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EFFECTS OF TEMPERATURES AND PLANT HOST SPECIES ON CERTAIN BIOLOGICAL CHARACTERS OF THE CASTOR BEAN WHITEFLY, *Trialeurodes ricini* MISRA (HIMEPTERA: ALYRODIDAE).

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ABSTRACT

Laboratory studies were carried out to determine the influence of temperature (abiotic) and host plant species (biotic) on the biological characters of the castor bean whitefly, *Trialeurodes ricini* Misra. Four temperatures namely 15, 20, 25 and 30°C, as well as the three plant species, castor bean (*Ricinus communis* L), Papaya (*Carica papaya* L.), and sweet potato (*Ipomoea batatas* L.) were tested. Various temperatures affected greatly the insect development, oviposition, life cycle and generation time when reared on castor bean plants. At 30 °C., egg incubation period, development of nymphal instars, adult longevity and life cycle were shortest, followed by 25 °C., while these characters were longer when the insect reared at 15 °C. The hatchability percentage and female fecundity were greater at both 30 and 25 °C. Meanwhile they were lower at 15 °C. The temperature threshold (t_0) and thermal accumulative effect (degree-days) were also calculated. The laboratory studies were confirmed by field applications regarding the relationship between temperatures among the geographical seasons and the insect populations. The study demonstrates that *T. ricini* can, in otherwise unlimited conditions, persist and increase in number within the range 20-30 °C. Therefore, the pest is well adapted to high temperatures and may extend its distribution if the mean world temperatures increase because of global warming.

Regarding the plant host species, the castor bean was the preferred host followed by papaya, while the sweet potato was not preferred for insect rearing. This indicated that the host plant species had a significant effect on egg hatchability, nymphal survival, female fecundity and the duration of life cycle of *T. ricini*.

Keywords: caster bean whitefly, *Trialeurodes ricini* Misra, biological aspects, effect of temperature, temperature threshold, thermal accumulative units, degree days, plant host, castor bean, papaya, sweet potato,

INTRODUCTION

In Egypt, many species of whiteflies have been recorded (Fathi, 1996; Abd-Rabou, 1999; Abdel-Baky, 2000). Beside *Bemisia argentifolii*, a heavy infestation of the castor bean whitefly (CBWF), *T. ricini*, was observed in Qalyubiya governorate and all the country (Idris *et al.*, 1997; Abdel-Baky, 2000). *Trialeurodes ricini* may be a senior synonym of *T. lauri* and recently has been introduced into Egypt (Martin *et al.*, 2000). Therefore, it was found for the first time in September 1997 on *R. communis* in Qalyubiya governorate, and rapidly became widespread (Idris *et al.*, 1997, Abd Rabou, 1999; Abdel-baky, 2000). At present it occurs in Dakaheliya, Sharkyia, Damietta, and Qalyubiya Governorates, as well as, New Damietta City (Abdel-Baky, unpublished data). It has been intercepted twice by UK on unspecified leaves from Cameroon and Nigeria (possibly *Amaranthus* leaves).

Currently, *T. ricini* has been recorded in Egypt (Martin *et al.*, 2000). It is also present in Iran and Iraq (Shishehbor and Brennan, 1995; Martin *et al.*, 2000; McLeod, 2002). This indicates that the pest is likely occurring in countries bordering the eastern Mediterranean (Martin, 1987; Martin *et al.*, 2000). Accordingly, *T. ricini* occurs mainly across the Middle East, Sub-Saharn Africa and in the oriental regions.

Indeed, *T. ricini* has characteristics that contribute to severe pest potential. The rapid reproduction continuously during spring, summer and fall and its distribution all over the Egyptian governorates in huge numbers indicate that it may possess climatic tolerances that permit its survival in many geographical and cropping zones.

