs were placed on a relatively small perforated plastic cover that based on the inner lid of cylindrical plastic box (9.5 x 5.0 cm. in diameter and depth, respectively) which filled with 50 ml. of distilled water. Then, the box was tightly covered with imperforated cover to allow the relative humidity of about 90% in order to obtain high percentage of hatched eggs. These boxes were put on the bench and daily inspected to observe eggs hatching. Thus, newly hatched larvae of almost the

same age (0.0 - 24 hrs.) were available to the experimental work that continued for two successive years from 22/6/2005 to 22/6/2007 using five palm varieties. The daily temperature degrees and relative humidity percentages prevailing during the period of the experiment were recorded using a thermohygrograph apparatus.

To study the duration of both larvae and pupae, 150 newly hatched larvae were used by introducing each larva in a small square piece of palm trunk (1.5 x 1.5 cm.) of each variety (Hayani, Eglany, Amry, Zaghlool date palms and Pritchardia ornamental palm) by using a soft hair brush no. 0. Each piece was introduced in a plastic box (2 x 5 cm. in diameter and depth) and tightly covered with a perforated cover. These boxes were placed on a wooden bench in the laboratory and the food (pieces of trunk palm trees) was replenished every day. When larvae were arrived to the tenth instar, they were put in a cylindrical plastic box (9.5 x 5.0 cm. in diameter and depth) and tightly covered with a perforated cover and reared on a small trunk steak of each palm variety (2 - 3 cm. in thickness and 40 g. in weight) and changed every 4 - 5 days by new one. After the adult emergence from cocoons, adults were taken and put in the previously mentioned cylindrical plastic boxes and tightly covered (one pair/each box). These boxes were provided with rasped shreds of trunk palm pieces 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 fecundity of eggs, male and female longevity and complete developmental period.

All the obtained results were statistically analyzed according to complete randomized design and factorial experiments (Little and Hills, 1975). The proper "F" value was calculated as described by Fisher (1944 and 1950) and Snedecor (1957). To make all possible individual comparisons between means of different treatments which proved to be statistically significant, L.S.D. (least significant difference) test was used. The records of temperature and atmospheric relative humidity were used to show the effect of each factor on the studied biological aspects of the insect by calculating the values of simple correlation and simple

regression according to Fisher (1950).

RESULTS AND DISCUSSION

Effect of Different Palm Varieties on Certain Biological Aspects

Duration of larval stage

Data in Table 1 show that feeding of the red palm weevil, *Rhynchophorus ferrugineus* (Olivier) on different palm varieties had a highly significant effect on the duration of larvae of the first generation, wherethrough the larvae fed on trunk pieces of Eglany and Hayani date palms slowly developed to exhibit the long durations of 125.28 and 124.06 days, respectively. Meanwhile, the larvae fed on the other palm varieties showed a gradual shortage in larval periods to give means of 122.13 , 109.91 and 96.75 days with Amry, Zaghlool date palms and Pritchardia ornamental palm varieties, respectively. According to L.S.D.value, the differences between any two means were highly significant at 0.01 level of probability with the exception of those between Hayani, Eglany and Amry date palms as well as between Amry and Zaghlool date palms which appeared to be not significant at 0.05 level.

As clearly shown in Table 1, the effect of different varieties of date and ornamental palms on larval period of *R. ferrugineus* in the 2nd generation was statistically highly significant. The longest mean period (287.25 days) was obtained with Pritchardia ornamental palm. When the comparisons between the different means of the treatments were made using L.S.D. value, it was found that the differences between means recorded with larval period on the four tested varieties of date palm were insignificant (248.57 days on Hayani, 244.08 days on Eglany, 240.67 days on Amry and 250.42 days on Zaghlool). But, the difference between Pritchardia ornamental palm and each of date palm varieties seemed to be highly significant showing the prolongest mean period with the former variety.

Respecting the third generation, data in Table 1 indicate that the variance in the development of *R. firrugineus* larvae on three date palm varieties (Eglany, Amry and Zaghlool) seemed to be significant. The used date palm varieties can

Table 1. Effect of different palm varieties on the duration (days) of different stages of the red palm weevil, *Rhynchophorus ferrugineus* (Olivier) reared during two successive years from 22/6/2005 to 22/6/2007 under laboratory conditions

Generations	Varieties	Starting date	Mean Larval period	Mean pupal period	Mean longevity of adult		Mean number of eggs/ female
					male	female	
First	Hayani	22/ 6/2005	124.06 A	16.85 B	147.80	136.25 A	63.00 BC
	Eglany	22/ 6/2005	125.28 A	20.48 A	116.60	120.10 A	79.40 B
	Amry	22/ 6/2005	122.13 AB	19.25 AB	115.20	114.17 A	107.33 A
	Zaghlool	22/ 6/2005	109.91 B	15.30 BC	109.50	78.00 B	42.67 CD
	Pritchardia	22/ 6/2005	96.75 C	12.69 C	133.40	125.40 A	22.86 D
	F. test		**	**	N.S.	**	**
Second	Hayani	3/ 1/2006	248.57 B	6.71 B	98.67 B	63.00	93.00 A
	Eglany	9/12/2005	244.08 B	9.00 A	145.00 A	72.00	113.50 A
	Amry	20/12/2005	240.67 B	7.31 B	56.00 B	57.13	97.75 A
	Zaghlool	3/12/2005	250.42 B	7.30 B	97.50 B	80.50	127.50 A
	Pritchardia	24/11/2005	287.25 A	8.33 AB	102.25 B	73.33	35.33 B
	F. test		**	**	**	N.S.	*
Third	Hayani	5/10/2006	-	-	-	-	-
	Eglany	7/ 9/2006	255.19 A	8.85	-	-	-
	Amry	13/ 9/2006	242.20 B	10.36	-	-	-
	Zaghlool	26/ 9/2006	253.75 AB	8.33	-	-	-
	Pritchardia	21/10/2006	-	-	-	-	-
	F. test		*	N.S.			

