Biology and Life Table Parameters of the Date Palm Dust Mite, *Oligonychus afrasiaticus* (McGregor) (Acari: Tetranychidae) as affected by Host and Controlled conditions

A. S. H. El-Halawany
Fruit Acarology Dept., PPRI, Agric. Research Centre, Giza, Egypt

ABSTRACT

Developmental times and reproduction rates of the date palm dust mite *Oligonychus afrasiaticus* (McG.) were studied on three different date Palm tree parts (i.e. kamry fruit stage (characterized by the green color of fruits), yellow khelal stage and inner frond) of Khalas variety at laboratory conditions of 15, 25 & 35 ± 2°C; 30 & 70 ± 5% R.H. and 16:8 L:D. The mite failed to develop at 15°C. Immatures developmental time was fastest on kamry stage (10.60 days) followed by yellow khelal (12.35 days) then inner fronds (12.71 days). Adult female longevity averaged 15.08, 14.62 and 13.83 days on kamry and khelal yellow stages and inner frond, respectively. The shortest generation time was 9.5, 11.32 and 16.04 days at 35°C & 30% R.H., while the longest was 22.74, 26.74 and 26.68 days at 25°C & 70% R.H. on kamry, yellow khelal stage and inner frond; respectively. Sex ratio was affected by temperature as proportion of females increased with temperature increase. In addition, the values of r_m, R_0 and λ increased with temperature increase and decreased with R.H. increase. The mean generation time (T) and generation doubling time (DT) values decreased with temperature increase and R.H. decrease; thus the reproduction of mite increase. This mite favored high temperature and low R.H. Also immature date (kamry stage) was the favorable followed by yellow khelal then inner frond.

Key Words: *Oligonychus afrasiaticus*, Development, Life table, Temperature, Relative Humidity, Host.

INTRODUCTION

The date palm dust mite (DPDM), *Oligonychus afrasiaticus* (McGregor) is an important pest of the date palm trees *Phoenix dactylifera* L., particularly in the recent years in Saudi Arabia, Tunisia, Iraq and Yemen. It attacks the dates from its early stages of development (kamry and khelal fruit stages), spinning its web around the date bunches and multiplies in large numbers. The web collects dust plus different developmental stages of the mite making the date bunches look dusty. It feeds on the sap as it sucks off the dates and rendering it unfit for human consumption (Jeppson, *et al.*, 1975; Ba-Angood & Bashih, 2000; Al-Jabr *et al*., 2003; Al-Sweedy, 2003; Al-Jaboory & Al-Sweedy, 2006; Al-Sweedy *et al*., 2006 and Ben Chaaban, *et al*. (2011).

This mite is the dominant spider mite pest of date palm fruit in the Southern Arava Valley of Palestine (Palevsky *et al.*, 2003). The optimum temperature for DPDM development ranged between 30.5 and 32.7˚C (Al-Haidari *et al.*, 1982). Kadjbaf and Kamali (1993) in Iran reported that the old world mite, *O. afrasiaticus* was a serious pest of dates in Khuzestan. Also Chaaban, *et al*. (2011) in Tunisia, indicated that DPDM is a serious pest of palm date fruit. In Saudi Arabia, Al-Jabr *et al.* (2003) revealed that *Tetranychus sp*. and *O. afrasiaticus* were the most abundant mite species which infested the bunches and leaflets of the tested date palm cultivars.

The aim of this study was to compare the effect of three diets of Khalas date palm variety (kamry and khelal fruit stages and Inner frond) at different temperatures and relative humidities, on the biology and life table parameters of *O. afrasiaticus*.

MATERIALS AND METHODS

Biological Study on the dust mite, *O. afrasiaticus*: Mite cultures:

Mites were collected directly from a farm of date palm trees, *P. dactylifera*, and transferred to peach seedlings, after making sure of its identification. The dust mite was reared successfully on peach seedlings under green house condition.