T. ricini is a polyphagous species and has narrow-host range. Hosts in eight angiosperm families were listed (Mound and Halsey, 1978), but others have been recorded subsequently, under 14 plant families by Bink-Moenen (1983) from Chad alone. Mostly, *T. ricini* is associated with the castor oil plants (*R. communis*). The following plants were reported as preferred hosts, which included *R. communis* (castor bean), *Dolichos lablab* (Lablab), and *Gossypium hirsutum* (cotton). It can also feed on *Cucurbita maxima* (pumkin), *I. batatas* (sweet potato), *Solanum melongena* (aubergine), *Phaseolus vulgaris* (bean), *Lycopersicon esculentum* (tomato), *Solanum tuberosum* (potato), *Cucurbita pepo* (melon), and *Cumumis sativa* (cucumber). It may also damage vegetable crops grown under glasshouse conditions. An additional concern is the transmission of tomato yellow leaf curl begomovirus (Idris *et al.*, 1997; Nelson *et al.*, 2004).

The life history of *T. ricini* was studied on eight host plant species (Shishehbor and Brennan, 1996 a). Significant differences in oviposition rate were observed on host plant species. The insect survival on hosts ranked as follows; aubergine, cotton, pumpkin, French bean, and potato. The authors followed ovipositional and survival rates on four plant species. They concluded that the plant species affected greatly the development time, adult size and sex ratio of *T.ricini*.

T. ricini is a tropical and sub-tropical pest (most favorable temperatures are 25 to 30 °C). However, it may occur in southern Europe, where many of its host plants are grown. Shishehbor and Brennan (1996 b) reported that *T. ricini* can increase in number and causes outbreaks within the range of 20 to 35 °C. Determination of the temperature preferences of an insect is important because insects have a limited ability to regulate their body temperature and temperature determines developmental time, fecundity and population growth (Hagstrum *et al.*, 1998). Therefore, the current study aims to estimate the developmental threshold, thermal requirements of egg incubation, nymphal stage, adult longevity, the development from egg to adult as well as female fecundity of the castor bean whitefly, *T.ricini* under four constant temperatures. In addition, the effects of three plant hosts on the previous biological characters of *T. ricini* under laboratory conditions were also investigated

MATERIAL AND METHODS

I. General considerations:

This study was designed to interpret the effect of certain abiotic and biotic ecological factors on some biological characters of the castor bean whitefly, *Trialeurodes ricini.* These factors included four constant temperatures, together with some plant host species. For establishing the castor whitefly colony, the adults of *T. ricini* were collected from the castor plants at Mansoura University Campus and maintained on potted young castor plants under screen cages. The insect was reared under the constant temperature of 25±1°C and 70±5% R. H. for many generations.

II. Role of various constant temperatures on the biology of *T. ricini*:

All experiments were conducted on young castor plants, *R. communis*, in temperature controlled cabinets set at four constant temperatures namely 15, 20, 25 and 30 °C and 70±5% R. H. and a photoperiod 14 L: 10 D. *Trialeurodes ricini* adults were collected from castor plant at Dakahelia governorate and reared continuously on young castor plants in wooden cages covered with nylon cloth. The castor plants were used as a host and 10 replicates (castor plants) were initiated for each temperature.

To determine the egg incubation period, 10 small plastic cups cultivated with castor plants which their leaves bearing newly deposited eggs (20 eggs per plastic cup) were incubated at the four experimental temperatures, 15, 20, 25 and 30 °C. The eggs were inspected every 24 hours until appearance of the 1st instar nymphs (crawlers). The hatchability percentages were also calculated under the same conditions.

The nymphal development was also studied. Immediately after hatching, the development of the 1st instar nymphs was determined by confined a single nymph in a sector of leaf under a clip cage. There were 10 replicates for each treatment. The nymphs were investigated daily and transformations among instars were determined based on molting, size and morphological differences between nymphs. The total nymphal development was also calculated. In addition, the ovipositional periods, the adult longevity, female fecundity were all recorded at the four constant temperatures.