- N.S. indicate that the differences between means are not significant at 0.05 level of probability. - * indicates that the differences between means are significant at 0.05 level of probability. - ** indicate that the differences between means are highly significant at 0.01 level of probability. - Means followed by similar letters indicate that the differences between means are not significant at 0.05 level of probability.

be arranged descendingly according to their suitability for larval development as fallows: Amry (242.20 days), Zaghlool (253.75 days) and Eglany (255.19 days). Comparisons between means of larval period obtained with feeding on different tested treatments using L.S.D. test clearly revealed that the difference between any means was significant with the exception of those between Eglany and Zaghlool as well as between Amry and Zaghlool date palm varieties which appeared to be insignificant.

Similar results were obtained by some authors such as Hussein (1998) who reared the larvae of red palm weevil on three date palm varieties (Hayani, Amry and Zaghloul) as well as ornamental palm under the laboratory conditions of 14-38 °C. and 45-90 % R.H. and found that the larval period was high significantly differed between palm cultivars. Zahgloul date palm appeared to be the most suitable host showing the shortest mean period of larval stage (23.00 days) whereas, the longest one of 47.88 days was obtained with ornamental palm. Kaakeh (2005) stated that the developmental times of larvae ranged from 70.8 to 102.2 days when reared on artificial diets of oat, potato, pineapple, and palm fiber sheath, and on natural diets of sugarcane, palm heart, and palm leaf base. Also, Abdel-Salam *et al.* (2008) stated that there were significant differences between ten palm cultivars (Samany, Barhi, Amri, Sewi, Bartamouda, Sakkoti, Canarien, Seykas, Pritchardia and Meloky) in larval stage recording the shortest period of 37.30 days with Samany date palm whereas, the longest ones of 65.50 and 69.81 days were investigated with Pritchardia and Meloky ornamental palms, respectively.

Duration of pupal stage

Respecting pupal periods of the first generation of red palm weevil, statistical analysis of the results presented in Table 1 showed highly significant differences between the tested palms. The longest mean pupal period of 20.48 days was recorded with pupae resulting from larvae fed on Eglany date palm variety. It was gradually shortened to 19.25, 16.85, 15.30 and 12.69 days for Amry, Hayani, Zaghlool date palms and Pritchardia ornamental palm, respectively. According to L.S.D. value, it is obvious that the

differences between mean durations of pupal stage concerning larvae fed on the tested five palm varieties proved to be highly significant. The differences between any two means were significant excepting those between Eglany and Amry date palms as well as between Hayani, Amry and Zaghlool date palms and also between Zaghlool date palm and Pritchardia ornamental palm which appeared to be insignificant. With regard to the second generation, statistical analysis of the results given in Table 1 revealed that the differences in pupal periods proved to be highly significant. The longest mean pupal period of 9.00 days was recorded on Eglany date palm. The shortest mean period of 6.71 days was obtained from larvae fed on Hayani date palm. The comparisons between different tested palm varieties showed that the differences between any two means were significant excepting those between Hayani, Amry, Zaghlool date palms and Pritchardia ornamental palm as well as between Eglany date palm and Pritchardia ornamental palm which appeared to be not significant.

As regards the effect of rearing larvae on different palm varieties on the pupal duration in the third generation, the data in Table 1 clearly indicate that this effect proved to be statistically not significant at 0.05 level of probability. The longest mean pupal period of 10.36 days was recorded on Amry date palm variety. It was gradually shortened to 8.85 days with Eglany and 8.33 days with Zaghlool date palms.

These results are in agreement with those obtained by many authors such as Leefmans (1920) who reported that the pupal stage of red palm weevil was about 13-15 days. Also, many authors recorded various pupal periods of the red palm weevil such as Hutson (1922), Corbett and Ponniah (1923), Hutson (1933), Butani (1975), Rahalkar *et al.* (1985), Alfazairy *et al.* (2003) and Kaakeh (2005) who mentioned that the pupal period of *R. ferrugineus* reared on certain natural and artificial diets was 2 weeks, 25 days, 12-25 days, 18-34 days, 12-20 days, 15-17 days and 16.1-22.0 days, respectively. Abdel-Salam *et al.* (2008) found that the pupal period of *R. ferrugineus* insignificantly differed according to palm cultivars to partially agree with the present results and this may be attributed to the

differences either in the used palm varieties, prevailing ambient temperature and atmospheric relative humidity during the experimental period.

Duration of adult stage

The results in Table 1 obviously reveal that the type of diet had insignificant and highly significant effects on the longevity of adult males and females of the first generation of this palm weevil, successively. The longest mean of longevity of 147.80 days for males and 136.25 days for females were obtained with adults emerged from cocoons of larvae fed on Hayani date palm variety; whereas, the shortest ones of 109.50 days for males and 78.00 days for females were recorded with adults emerged from cocoons of larvae reared on Zaghlool date palm. When comparisons between the different means of the varietal treatments were made using L.S.D. value, it was found that Zaghlool date palm variety high significantly differed when compared with the other tested palm varieties respecting female longevity, whereas variance between the other group of varieties did not reach the significancy degree at 0.05 level of probability.