Rearing dust mite on date palm inner frond:

The study of the mite life cycle was carried out on Khalas date palm variety at 15, 25, 35°C and 30, 70% R.H. Nine holes (2 cm diameter) were opened in a Petri dish (15 cm diameter) plastic cover. Small other holes in the cover were made to provide water with the help of a medical syringe. Three pieces of palm pinnae (leaves) (10-12 cm.) were put on cotton piece in Petri-dish. All leaves were placed ventral-side up. Pinnae pieces were replaced when needed to maintain the level of nutrition and vitality. A piece of cotton dampened with water put between the cover plate and around the edges of the disk and painted with Vaseline to prevent mites escape. Approximately 50 adult females from the stock culture were introduced each to a leaf disc (frond). After mating on the leaves in the laboratory, females were allowed to lay eggs for 12-h periods. One egg was transferred for each disc

using a brush and up to 45 replicates were made for each treatment. Dishes were kept in incubators at 35, 25, 15 ± 2°C and 30 & 70% R.H. Illumination was provided by fluorescent tubes, for 16-h/ day photophase. Plastic plates were examined twice daily to record the different stages. This method was proposed by Al-Sweedy (2003).

Rearing dust mite on Kamry and yellow Khelal fruit stages:

This method was carried out on Khalas fruit variety at the same mentioned conditions. Kamry fruit (immature dates) was collected from date palm trees. Experiment was repeated when fruits reached khelal stage. Also yellow fruit khelal stage was collected from date palm trees and tested as rearing target. The same method conducted on leaves (pinnae) was used with the fruits, with cotton dampened with water and encircled by Vaseline mixed with citronella and castor oil to prevent mite individuals from escaping.

Life table parameters of the DPDM:

When O. *afrasiaticus* females reached adult stage they were transferred one at a time onto a new leaf disc with a single young male. Eggs were collected daily and reared to adult. During developmental period, mortalities of different stages and sex ratio of progeny were determined. Oviposition by resultant females was recorded daily for each female. Life table parameters were estimated according to (Birch, 1948) using the Life48, BASIC Computer Program (Abou-Setta *et al.*, 1986).

Statistical analysis:

Data were analyzed using Proc ANOVA and mean separation was conducted using Duncan's multiple range test ($P \leq 0.05$). The multiple regression equation

$Y = a \pm b_1$*Temperature $\pm b_2$* relative humidity

where: a is the intercept

b is the slope.

These analyses were conducted using SAS statistical software (SAS Institute, 2010).

RESULTS AND DISCUSSION

The dust mite was reared successfully on peach seedling. *O. afrasiaticus* eggs did not hatch at 15˚C, but developed successfully to adult stages at 25 and 35˚C.

Developmental time and longevity at 25°C:

O. afrasiaticus passed through four developmental stages with quiescence stages at the end of larval and nymphal stages. The duration of its various developmental stages on different three targets, kamry, yellow khelal and inner frond at 25˚C and (30 & 70% R.H.) is presented in table (1).

O. afrasiaticus larva hatched after a shortest egg incubation period of 4.94 days on kamry at 30% R.H. It took the longest duration of 6.17 & 6.37 days at 70 & 30% R.H. on inner frond. Larvae then transformed to eight legged protonymphs. Before transforming to protonymph it passed through a short inactive period which called chrysalis. The shortest durations of different stages, generation and life span was observed on Kamry stage at 30 & 70% R.H.; while the longest were recorded on yellow khelal and inner frond at 70% R.H. Low relative humidity (30%) accelerated mite development; while high R.H. (70%) retarded development to adult. Oviposition period and longevity increased as relative humidity decreased, the longest oviposition period was 17.15 days at 30% R.H. on kamry stage; while the shortest period was 12 days at 70% R.H. on inner frond. The longest adult female longevity was observed at 70% R.H. on kamry stage as 20.58 days; while the shortest was 17.13 days on inner frond at 70% R.H. The highest mean number of eggs laid by female was 20.85 eggs/female with a daily rate of 1.57 eggs/♀/day on yellow khelal stage at 30% R.H. The lowest fecundity was 11 eggs/♀ on inner frond with a daily rate of 0.97 /♀/day at 70% R.H.