Thermal requirements for development of *T. ricini*

The developmental thresholds and thermal constants were calculated for each immature stage. The linear regression equation y = a + bx (where y = 1/D) and the coefficients of determination R^2 were used as the independent variables (Ali and Darwish, 1984). Dependent variables included incubation period of eggs, nymphal development and the development from egg to adult at each temperature (Campbell *et al.*, 1974). The temperature threshold for development (t_0) was calculated at the point of interception of the regression line with the X axis. The thermal constant, K, was determined as 1/b according to Johnson *et al.* (1979) and Stathas (2000).

The thermal summation method was used to estimate the thermal constant (K) or degree-days (DD). The constant is the number of degree-days required to complete the development of one stage according to the formula $K= D (T-t_0)$, where D = days for development at temperature T=

experiment temperature in degrees centigrade t_0= the developmental threshold.

III. Effect of plant host species on *Trialeurodes ricini* biological characters:

Three host plants were tested, namely castor bean plant, *R. communis* (Family, Euphorbiaceae); Papaya plant, *C. papaya* (Family, Papayaceae); and sweet potato, *I. batatas,* (Family, Convolvaceae). The experiments were carried out at 30±1 °C and 70±5% R. H. under a photoperiod of 14 L: 10 D.

Confining 10 adult females on the undersurface of each host plant leaf by means of screen cages conducted the experiments. After 24 hours, the adults were removed from the cages and the numbers of *T. ricini* eggs laid were recorded. Fifteen replicates of each host plant were applied because the leaves of the tested plants sometimes died or become unsuitable. The plants were then monitored daily until adult emergence. Hatchability, nymphal developmental period, percentage of adult emergence, adult longevity and total fecundity of the female were recorded. The variations among the three host plants were recoded and analyzed.

IV. *Trialeurodes ricini* population and atmospheric temperature:

An outdoor survey was fulfilled by choosing 50 caster bean trees distributed in Dakahelia governorate. Three leaves were selected randomly from upper, middle and lower main stem of the tree. Selected leaves were inserted in the plastic bags and transferred directly to the laboratory for investigations. Three squares centimeters were selected randomly from the edges and the middle of the leaf, and the eggs and nymphs of were counted by the aid of a stereomicroscope. This study was continued over two years from January 2002 till December 2003. The atmospheric temperatures (minimum and maximum) were obtained from the Agricultural Authorities in Dakahelia governorate.

V. Statistical Analysis:

The analysis of variance among the insect biological characters was fulfilled with regard to effects of both temperatures and plant hosts, by using CoStat software program (1990). The significant differences were estimated at 5 and 1% level.

RESULTS

I. Impact of temperature on the insect biological characters:

The temperature affected greatly the following biological characters of *T. ricini*:

A. Egg Stage:

The egg incubation period varied at different temperatures. At 30 °C., this period averaged 3.8±0.58 days, followed by 25 °C. (6.0±1.13 days), while it was longer at 15 °C. (17.4±3.24 days). In addition, the hatchability percentages were greater at higher temperatures (Table 1). These percentages were 90, 76.6, 50.5 and 24.0% at 30, 25, 20 and 15 °C, respectively. This was possibly due to faster embryonic development at higher temperature (Table 2).

B. Nympahl stage:

The castor whitefly has five nymphal instars, which were influenced by temperatures. At 30 °C, the durations of the instars averaged 3.2±0.24, 3.60±0.65, 3.40±0.57, 3.20±0.45 and 2.60±0.45 days for the 1st, 2nd, 3rd, 4th and 5th instars, respectively. Meanwhile, the durations were 4.6±0.65, 4.80±0.89, 4.40±0.87, 4.60±0.69 and 3.60±0.69 days at 25 °C for the 1st, 2nd, 3rd, 4th and 5th instars, respectively (Table 1). At 20 and 15 °C., the nymphal durations increased. At 15 °C., the 1st, 2nd, 3rd, 4th and 5th instars were 10.8±1.58, 13.8±1.25, 12.6±1.74, 8.40±1.68 and 8.0±1.68 days, respectively. The average total development of nymphal stages lasted 16.20±1.65, 22.00±1.99, 36.2±2.98, and 52.4±3.21 days at 30, 25, 20 and 15 °C, respectively (Table 1). The statistical analysis revealed that the nymphal durations varied significantly according to the temperature (P≥0.05). The rate of development of nymphal stage was apparently faster at higher temperatures, while it was retarded and longer at lower temperatures as shown in Table (2).