Statistical analysis of variance using F. test of the results regarding the differences between means of adult longevity for both males and females of the second generation proved to be highly significant for males and insignificant for females. The longest mean of longevity of 145.00 days for males and 80.50 days for females were recorded on Eglany and Zaghlool date palm vars. respectively. On the contrary, the shortest means of 56.00 days for males and 57.13 days for females were obtained with adults emerged from larvae fed on Amry date palm. The value of L.S.D. test obviously demonstrates that the differences between means concerning male longevity obtained with Eglany variety and the others seemed to be highly significant; whereas, those between means of Hayani, Amry, Zaghlool date palms and Pritchardia ornamental palm were not significant at 0.05 level of probability.

The different results respecting the longevity of both adult males and females of *R. ferrugineus* are confirmed with those obtained by some authors such as Leefmans (1920) and Nirula (1956) who stated that the longest period of

adult life in captivity was 107 days (the first) and adults survived for 2-3 months (the latter). Hussein (1998) showed the effect of feeding of the newly hatched larvae on trunk pieces of offshoots of three date palm varieties namely Zaghloul, Hayani and Amry as well as on those of ornamental palm under the laboratory conditions of 14-38°C. and 45-90% R.H. on males and females longevity and mentioned that it was highly significant. Longevity of male and female recorded the longest periods of 232.75 and 231.50 days with Zaghloul date palm, whereas the shortest periods of 167.00 and 183.50 days with ornamental palm, respectively. Also, Muralidharan *et al.* (2000) found that the longevity of adult male and female of this palm weevil was 70 ± 6.95 and 58 ±3.49 days, respectively. Alfazairy *et al.* (2003) reported that the male longevity was 77-162 (113.91 ± 9.70 days) on cooked diet, while females survived for 80-180 (113.90 ± 8.50 days); but, the corresponding figures for weevils rearing on peeled pieces of sugarcane internodes were 79-137 (100.10 ± 5.10 days) and 44-174 (106.90±5.70 days), consecutively. Abdel-Salam *et al.* (2008) stated that there were significant differences between ten palm cultivars in case of longevity of red palm weevil male and female. Longevity of male and female indicated the shortest periods (73.50 and 76.14 days in case of males and 76.40 and 74.25 days in case of females) with Pritchardia and Meloky ornamental palms, whereas the longest periods of 103.20 and 108.20 days (males) and 101.40 and 99.80 days (females) were recorded with Samany and Barhi date palm varieties, respectively.

Female fecundity of eggs

With respect to the first generation, statistical analysis of the results given in Table 1 revealed that the number of eggs deposited by emerged females from larvae fed on palm trunk of the five tested varieties was high significantly varied according to the diet used. From the obtained results, the insect fecundity can be arranged descendingly as follows: 107.33, 79.40, 63.00, 42.67 and 22.86 eggs/female in case of larvae fed on Amry, Eglany, Hayani, Zaghlool varieties of date palm and Pritchardia ornamental palm, respectively. When the comparisons between the different means of the treatments were made using L.S.D. value, it is clear to

show that the differences between any two means proved to be statistically significant excepting that between means recorded with Hayani and Eglany date palms as well as Hayani and Zaghlool or between Zaghlool date palm and Pritchardia ornamental palm.

Considering the mean number of eggs laid by emerged females in the second generation with the different tested feeding varietal treatments, the effect proved to be statistically significant at 0.05 level of probability the highest mean number of 127.50 eggs/female occurred with Zaghlool date palm variety. The number of eggs decreased gradually to show means of 113.50, 97.75, 93.00 and 35.33 eggs/females when larvae and adults were fed on trunks of palm of Eglany, Amry, Hayani date palms and Pritchardia palm, successively. When comparisons between the different means of the varietal treatments were made using L.S.D. value, it was found that Pritchardia ornamental palm variety significantly differed when compared with the other tested palm varieties.

The mean number of eggs /female differently varied according to varieties or generations (Hutson, 1922; Nirula, 1956; Butani, 1975; Sivapragasam *et al.*, 1990) Hussein (1998) who found that the mean number of eggs/female was high significantly differed between palm cultivars. Muralidharan *et al.* (2000) and Salama & Abdel-Razek (2002) stated that Zahgloul date palm appeared to be the most suitable host showing the highest mean number of eggs/female (306.00 eggs) whereas, the lowest one of (259.75 eggs) was recorded with ornamental palm. Results obtained by Abdel-Salam *et al.* (2008) confirmed our results where they found significant differences between palm cultivars recording the highest mean number of eggs/female (394.00) with Barhi date palm, whereas the lowest one (213.80) with Pritchardia ornamental palm.

Effect of Temperature and Relative Humidity on Certain Biological Aspects

Duration of larval stage

Data in Table 2 reveal that the longest periods of *R. ferrugineus* larvae of 125.28 ± 19.19, 255.19 ± 11.93 and 287.25 ± 21.47 days were recorded with Eglany date palm in both 1st and 3rd generations and Pritchardia ornamental palm in the 2nd one at daily means of 29.25°C., 57.27 % R.H.; 20.10°C.