Developmental time and longevity at 35 °C:

Obtained results are presented in table (2). Differences between the low R.H. (30%) and high R.H. (70%) were small. Significant differences were found between the three rearing targets. The shortest incubation period, larva stage, life cycle and generation period were 2.52, 1.42, 8.75 and 9.5 days at 30% R.H. on kamry stage; while the longest were 3.42, 2.2, 12.03 and 13.58 days at 70% R.H. on inner frond; respectively. The longest protonymphal and deutonymphal stages were 1.52 & 1.82 days on yellow khelal stages at 70% R.H.; while the shortest were 1 and 1.27 days at 30% R.H. on kamry stage; respectively.

The highest mean fecundity of female was 35.2 eggs/♀ and a daily rate of 4.25 eggs/♀/day on kamry stage at 30% R.H.; while the lowest was 24.95 eggs/♀ and as 3.41eggs/♀/day at 70% R.H. on inner frond. There was no significant differences in oviposition period and longevity between the three targets at 35°C.

Effect of temperature and R.H. on developmental rate.

Laboratory studies of *O. afrasiaticus* suggested the greatest potential for population growth

Table (1) Duration in days of *O. afrasiaticus* different stages at 25°C and two relative humidities on three rearing targets

Developmental stages	Kamry		Yellow Khelal		Inner frond		L.S.D
	30% RH	70% RH	30% RH	70% RH	30% RH	70% RH	
Incubation period	4.94 d	5.40 c	5.62 bc	5.97 ab	6.17 a	6.37 a	0.42
Larva	3.25 c	3.07 d	3.52 bc	4.00 a	3.55 bc	3.80 ab	0.35
Protonymph	2.95 d	3.12 cd	3.45 bc	3.75 b	3.35 bc	4.15 a	0.36
Deutonymph	2.90 c	3.22 b	3.32 b	3.90 a	3.47 b	3.50 b	0.28
Immature stages	14.05 c	14.83 c	15.93 b	17.45 a	16.55 b	17.83 a	0.77
Life cycle	19.00 e	20.23 d	21.55 c	23.43 ab	22.73 b	24.2 a	1.08
Generation	20.95 d	22.74 c	24.13 b	26.63 a	24.58 b	26.68 a	1.14
Pre-Oviposition	1.95 c	2.55 b	2.55 b	3.2 a	1.90 c	2.47 b	0.38
Oviposition	17.15 a	16.00 ab	14.75 bc	13.95 cd	13.85 cd	12.00 d	1.89
Post-Oviposition	1.10 c	2.02 b	2.00 b	2.00 b	1.92 b	2.65 a	0.39
Longevity	20.10 a	20.58 a	19.3 ab	19.15 abc	17.68 bc	17.13 c	1.96
Fecundity (eggs/♀)	17.10 c	19.45 ab	20.85 a	18.05 bc	14.05 d	11.00 e	1.69
Daily rate (eggs/♀/ day)	1.01 cd	1.24 bc	1.57 a	1.32 b	1.03 cd	0.97 d	0.22
Life span	39.20 b	40.8 ab	40.85 ab	42.58 a	40.4 ab	41.33 ab	2.01

Table (2) Duration in days of *O. afrasiaticus* different stages at 35°C and two relative humidities on three rearing targets