C. Adult Longevity:

The adult longevity was 20.0±2.10, 18.0±2.12, 12.0±1.65 and 08.40±1.23 days at 15, 20, 25 and 30 °C, respectively. Statistically, it varied significantly at the level 5% according to temperature.

D. Egg-adult period (generation):

The period from egg to adult was shorter at higher temperatures and longer at lowering ones. These periods were 21.20±1.25, 28.4±2.12, 50.40±2.86 and 101.2±3.52 days at 30, 25, 20 and 15 °C, respectively (Table 1). The rates of development are shown in Table (2).

E. Female Fecundity:

The female fecundity was also affected by temperature (Table 1). Higher numbers of eggs laid per female were deposited at higher temperatures, and decreased at lower ones. The castor whitefly female deposited an average of 265.2±9.84 eggs at 30°C, 238.4±4.89 eggs at 25°C, 162.0±5.42 eggs at 20 °C and 97.4±7.52 eggs at 15°C (Table 1).

Table (1): Biological characters of the castor bean whitefly, *T. ricini* reared at four constant temperatures.

Biological Aspects of *T. ricini*		Various Constant Temperatures (Means)			
		15 °C	20 °C	25 °C	30 °C
Egg incubation period (days)		17.4±3.24 a	14.4±2.89 b	6.0±1.13 c	3.8±0.58 d
Egg Hatchability %		24 d	50.5 c	76.6 b	90.00 a
Nymphal stage (in Days)	1st instar	10.8±1.58 a	8.60±0.98 b	4.6±0.65 c	3.2±0.24 c
	2nd instar	13.8±1.25 a	8.00±0.92 b	4.80±0.89 c	3.60±0.65 d
	3rd instar	12.6±1.74 a	7.80±0.87 b	4.40±0.87 c	3.40±0.57 c
	4th instar	8.40±1.68 a	5.80±0.81 b	4.60±0.69 c	3.20±0.45 c
	5th instar	8.0±1.68 a	5.0±0.81 b	3.60±0.69 c	2.60±0.45 c
Total development of nymphal stage (days)		52.4±3.21 a	36.2±2.98 b	22.00±1.99 c	16.20±1.65 d
Nymphal survival %		22.4 d	52.8 c	77.8 b	91.9 a
Adult Longevity (days)		20.0±2.10 a	18.0±2.12 b	12.0±1.65 c	8.40±1.23 d
Egg – Adult (days)		101.2±3.52 a	50.40±2.86 b	28.4±2.12 c	21.20±1.25 d
Average fecundity /female		97.4±7.52 d	162.0±5.42 c	238.4±4.89 b	265.2±9.84 a

[a] the numbers followed by the same letter within a row are not significantly different at 5% level.

Table (2): Rate of development of the castor whitefly, *T. ricini* reared at four constant temperatures.

T. ricini stages	Various Constant Temperatures			
	15 °C	20 °C	25 °C	30 °C
Egg stage	05.47	06.94	16.60	26.30
1st instar	09.25	11.62	21.73	31.25
2nd instar	07.24	12.50	20.83	27.77
3rd instar	07.93	12.82	22.72	29.41
4th instar	11.96	14.70	21.73	31.25
5th instar	12.50	20.00	27.70	38.46
Total development of nymphal stage	1.94	02.76	04.54	06.17
Egg - Adult	00.99	01.98	03.52	04.72

II. Temperature threshold for development and thermal units (Degree-Days):

The linear regression equations that describe the relationship between *T. ricini* developmental stages and temperatures and thermal units required for development were determined (Tables 3 & 4) and Figure (1). The temperature threshold for egg development was found 12.37 °C. Moreover, egg development required 74.60 thermal units (DD) to complete its development (Table 4).

Table (3): Regression equations as an indicator of the castor whitefly, *T. ricini* development reared at four constant temperatures and development threshold (t_0).