Table 2. Coefficients of correlation (r) and regression (b) between larval and pupal durations (days) of the red palm weevil, *Rhynchophorus ferrugineus* (Olivier) and daily means of temperature and relative humidity during two successive years from 22/6/2005 to 22/6/2007

Generations	Varieties	Starting date	No. of individuals	Mean duration ± S. D.	Daily mean		r		b	
					Temp. °C.	R.H.%	Temp. °C.	R.H.%	Temp.°C.	R.H.%
Larval stage	Hayani	22/ 6/2005	18	124.06 ± 27.82	29.21	57.36	-0.985**	0.736**	20.33	31.50
	Eglany	22/ 6/2005	29	125.28 ± 19.19	29.25	57.27	-0.991**	0.706**	18.73	33.11
First	Amry	22/ 6/2005	16	122.13 ± 12.39	29.45	57.18	-0.990**	0.553*	18.40	54.10
	Zaghlool	22/ 6/2005	11	109.91 ± 5.97	30.04	57.18	-0.981**	-0.778**	34.48	67.14
	Pritchardia	22/ 6/2005	20	96.75 ± 6.55	30.37	57.34	-0.987**	-0.935**	60.41	34.58
	Hayani	3/ 1/2006	7	248.57 ± 15.63	24.30	57.66	0.994**	-0.012	40.19	5.44
	Eglany	9/12/2005	12	244.08 ± 5.82	22.72	58.47	0.918**	-0.958**	23.66	90.73
Second	Amry	20/12/2005	21	240.67 ± 18.51	23.14	58.02	0.993**	-0.584**	32.93	67.81
	Zaghlool	3/12/2005	19	250.42 ± 21.41	22.58	58.78	0.991**	-0.838**	28.38	70.83
	Pritchardia	24/11/2005	8	287.25 ± 21.47	23.31	58.91	0.992**	-0.927**	33.84	41.44
	Hayani	5/10/2006	-	-	-	-	-	-	-	-
	Eglany	7/ 9/2006	16	255.19 ± 11.93	20.10	64.09	0.997**	-0.997**	35.11	16.73
Third	Amry	13/ 9/2006	35	242.20 ± 19.85	19.81	64.33	0.523**	-0.430**	13.17	4.60
	Zaghlool	26/ 9/2006	8	253.75 ± 15.10	19.90	63.53	0.990**	-0.983**	31.69	18.90
	Pritchardia	21/10/2006	-	-	-	-	-	-	-	-
Pupal stage	Hayani	22/ 6/2005	13	16.85 ± 7.02	22.66	58.48	0.804**	0.820**	1.45	2.17
	Eglany	22/ 6/2005	23	20.48 ± 5.75	21.16	59.27	-0.911**	0.734**	3.17	1.32
First	Amry	22/ 6/2005	12	19.25 ± 3.96	22.09	57.72	-0.734**	0.873**	1.57	3.38
	Zaghlool	22/ 6/2005	10	15.30 ± 3.34	23.73	56.66	-0.456	0.704*	1.62	3.30
	Pritchardia	22/ 6/2005	16	12.69 ± 1.35	27.16	56.18	-0.701**	0.436	0.71	0.53
	Hayani	3/ 1/2006	7	6.71 ± 1.89	29.79	57.28	0.443	0.607	0.86	0.53
	Eglany	9/12/2005	8	9.00 ± 0.76	31.26	58.71	0.074	0.002	0.11	0.00
Second	Amry	20/12/2005	13	7.31 ± 1.32	31.20	58.72	-0.299	-0.161	0.32	0.07
	Zaghlool	3/12/2005	10	7.30 ± 0.68	31.15	57.14	-0.308	-0.095	0.35	0.02
	Pritchardia	24/11/2005	6	8.33 ± 0.82	29.67	57.51	-0.220	0.684	0.18	0.51
	Hayani	5/10/2006	-	-	-	-	-	-	-	-
	Eglany	7/ 9/2006	13	8.85 ± 0.90	27.72	49.42	0.024	0.018	0.02	0.01
Third	Amry	13/ 9/2006	28	10.36 ± 3.64	26.47	51.07	-0.887**	0.866**	1.29	0.88
	Zaghlool	26/ 9/2006	6	8.33 ± 0.52	28.45	48.79	0.889*	0.438	0.61	0.14
	Pritchardia	21/10/2006	-	-	-	-	-	-	-	-

and 64.09 % R.H. and 23.31 °C., 58.91 % R.H., respectively. Whereas, the shortest periods of 96.75 ± 6.55, 240.67 ± 18.51 and 242.20 ± 19.85 days were obtained in case of Pritchardia ornamental palm in the first generation, Amry date palm in both second and third generations at daily means of 30.37 °C. , 57.34 % R.H.; 23.14 °C., 58.02 % R.H. as well 19.81 °C., 64.33 % R.H., successively. From the present results, it is evident that the larval period of this insect varied from one generation to another for the tested varieties where decreasing temperature and increasing atmospheric relative humidity during the three tested generations induced a highly significant prolongation in the larval period. Statistical analysis using correlation and regression coefficients indicated that the effect of temperature was negative with the five tested palms during the 1st generation, but it was positive with both 2nd and 3rd generations. On the other hand, relative humidity negatively as well as significantly affected the mean duration of larvae in all generations except with Hayani, Eglany and Amry date palms in the first generation showing positive relationships and it had insignificant influence with Hayani in the second generation.