Developmental stages	Kamry		Yellow Khelal		Inner frond		L.S.D
	30% RH	70% RH	30% RH	70% RH	30% RH	70% RH	
Incubation period	2.52 c	2.73 bc	2.95 b	3.32 a	2.85 bc	3.42 a	0.33
Larva	1.42 c	1.63 bc	1.57 bc	1.77 b	2.10 a	2.20 a	0.29
Protonymph	1.00 b	1.47 a	1.47 a	1.52 a	1.25 a	1.42 a	0.31
Deutonymph	1.27 b	1.47 ab	1.60 ab	1.82 a	1.52 ab	1.55 ab	0.33
Immature stages	6.22 d	7.32 c	7.60 c	8.45 ab	7.90 bc	8.60 a	0.55
Life cycle	8.75 c	10.00 d	10.55 b	11.78 a	10.75 b	12.03 a	0.79
Generation	9.50 d	10.95 c	11.32 bc	13.32 a	11.97 b	13.58 a	0.84
Pre-Oviposition	0.75 c	0.90 c	0.75 c	1.55 a	1.22 b	1.55 a	0.25
Oviposition	8.75 a	7.80 a	8.20 a	7.50 a	8.05 a	7.50 a	1.14
Post-Oviposition	0.62 b	0.75 b	0.75 b	1.30 a	1.07 a	1.15 a	0.28
Longevity	10.13 a	9.45 a	9.70 a	10.35 a	10.35 a	10.20 a	1.18
Fecundity (eggs/♀)	35.2 a	31.05 b	30.15 b	27.55 c	26.55 cd	24.95 d	2.31
Daily rate (eggs/♀/ day)	4.25 a	4.16 ab	3.96 abc	3.78 abc	3.51 bc	3.41 c	0.64
Life span	18.88 c	19.51 c	20.25 bc	22.13 a	21.1 ab	22.23 a	1.50

Means in the same row followed by the same letter are not significantly different ($P < 0.05$).

Table (3) Multiple regression analysis values for the effect of temperature and relative humidity on *O. afrasiaticus* developmental rate

stage	a	b_1	P	b_2	P	F value	P	R^2
Egg	12.2	-0.27	0.0001	0.009	0.0001	472.3	0.0001	0.79
Larva	7.6	-0.174	0.0001	0.004	0.019	273	0.0001	0.69
Protonymph	8.2	-0.204	0.0001	0.006	0.0005	357	0.0001	0.75
Deutonymph	7.7	-0.184	0.0001	0.005	0.0010	367.8	0.0001	0.75
Immature stages	35.8	-0.842	0.0001	0.025	0.0001	1038	0.0001	0.89
Life cycle	48.1	-1.120	0.0001	0.034	0.0001	959	0.0001	0.89
Generation	53.2	-1.252	0.0001	0.047	0.0001	1035	0.0001	0.89
Pre-Oviposition	5.0	-0.131	0.0001	0.012	0.0001	175	0.0001	0.59
Oviposition	32.4	-0.665	0.0001	-0.250	0.004	187.4	0.0001	0.61
Post-Oviposition	3.97	-0.100	0.0001	0.010	0.0001	91.2	0.0001	0.43
Longevity	41.5	-0.897	0.0001	-0.002	0.8110	330.5	0.0001	0.73
Fecundity	-12.01	1.249	0.0001	-0.049	0.0008	235.3	0.0001	0.66
Daily rate	-5.35	0.265	0.0001	-0.001	0.4770	326.9	0.0001	0.73
Life span	89.66	-2.01	0.0001	0.032	0.0006	1424.4	0.0001	0.92

a = Intercept, b_1 = slope of temperature, b_2 = slope of RH, P = probability Developmental rate = $a + b_1$*temp. + b_2*RH

Table (4) Factorial analysis of obtained biological aspects of *O. afrasiaticus* as affected by temperature, relative humidity and rearing target