T. ricini developmental stage	Regression Equations	R^2	t_0
Egg stage	Y=1.4274 x – 18.219	0.9217	12.37
1st instar	Y=1.5220x – 15.785	0.9468	10.37
2nd instar	Y=1.3684x – 13.829	0.9933	10.10
3rd instar	Y=1.4868x – 15.233	0.9851	10.24
4th instar	Y=1.3016x – 9.3910	0.9487	07.20
5th instar	Y= 1.7116x –13.846	0.9917	08.10
Total development of nymphal stage	Y=0.2570x –02.050	0.9529	07.97
Egg – Adult	Y= 0.2546x –2.9260	0.9938	11.48

Table (4): Thermal units (Degree-Days) required for the complete development of the castor whitefly, *T. ricini* reared at four constant temperatures.

Stage	Thermal Units (Degree-Days)				Mean
	15 °C	20 °C	25 °C	30 °C	(TU)
Egg	45.76	109.87	75.78	66.99	74.60
1st instar	50.00	82.82	67.30	62.82	65.73
2nd instar	67.62	79.20	71.52	71.64	72.50
3rd instar	59.98	76.13	64.94	67.18	67.06
4th instar	65.52	87.04	81.88	72.96	76.85
5th instar	55.20	59.50	60.84	56.94	58.12
Total Nymphal stage	369.37	442.00	378.62	359.80	387.45
Egg - adult	356.22	429.41	438.05	342.62	404.08