The present results are in harmony with the findings of some authors such as Hussein (1998) who reared the larvae of *R. ferrugineus* on date palm during three successive generations and revealed that the shortest duration of larval stage of 54.75 ± 1.73 days was recorded in the first generation at the highest daily mean of 32.15 °C. and the lowest daily mean of 50.82 % R.H.. Decreasing temperature and increasing relative humidity in both second and third generations induced a highly significant prolongation in the larval period to exhibit means of 92.09 ± 4.06 and 157.71 ± 2.62 days at daily temperature means of 25.73, 16.60 °C. and daily means of 62.62, 74.89 % R.H.. El-Muhanna *et al.* (2000) found that the average duration of 12 instars of red palm weevil was 58 to 99 days at 28 ± 2 °C. and 85 ± 5 % RH. Abbas (2005) reported that the larval duration of *R. ferrugineus* on sugarcane stem slices was 144, 67 and 48.5 days at 15, 27 and 35 °C., respectively.

Duration of pupal stage

Data presented in Table 2 indicate that the pupal stage was

more sensitive to the changes of daily mean temperature where in the first generation, the pupal period ranged between 12.69 ± 1.35 – 20.48 ± 5.75 days at means of daily temperatures in the range of 21.16 – 27.16 °C.; but in the second generation, the increase of temperature (29.67 – 31.26 °C.) the decrease of pupal period (6.71 ± 1.89 – 9.00 ± 0.76 days). In the third generation, the ranges of both pupal period and temperature were moderate where they were 8.33 ± 0.52 – 10.36 ± 3.64 days and 26.47-28.45 °C., respectively. The calculation of simple correlation coefficient using statistical methods for the two tested weather factors i.e., temperature and atmospheric relative humidity clearly show that the pupal period was high significantly affected by changing either daily mean temperature or relative humidity during the first generation excepting the insignificant effect of temperature with Zaghlool date palm variety and that concerning relative humidity with Zaghlool and Pritchardia ornamental palm that proved to be significant and insignificant, consecutively. In the second generation, the impact of the two tested factors was not significant, whereas in the third generation it was highly significant at 0.01 % level of probability with the two factors in case of Amry date palm and significant at 0.05% level with temperature only in case of Zaghlool date palm.

These results are partially confirmed by those obtained by some investigators such as Hussein (1998) who studied the biology of the red palm weevil under laboratory conditions in Zagazig, Egypt and indicated that pupal period for three consecutive generations throughout one year ranged between 7-17,10-23 and 9-13 days for the three generations, at daily means of 31.19, 19.91 , 27.70 °C. and 56.83, 68.08 and 64.14% R.H., respectively. El-Muhanna *et al.* (2000) found that the period between the beginning of pupation and the emergence of adults ranged from 13 to 24 days at 28 ± 2 °C. and 85 ± 5 % RH.. Abbas (2005) reported that the pupal duration of *R. ferrugineus* reared on sugarcane stem slices was 12 -21 days.

Duration of adult stage

Data in Table 3 indicate that the shortest mean periods of male longevity were 109.50 ± 49.32 and 56.00 ± 23.58 days that recorded with Zaghlool (in the first

Table 3. Coefficients of correlation (r) and regression (b) between male and female longevity (days) of the red palm weevil, *Rhynchophorus ferrugineus* (Olivier) and daily means of temperature and relative humidity during two successive years from 22/6/2005 to 22/6/2007

Generations	Varieties	Starting date	No. of individuals	Mean duration ± S. D.	Daily mean		r		b	
					Temp. °C.	R.H.%	Temp. °C.	R.H.%	Temp. °C.	R.H.%
Male	Hayani	22/ 6/2005	5	147.80 ± 28.24	17.46	65.31	0.981**	-0.899*	37.27	15.75
	Eglany	22/ 6/2005	10	116.60 ± 24.04	17.09	66.18	-0.493	0.195	26.17	5.17
First	Amry	22/ 6/2005	5	115.20 ± 16.48	16.59	67.14	0.908*	-0.884*	43.07	16.51
	Zaghlool	22/ 6/2005	4	109.50 ± 49.32	18.16	64.45	-0.894	0.915	38.88	45.14
	Pritchardia	22/ 6/2005	5	133.40 ± 13.05	17.60	65.49	-0.770	0.724	35.73	19.26
	Hayani	3/ 1/2006	3	98.67 ± 3.22	23.31	62.58	0.988	-0.988	5.54	36.04
	Eglany	9/12/2005	4	145.00 ± 38.97	21.05	64.12	0.438	-0.828	60.85	40.03
Second	Amry	20/12/2005	5	56.00 ± 23.58	28.15	58.35	0.098	-0.126	0.32	0.59
	Zaghlool	3/12/2005	7	97.50 ± 28.45	28.02	58.27	-0.852*	0.925**	9.29	10.68
	Pritchardia	24/11/2005	3	102.25 ± 7.63	24.18	62.05	0.943	-0.943	2.83	3.05
	Hayani	5/10/2006	-	-	-	-	-	-	-	-
	Eglany	7/ 9/2006	-	-	-	-	-	-	-	-
Third	Amry	13/ 9/2006	-	-	-	-	-	-	-	-
	Zaghlool	26/ 9/2006	-	-	-	-	-	-	-	-
	Pritchardia	21/10/2006	-	-	-	-	-	-	-	-
Female	Hayani	22/ 6/2005	4	136.25 ± 19.36	17.39	65.33	0.582	-0.768	33.70	24.09
	Eglany	22/ 6/2005	10	120.10 ± 18.50	16.71	66.85	0.964**	-0.967**	36.59	16.51
First	Amry	22/ 6/2005	6	114.17 ± 8.98	16.83	66.66	0.529	-0.502	12.37	5.90
	Zaghlool	22/ 6/2005	3	78.00 ± 7.81	18.04	64.38	-0.893	0.913	7.76	3.93
	Pritchardia	22/ 6/2005	5	125.40 ± 26.35	18.38	64.42	-0.736	0.759	16.64	11.96
	Hayani	3/ 1/2006	4	63.00 ± 12.19	24.50	60.74	-0.863	0.884	3.86	3.80
	Eglany	9/12/2005	4	72.00 ± 18.74	28.77	57.30	-0.980*	0.997**	24.20	20.27
Second	Amry	20/12/2005	8	57.13 ± 11.45	29.51	57.63	-0.884**	0.506	8.46	8.00
	Zaghlool	3/12/2005	2	80.50 ± 7.78	27.64	57.49	-1.000**	1.000**	18.53	8.42
	Pritchardia	24/11/2005	3	73.33 ± 9.07	21.77	64.00	-0.382	0.520	5.39	4.45
	Hayani	5/10/2006	-	-	-	-	-	-	-	-
	Eglany	7/ 9/2006	-	-	-	-	-	-	-	-
Third	Amry	13/ 9/2006	-	-	-	-	-	-	-	-
	Zaghlool	26/ 9/2006	-	-	-	-	-	-	-	-
	Pritchardia	21/10/2006	-	-	-	-	-	-	-	-