Factor level	Diet			Tem.		RH.	
	Kamry	Khelal	Frond	25°C	35°C	30%	70%
Egg	3.90c	4.46 b	7.70 a	5.75 a	2.96 b	4.17 b	4.53 a
larva	2.34 c	2.71 b	2.91 a	3.53 a	1.78 b	2.57 b	2.74 a
Protonymph	2.13 b	2.50 a	2.58 a	3.43 a	1.38 b	2.27 b	2.54 a
Deutonymph	2.21 b	2.66 a	2.51 a	3.38 a	1.54 b	2.35 b	2.57 a
Immatures	10.60 c	12.35 b	12.71 a	16.10 a	7.68 b	11.37 b	12.41 a
Life cycle	14.50 c	16.82 b	17.42 a	21.85 a	10.65 b	15.55 b	16.95 a
Generation	16.04b	18.83a	19.21a	24.29a	11.77b	17.07b	18.98a
Pre-oviposition	1.53 c	2.01 a	1.78 b	2.43 a	1.12 b	1.52 b	2.03 a
Oviposition	12.42 a	11.10 b	10.35 b	14.61 a	7.96 b	11.79 a	10.79 b
Post-oviposition	1.12 c	1.51 b	1.70 a	1.95 a	0.94 b	1.24 b	1.64 a
Longevity	15.08 a	14.62 b	13.83 b	19.0 a	10.02 b	14.55 a	14.47 a
Fecundity	25.70 a	24.15 b	19.13 c	16.75 b	29.24 a	23.98 a	22.0 b
Daily rate	2.67 a	2.66 a	2.23 b	1.19 b	3.84 a	2.55 a	2.48 a
Life span	29.59 b	31.45 a	31.26 a	40.85 a	20.68 b	30.11 b	31.42 a

Means in the same colon in the same factor not followed by the same letter are significantly different ($P< 0.05$ using LSD in SAS).

Table (5) Life table parameters of *O. afrasiaticus* under different rearing conditions

Target	°C	% RH	DT [a]	Survival rate	50% mortality [a]	Sex ratio	R_o [b]	r_m [c]	λ
Kamry	25	70	20.38	0.71	37.24	0.21	2.87	0.034	1.03
		30	15.4	0.66	34.45	0.33	3.73	0.045	1.04
	35	70	6.30	0.60	10.0	0.43	5.68	0.118	1.12
		30	4.07	0.64	16.0	0.50	11.29	0.179	1.19
Yellow Khelal	25	70	19.80	0.71	39.13	0.25	3.20	0.035	1.06
		30	17.32	0.66	35.63	0.28	3.80	0.043	1.04
	35	70	7.53	0.55	18.82	0.31	4.75	0.092	1.09
		30	6.30	0.60	17.82	0.33	5.79	0.116	1.12
Inner frond	25	70	33.0	0.66	36.20	0.25	1.98	0.021	1.02
		30	25.67	0.64	35.0	0.27	2.37	0.027	1.02
	35	70	7.53	0.55	20.8	0.36	4.87	0.092	1.09
		30	6.18	0.51	17.47	0.40	5.95	0.112	1.11

[a] Days [b] Per generation [c] Individuals/female/ day

occurring at high temperatures (35˚C). Multiple regression analysis of the obtained data presented in table (3) showed that, duration of developmental stages was highly influenced by temperature. The increase of temperature accelerated the developmental rate, but female fecundity and daily rate were positively affected. On the other hand, relative humidity had significant positive effect as at higher R.H. the development occurred slowly and except oviposition period and adult female longevity were negatively affected. This finding agrees with that of Al-Haidari *et al.,* (1982), Al-Sweedy, (2003) and Palevsky *et al.,* (2003).

Factorial analysis of obtained biological aspects of *O. afrasiaticus*

This type of analysis considers the effect of each studied factor (i.e. temperature, R.H. and date palm stage) regardless of other factors.