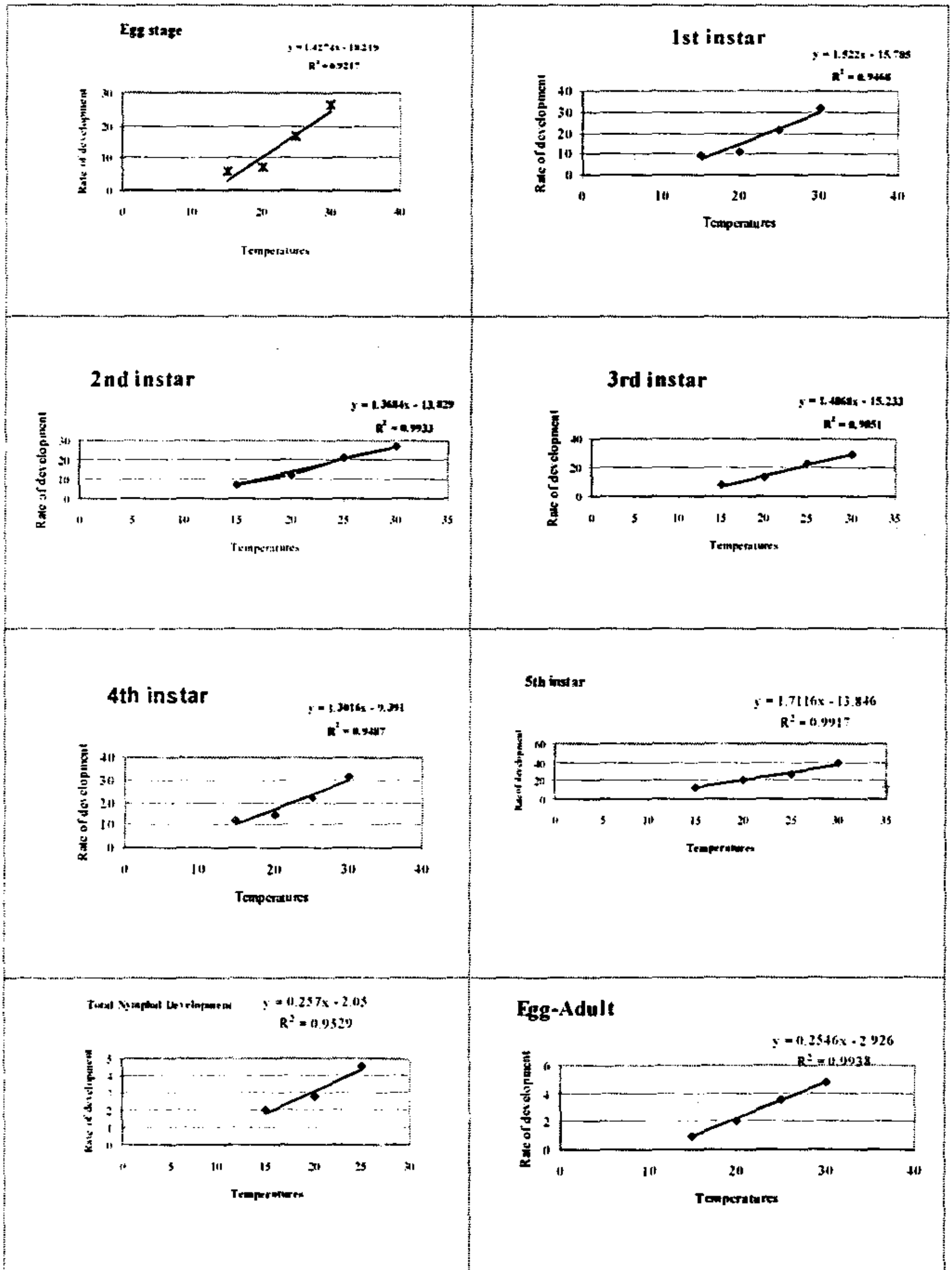

Figure (1): Developmental threshold (t_0) of the castor whitefly, *T. ricini* eggs, nyamphal instars, total nymphal development and egg to adult reared at four constant temperatures.

The temperature threshold (t_0) was almost equal for nymphal instars, except the 4th and 5th instars (Table 3). The temperature threshold was 10.37, 10.10, 10.24, 07.20 and 08.10 °C, for the 1st, 2nd, 3rd, 4th and 5th instars, respectively. Meanwhile, the threshold temperature for total nymphal development was 07.97 °C. The degree days required for the 1st, 2nd, 3rd, 4th and 5th instars and total nymphal development were 65.73, 72.50, 67.06, 76.85 58.12 and 387.45 DD (Table 4). The threshold for egg- adult development was 11.48 °C and needed 404.08 thermal units for its development (Tables 3 & 4).

Table (5): Average numbers of *T. ricini* eggs and nymphs/ cm² (Mean±SE) infested castor bean plants and average air temperature during the four geographical seasons at Dakahelia governorate.

Seasons	2002					2003				
	T. ricini/ cm²		Average Air Temperatures			*T. ricini*/ cm²		Average Air Temperatures		
	Eggs	Nymphs	Max.	Mini.	Mean	Eggs	Nymphs	Max.	Mini.	Mean
Winter 21 Dec. -20 March	1.08± 0.01	0.59± 0.03	22.3 ±3.11	8.90±1 .56	15.6± 1.32	0.87± 0.04	0.62± 0.03	18.53± 2.75	10.68± 1.59	14.61± 1.98
Spring 21 March -20 June	6.10± 0.24	1.81± 0.11	29.58 ±2.21	15.22± 2.8	22.4± 2.05	5.23± 0.65	2.23± 0.06	24.73± 2.45	17.38± 2.10	21.06± 2.[illegible]1
Summer 21 June-20 Sept.	24.14 ±1.89	9.19± 1.06	34.0 ±3.12	20.75± 2.41	27.38± [illegible].24	[illegible]5.24± 1.85	12.01± 1.06	[illegible]6.42± [illegible].12	22.83± 2.45	29.63± 3.65
Fall 21 Sept.-20 Dec.	32.46 ±2.59	21.3± 2.86	25.62 ±2.45	17.5± 1.75	21.56± 1.95	28.30± 2.11	24.33± 12.65	24.63± 2.32	15.07± 1.79	19.85± 2.41

III. *Trialeurodes ricini* and atmospheric temperature during the four geographical seasons:

The numbers of immature stages *T. ricini* /sampling unit varied from season to another (Table 5). The highest number of eggs and nymphs were recorded in the fall of each year followed by summer and spring. Meanwhile, the lowest numbers were obtained in winter (Table 5). This was attributed to the maximum atmospheric temperatures which averaged 25.62±2.45 and 24.63±2.32 °C in 2002 and 2003, respectively. Meanwhile the lowest varied from 17.5 °C in 2002 to 15.07 °C in 2003. Although the averages temperature in summer was 27.38 °C in 2002 and 29.63 °C in 2003, the numbers of *T. ricini* immature were lower than in the fall.