generation) and Amry (in the second one) at daily means of temperature and relative humidity of 18.16, 28.15 °C. and 64.45, 58.35 % , respectively. But, the longest means of male longevity were 147.80 ± 28.24 and 145.00 ± 38.97 days that occurred with Hayani and Eglany date palms in the 1st and 2nd generations, successively at means of 17.46 °C., 65.31 % R.H. in the first generation and 21.05 °C., 64.12 % R.H. in the second one. The present results indicate that in the first generation, the effects of temperature and relative humidity were negative in case of Eglany, Zaghlool date palms and Pritchardia ornamental palm (for the 1st factor) as well Hayani and Amry date palms (for the 2nd one). The correlation coefficients of both temperature and relative humidity were highly significant and significant for Hayani date palm, respectively and significant in case of Amry date palm. On the other hand, in the second generation, the effect of temperature was negative and significant in case of Zaghlool date palm only, but, relative humidity seemed to have a positive highly significant effect in case of the same variety.

As clearly shown from the results compiled in Table 3, the mean of female longevity was more sensitive to the changes of temperature where in the 1st generation, the female longevity ranged between 78.00 ± 7.81 – 136.25 ± 19.36 days at daily means of temperature in the range of 16.71 – 18.38 °C.; while, in the 2nd generation the increase of temperature (21.77 – 29.51 °C.) the decrease of female longevity period (57.13 ± 11.45 – 80.50 ± 7.78 days). The obtained results clearly show that the effect of temperature on this duration proved to be negative during the two generations except with Hayani, Eglany and Amry date palms in the first generation. But, statistical analysis proved that this effect was highly significant at 0.01% level of probability with Eglany (in the 1st generation), as well with Amry and Zaghlool (in the 2nd one), but it was significant at 0.05% level of probability with Eglany date palm (in the 2nd generation). In case of relative humidity, the correlation was negative in case of Hayani, Eglany and Amry in the 1st generation. The degree of significance of correlation coefficients between female longevity and daily means of relative humidity proved to be highly significant in case of Eglany (in both the 1st and 2nd

generations) and Zaghlool date palm (in the second generation), whereas other tested varieties showed insignificant impact in respect to this weather factor.

Similar results were obtained by some investigators such as Hussein (1998) who found that adult males and females of red palm weevil survived for a long time in the 2nd generation in which mean temperature was the lowest and relative humidity was the highest as compared with the correspondings means prevailing throughout the other two generations. Increasing temperature and decreasing relative humidity caused a noticeable shortage in males and females longevity in the 1st and 3rd generations. El-Muhanna *et al.* (2000) reported that the life span of females ranged from 30 to 90 days, whereas males longevity averaged from 29 to 107 days at 30 ± 2 °C. and 85 ± 5 % RH.. Abbas (2005) stated that the average of adult longevity of *R. ferrugineus* reared on sugarcane stem slices lasted for 88.5, 74.5 and 48 days at 15, 27 and 35 °C., successively.

Female fecundity of eggs

Data in Table 4 reveal that the lowest mean number of eggs of 22.86 ± 8.92 and 35.33 ± 5.13 laid by a female was recorded with Pritchardia ornamental palm at means of temperature of 16.97, 20.52 °C. and relative humidity of 67.49, 65.99% during the first and second generations, successively. Whereas the highest mean numbers of eggs of 107.33 ± 19.41 (with Amry date palm) and 127.50 ± 7.78 eggs/female (in case of Zaghlool date palm) occurred during the 1st and 2nd generations, respectively. The corresponding means of prevailing temperature and atmospheric relative humidity were 15.29, 27.29 °C. and 68.43, 57.17 %, respectively. Statistical analysis clearly revealed that the effect of temperature and relative humidity on the mean number of eggs was highly significant in case of Zaghlool (with both temperature and relative humidity in the 2nd generation). The effect of temperature was negative in case of Hayani, Zaghlool date palms and Pritchardia ornamental palm (in the 1st generation) and in case of Amry and Pritchardia ornamental palm (in the 2nd generation), but the correlation respecting relative humidity was negative in case of Amry date palm in the first generation and Hayani, Eglany and Zaghlool in the second generation.