Effect of date palm stages:

The duration of all developmental stages were longer on Inner frond followed by yellow khelal and kamry stages (Table 4). Significant differences were found between developmental periods of mites exposed to different source of food. The shortest generation time, pre-oviposition and post-oviposition periods were on kamry stage; while the longest of these periods were on inner fronds. Significant differences were also found between adult female longevity and oviposition period. The kamry stage was more favored to the mite followed by yellow khelal and inner frond. Immature fruit (kamry) may supply more suitable amino acids than inner frond and yellow khelal which reflected rapid development of the mite. In addition, significant differences occurred between the three target diets as fecundity was the highest on kamry stage and the lowest on inner frond.

Temperature:

The optimum temperature for development was 35°C being faster than 25°C. Significantly differences occurred between all stages at the two levels of temperatures. The highest fecundity and daily rate at 35°C was 29.24 eggs/female and 3.84 eggs/♀/day; while the lowest was at 25°C as 16.75 eggs/female and 1.19 eggs/♀/day.

Relative humidity:

Significant differences occurred between the low R.H. (30%) and the high (70%) on all mite developmental stages, the shortest period on 30% R.H.; while the longest was on 70%. Longevity was similar at both low and high R.H. Total fecundity and oviposition period was highly significant at low R.H. level and low at high level. This finding agrees with those of Al-Sweedy, (2003) and Al-Jboory & Al-Sweedy, (2006).

Life table parameters of *O. afrasiaticus* under different rearing conditions

Results presented in table (5) demonstrated that, the shortest time for population density doubling (DT) was 4.07 days at 35˚C-30% R.H. on kamry stage; while the longest period was 33 days at 25˚C-70% R.H. on inner frond. The daily age-specific survival rate was the highest on kamry followed by khelal and inner frond. The 50% mortality of *O. afrasiaticus* occurrence was short as 10 days at 35˚C-70% R.H. on kamry; while the longest was 39.13 days on yellow khelal at 25 ˚C-70% R.H.

Temperature, relative humidity and date palm stage affected the sex ratio (females/total) of the mite. The proportion of females in the offspring increased with temperature increase. On contrast, it decreased with R.H. increase. Sex ratio was the highest on kamry, followed by inner frond and yellow khelal. The maximum value of nature increase (r_m) and the finite rate of increase (λ) were obtained at 35˚C-30% R.H. on the three targets. Minimum values were obtained at 25˚C-70% R.H. Effect of temperature and R.H. on the biology of *Oligonychus partensis* (reported as r_m, R_o and λ) increased as temperature increased; while DT and generation time decreased (Berring *et al*., 1984 and Congedon & Logan, 1983).

The maximum net reproductive rate (R_o) occurred at 35˚C-30% R.H. on kamry, stabilized on inner frond before dropping to its lowest point on yellow khelal. These values were similar to that obtained by El-Sweedy *et al*., 2006 at 20, 25, 30 and 35˚C.

The daily age-specific survival rate was the highest at 25˚C and decreased as the temperature increase on the three date palm stages. The maximum number of eggs was produced on kamry stage at 35 ˚C-30% R.H. (at day 14 as 3.08 eggs/♀/day), followed by 35˚C-70% R.H. (at day 13.45 as 2.05 eggs/♀/day). The lowest values were obtained on inner frond at 25 ˚C-70%R.H. (at day 33.20 as 0.33 eggs/♀/ day). Observations on the biology of this mite in Iraq and Tunisia, revealed that the fecundity ranged between 30 and 100 eggs/female at 35ºC and 50% R.H.; incubation period was 3 days, larval period 2 days, nymphal period 4-7 days and generation period 8-14 days (Abdul-Hussein, 1969)

ACKNOWLEDGMENTS

Deepest thanks to Prof. Dr. M. Abou-Setta for critical review of the manuscript. Thanks are also due to Dr. A. Halawa and Dr. F. Al-Atawi who suggested the plan of this study. Thanks to members of Acarology Lab. Science food and Agri. College, King Saud Univ. for collecting samples of this mite.