IV. Effects of plant host on the biological characters of *T. ricini*:

Three plant hosts were used in this experiment at 30°C (Table 6). The incubation period differed significantly at 1% level based on the plant host species. The incubation period was lower when *T. ricini* was reared on the castor bean followed by papaya and was longer when reared on the sweet potato (Table 6). Moreover, the plant host affected greatly the egg hatchability percentage, which reached 89.4, 61.6 and 40.8% on castor, papaya and sweet potato, respectively.

The plant host also influenced the durations of nymphal instars. The duration was shortest on castor plants, followed by papaya, while it was longer on the sweet potato (Table 6). The total development of nymphal instars were 15.4±0.98 days on castor plant, 20.0±0.89 days on papaya plants and 21.6±0.96 days on the sweet potato plants. Statistically, the castor plants were the most preferred hosts by the nymphal stage to show shortest time to complete its development, and papaya was intermediate, while sweet potato was the least preferred host.

The adult longevity was longer on castor plants (15.8±1.25 days), followed by papaya (14.6±1.43 days), while it was shortest on the sweet potato plants (13.6±1.20 days). The life cycle (egg-adult) was shortest on castor plants, being 19.4±1.89 days, while it was longer on both papaya plants (25.2±1.69 days) and sweet potato (26.8±1.78 days).

Moreover, the plant host species also affected the female fecundity. The higher fecundity/female was observed on castor plants (297.2±5.65 eggs/female), followed by papaya (185.2±4.98 eggs/female). The female deposited the lowest number of eggs (116.4±8.90) on the sweet potato (Table 6).

Table (6): Biological characters of the castor whitefly, *T. ricini* reared at three plant hosts at 30 °C.

Biological Aspects of *T. ricini*		Host Plant Species		
		R. communis	*C. papaya*	*I. batatas*
Egg incubation period (days)		3.6± 0.25 b	4.8± 0.46 ab	5.2± 0.65 a
Egg Hatchability %		89.4 a	61.6 b	40.8 c
Nymphal stage In days)	1st instar	3.6±0.32 b	4.4±0.41 ab	5.0±0.24 a
	2nd instar	4.0±0.22 b	5.2±0.29 ab	5.6±0.70 a
	3rd instar	3.8±0.33 b	4.6±0.42 ab	5.2±0.65 a
	4th instar	2.8±0.12 b	4.4±0.36 ab	5.0±0.38 a
	5th instar	2.5±0.11 b	3.9±0.24 ab	5.4±0.41 a
Total developmental of nymphal stage (days)		15.4±0.98 b	20.0±0.89 a	21.6±0.96 a
Nymphal survival %		92.04 a	72.5b	45.9c
Adult Longevity (days)		15.8±1.25 a	14.6±1.43 ab	13.6±1.20 b
Egg – Adult (days)		19.4±1.89 b	25.2±1.69 a	26.8±1.78 a
Average fecundity / female		297.2±5.65 a	185.2±4.98 b	116.4±8.90 c

[a] the numbers followed by the same letter within a row are not significantly different at 1% level.

V. Natural incidence of *T. ricini* immatures on castor and papaya plants.

The numbers of *T. ricini* immatures stages were higher on castor bean, being 68.67 and 66.71 % of the total collected insects on both hosts in 2002 and 2003, respectively (Fig.2). Meanwhile, these numbers were 31.33 and 33.29% on papaya plants.