Table 4. Coefficients of correlation (r) and regression (b)between number of eggs deposited per female (days) of the red palm weevil, *Rhynchophorus ferrugineus* (Olivier) and daily means of temperature and relative humidity during two successive years from 22/6/2005 to 22/6/2007

Generations	Varieties	Starting date	No. of females	Number of eggs/ female ± S. D.	Daily mean		r		b	
					Temp.°C.	R.H.%	Temp. °C.	R.H. %	Temp. °C.	R.H.%
First	Hayani	22/ 6/2005	4	63.00 ± 23.64	17.54	64.05	-0.054	0.004	0.77	0.02
	Eglany	22/ 6/2005	10	79.40 ± 20.08	16.67	67.15	0.080	0.116	0.81	0.78
	Amry	22/ 6/2005	6	107.33 ± 19.41	15.29	68.43	0.419	-0.214	18.34	8.66
	Zaghlool	22/ 6/2005	3	42.67 ± 16.50	17.27	66.50	-0.847	0.109	8.56	1.23
	Pritchardia	22/ 6/2005	7	22.86 ± 8.92	16.97	67.49	-0.709	0.220	5.49	1.91
Second	Hayani	3/ 1/2006	4	93.00 ± 19.39	24.12	61.19	0.703	-0.646	4.56	4.73
	Eglany	9/12/2005	4	113.50 ± 48.89	28.51	56.90	0.206	-0.169	16.19	9.97
	Amry	20/12/2005	8	97.75 ± 23.17	29.14	57.65	-0.537	0.032	9.96	1.59
	Zaghlool	3/12/2005	2	127.50 ± 7.78	27.29	57.17	1.000**	-1.000**	53.81	39.68
	Pritchardia	24/11/2005	3	35.33 ± 5.13	20.52	65.99	-0.485	0.521	3.71	2.17
Third	Hayani	5/10/2006	-	-	-	-	-	-	-	-
	Eglany	7/ 9/2006	-	-	-	-	-	-	-	-
	Amry	13/ 9/2006	-	-	-	-	-	-	-	-
	Zaghlool	26/ 9/2006	-	-	-	-	-	-	-	-
	Pritchardia	21/10/2006	-	-	-	-	-	-	-	-

The present results are confined by those obtained by some authors such as Hussein (1998) who indicated that female fecundity of eggs greatly differed from one generation to another and the highest mean number of 276.50 eggs /female was recorded in the third generation at means of 28.54 °C. and 57.18% R.H.. He added that number of eggs gradually decreased to 223.38 and 68.50 eggs /female at means of 28.20, 16.53°C. and 59.37, 76.43% R.H. in the first and second generations, respectively. El-Muhanna *et al.* (2000) stated that females (reared on 30 ± 2 °C. and 85 ± 5% R.H.) which lived for 30, 60 and 90 days laid an average 26. 186 and 276 eggs/female, respectively. The average number of eggs per female was 183, 238 and 173 at 15, 27 and 35 °C., consecutively (Abbas, 2005).

Complete developmental period

The data presented in Table 5, indicate that the complete developmental period of this weevil from egg laying to adult emergence was high significantly affected by changing either daily mean temperature or relative humidity through the three consecutive generations except with Pritchardia ornamental palm (in case of relative humidity only in the 1st generation) that proved to be have a significant impact at 0.05% level of probability as well as with both Eglany and Amry date palms (in case of the same factor in the 2nd generation) demonstrating a nonsignificant effect. The impact of temperature was negative in the first generation only, but, that regarding the relative humidity was positive with the tested varieties in the first generation and in case of both Hayani and Amry date palms in the second generation. From the obtained results, it appears that the longest mean complete developmental periods of the insect immature stages of 179.09 ± 13.40, 304.33 ± 25.77 and 272.83 ± 12.47 days were obtained with Amry date palm, Pritchardia ornamental palm and Eglany date palm in the 1st, 2nd and 3rd generations at means of 26.36, 23.62, 20.68 °C. and 58.86, 58.83, 63.01% R.H., respectively. Meanwhile, this period was gradually shortened to 121.94 ± 11.72, 248.83 ± 7.81 and 257.50 ± 15.05 days that occurred with Pritchardia ornamental palm in the first generation and Amry date palm in both second and third generations at daily means of 29.46, 23.46 and 20.11 °C. and 57.15, 58.02 and 63.78% R.H., alternatively.