REFERENCES

Abdul-Hussein, A. 1969. Biology of *Paratetranychus afrasiaticus* McGr. infesting date palms in Iraq. Bull. Soc. Ent. Egypte., 53 : 221-225.

Abou-Setta, M. M.; Sorrell, R.W. and Childers, C.C. 1986. Life 48: a BASIC computer program to calculate life table parameters for an insect or mite species. Florida Entomologist., 69: 690-697.

Al-Haidari, H. S.; Al-Safi, G.; Mechael, N. and Sallam, N. 1982. Effect of temperature on the development of *Oligonychus afrasiaticus* (McGregor). Plant protection Researche Year Book, 2:165-167 (in Arabic).

Al-Jabr, A. M.; Al-Shagag, A. A.; Al-Bazer, M. and Al-Samhan, A. A. 2003. Survey of mites infesting some date palm cultivars (*Phoenix datcylifera* L.) in AL-Hassa Oasis, Kingdom of Saudi Arabia. Saudi, J. Biol. Sci., 10(2): 37-45 .

Al-Jboory, I. J. and Al-Sweedy, T. M., 2006. Effect of different temperatures on the biology of old world date mite, *Oligonychus afrasiaticus* (McGregor). Proceeding of the 12th Int. Con. of Acarology 21-26/August, 2010 Amsterdam. pp361-363.

Al-Sweedy, T. M., 2003. Heat accumulation, fecundity schedules and life table structure of Old World Date Mite (Ghobar mite) *Oligonychus afrasiaticus* (McGregor) (Acari: Tetranychidae). M.Sc. Thesis, College of Agric., Baghdad Univ., Iraq. 94pp.

Al-Sweedy, T. M.; Al-Jboory, I.J. and Ahmad, T. R. 2006. Age-specific fecundity of Old World Date Mite *Oligonychus afrasiaticus* (McGregor) (Acari: Tetranychidae). Arab J. Pl. Prot., 24: 14-19.

Ba-Angood, S. and Bashih, G. 2000. A study on the effect of dust mite *Oligonychus afrasiaticus* (McGregor) (Acari: Tetranychidae) on the physicochemical properties of dates in Wadi Hadhramaut, Yemen. Arab J. of Plant Protection, 18: 82-85.

Ben Chaaban, S.; Chermiti B. and Kreiter, S. 2011. Comparative demography of the spider mite, *Oligonychus afrasiaticus* (McGregor) on four date palm varieties in Southernweastern Tunisia. J. of Insect Sciences, 11 :136 available online: insectscience.org/11.136.

Berring, T. M.; Holtzer, T.O. and Toole, J. L. 1984. Influences of temperature and humidity on pre-adult development of the Bank Grass Mite (Acari: Tetranychidae). Environ. Entomol., 13: 338-343.

Congdon, B. D. and Logan, J.A. 1983. Temperature effects on development and fecundity of *Oligonychus pratensis* (Acari: Tetranychidae). Environ. Entomol., 12 (2): 359-362.

Kadjbaf Vala, G. R. and Kamali, K. 1993. Biology of old world date mite *Oligonychus afrasiaticus* (Mc G.) in Khuzestan. The scientific J. Agric., 16: (1-2).

Jeppson, L. R.; Keifer, H. H. & Baker E. W. 1975. Mites injurious to economic plants. University of California Press, California, 614 pp.

Palevsky, E.; Ucko, O.; Peles, S.; Yablonski, S. and Gerson, U. 2003. Species of *Oligonychus* infesting date palm cultivars in the Southern Arava Valley of Israel. *Phytoparasitica*, 31(2): 350-355.

Rawash, A. F. 2003. Environmental and biological studies on some mites that affect date palm trees and its control. M.Sc. Thesis, Fac. Agric., Zagazig Univ., Benha Branch, 88 pp.

SAS Institute. 2010. SAS Statistics and Graphics Guide, Release 9.1. SAS Institute, Cary, North Carolina, 27513, USA.