Table 5. Coefficients of correlation (r) and regression (b)between mean complete development (days) of the red palm weevil, *Rhynchophorus ferrugineus* (Olivier) and daily means of temperature and relative humidity during two successive years from 22/6/2005 to 22/6/2007

Generations	Varieties	Starting date	Rang	Mean duration ± S. D.	Daily mean		r		b	
					Temp. °C.	R.H.%	Temp. °C.	R.H.%	Temp. °C.	R.H.%
First	Hayani	22/ 6/2005	103 - 201	153.60 ± 30.93	27.71	58.02	-0.999**	0.915**	18.96	32.042
	Eglany	22/ 6/2005	132 - 214	157.71 ± 25.73	27.15	58.19	-0.702**	0.654*	10.20	11.121
	Amry	22/ 6/2005	161 - 200	179.09 ± 13.40	26.36	58.86	-0.999**	0.994**	19.33	20.202
	Zaghlool	22/ 6/2005	138 - 161	150.38 ± 7.84	27.84	57.47	-0.999**	0.981**	17.10	28.492
	Pritchardia	22/ 6/2005	106 -151	121.94 ± 11.72	29.46	57.15	-0.995**	0.590*	18.80	74.284
Second	Hayani	3/ 1/2006	248 - 271	262.40 ± 11.82	24.62	57.63	1.000**	0.999**	53.40	182.876
	Eglany	9/12/2005	245 - 265	258.25 ± 6.52	23.18	58.48	1.000**	0.038	29.44	6.923
	Amry	20/12/2005	234 - 264	248.83 ± 7.81	23.46	58.02	0.995**	-0.475	31.05	79.070
	Zaghlool	3/12/2005	214 - 272	252.11 ± 19.15	22.67	58.80	0.999**	-0.890**	27.69	90.097
	Pritchardia	24/11/2005	255 - 324	304.33 ± 25.77	23.62	58.83	0.989**	-0.941**	41.61	197.088
Third	Hayani	5/10/2006	-	-	-	-	-	-	-	-
	Eglany	7/ 9/2006	247 - 287	272.83 ± 12.47	20.68	63.01	0.747**	-0.775**	26.26	14.606
	Amry	13/ 9/2006	247 - 288	257.50 ± 15.05	20.11	63.78	0.994**	-0.991**	32.74	17.389
	Zaghlool	26/ 9/2006	243 - 270	260.80 ± 11.19	20.17	63.07	1.000**	-0.999**	29.03	18.804
	Pritchardia	21/10/2006	-	-	-	-	-	-	-	-

These results are in agreement with those obtained by Hussein (1998) who reported that the complete developmental period of the red palm weevil was in a long mean period of 177.75 ± 1.97 days throughout third generation at means of 17.23 °C. and 73.81 % R.H.. The same author added that increasing temperature and decreasing relative humidity to 25.04, 31.93 °C. and 63.18, 51.50 % R.H. induced an obvious shortage in this period showing means of 106.31 ± 2.99 and 64.82 ± 1.35 days in the second and first generations, successively.

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بعض المظاهر البيولوجية لسوسة النخيل الحمراء ومدى تأثرها بالتربية على بعض أصناف النخيل، درجة الحرارة و الرطوبة النسبية

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تم دراسة بعض المظاهر البيولوجية لسوسة النخيل الحمراء مثل فترة الطور اليرقى وفترة طور العذراء وفترة حياة الذكور والإناث وكذلك إنتاجية الإناث من البيض وذلك لمدة عامين متتاليين من ٢٠٠٥/٦/٢٢م الى ٢٠٠٧/٦/٢٢ م على خمسة من أصناف النخيل والمسماه بالحيانى والعجلانى والعامرى والزغلول لنخيل البلح وصنف بريتشارديا لنخيل الزينة تحت ظروف المعمل. أوضحت النتائج أن فترة كل من طورى اليرقة والعذراء تأثرت تأثيراً عالى المعنوية بالأصناف المختبرة خلال الجيلين الأول والثانى. فى الجيل الأول تأثرت فترة حياة كل من الذكور والإناث تاثيراً غير معنوى وعالى المعنوية مع أصناف النخيل على التوالى، ولكن خلال الجيل الثانى كان العكس صحيحاً. أعطت الإناث التى تغذت على صنفى

العامرى والزغلول لنخيل البلح أعلى متوسطات لعدد البيض ١٠٧,٣٣ و ١٢٧,٥٠ بيضة/أنثى وذلك في الجيلين الأول والثانى على التوالى وكانت إنتاجية الإناث من البيض أقل مع نخيل الزينة فى الجيلين المشار اليهما سابقاً.

أظهرت مدة الطور اليرقى إرتباطاً معنوياً مع كل من درجة الحرارة والرطوبة النسبية على كل الأصناف المختبرة خلال الثلاثة أجيال. فى الجيل الأول، إرتبطت فترة طور العذراء معنوياً مع كل من الحرارة والرطوبة باستثناء مع صنف الزغلول (درجة الحرارة) وصنف بريتشارديا لنخيل الزينة (الرطوبة النسبية) حيث كان الإرتباط غير معنوى. وجد إرتباط بين كل من الحرارة والرطوبة النسبية وفترة حياة كل من الذكور والإناث وقد أختلف هذا الإرتباط وفقاً للأصناف المختبرة. خلال الجيل الثانى إرتبط متوسط العدد الذى تضعة الأنثى من البيض إرتباطاً معنوياً مع درجة الحرارة والرطوبة النسبية وذلك فى حالة صنف الزغلول. أظهر متوسط فترة التطور الكامل إرتباط عالى المعنوية وموجب مع درجة الحرارة خلال الثلاثة أجيال باستثناء خلال الجيل الأول حيث كان الإرتباط سالباً، ولكن الإرتباط كان عالى المعنوية مع الرطوبة النسبية خلال الثلاثة أجيال فيما عدا فى حالة صنفى نخيل البلح العجلانى والعامرى فى الجيل الثانى حيث كان الإرتباط غير معنوى.