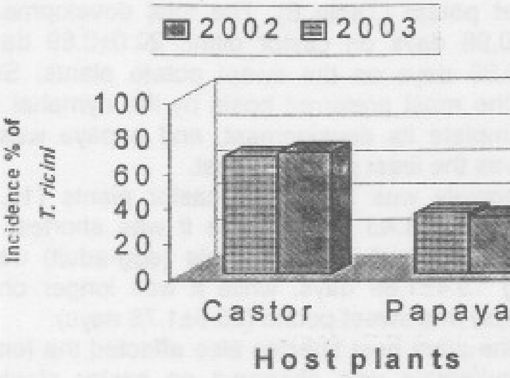

Figure (2): Incidence percentage of *T. ricini* immatures on castor bean and papaya.

DISCUSSION

Abiotic and biotic factors can both influence growth, consumption and food efficiencies of herbivorous insects (Bernays and Chapman, 1994 and Levesque *et al.*, 2002). Among these factors, variation in temperature and food source can strongly affect insect biological characters (Levesque *et al.*, 2002).

Temperatures can have an impact on egg incubation period, duration of nymphal stage, adult longevity and female fecundity. However, the degree of temperature varies from insect to another (Taylor, 1981). Estimation of the temperature threshold and degree-days (DD) for insect development can substantially contribute to the prediction of insect appearance, insect outbreak under different environmental conditions, as well as, determine the suitable time for applying control measures.

The current study pointed out that temperatures between 25 and 30 °C. were the most favorable degrees for insect development and egg incubation period to be shorter than other temperatures. These results comply with Shishehober and Bernnan (1996 b) who found that the 30°C was the best degree for *T. ricini* development from egg to adult and nymphal survival. They also determined longevity and reproductive potential of adult males and females of the same insect at four constant temperatures (20, 25, 30, and 35 ±1°C).

The current research proved that female fecundity varied according to temperature. It was found that the highest eggs number was recorded at 30 °C., followed by 25°C. Shishehober and Bernnan (1995 and 1996 b) also reported that *T. ricini* females oviposited an average of 183, 224, 294, and 132 eggs at 20, 25, 30, and 35 °C, respectively, and had a mean longevity of 38.52, 28.15, 15.78, and 10.11 days at the same four temperatures. This means that temperatures between 25 and 30 °C. were favorable for insect ovipostion and physiological activity. In addition, the generation times decreased from 69.88 to 24.92 days with increasing temperature.

The nymphal survival, in this investigation, was higher and ranged from 77.7 to 91.9% at both 25 and 30 °C, which it decreased to 22.4% at 15 °C. This is in harmony with Shishehbor and Brennan (1995) who found that immature survival increased from 64.5% at 20 °C to 92.8% at 30 °C. The total developmental time from egg to adult of *T.ricini* varied from 54.4 days at 20 °C. to 16.8 days at 30 °C (Shishehbor and Brennan, 1995). The present results proved that the developmental time form egg to adult required 70.55±3.52 days at 15 °C and decreased to 20.17±1.25 at 30 °C. Regarding the accumulative temperature, Shishehbor and Brennan (1995) found that development of the egg and the first-to fifth-instars larva required 63 and 180 DD, respectively above the threshold level. The degree-days have been shown to be useful for prediction of the emergence of an insect pest (Wilson and Barnett, 1983). It could be also used for monitoring population development (Rummel and Hatfield, 1988).

In India, David, *et al.* (1973) studied the influence of weather factors (such as maximum and minimum temperatures, humidity and rainfall) on the population of the castor whitefly *T.ricini.*They reported that the pest appeared in very low in numbers or was absent during the period from November to mid-February and gradually increased thereafter. There was a positive relation between population size and maximum temperature. In other way, weather factors can produce effects on insect populations in four ways, by modifying, 1) the activity of the endocrine system; 2) survival; 3) development and 4) reproduction (Varley *et al.*, 1973).

The laboratory studies were confirmed by outdoor survey which revealed that *T. ricini* outbreaks and increased in numbers during the fall and summer. The insect exhibited numbers were higher in fall than in summer (Table 6), although the average temperature in summer was about 30 °C. The present results support the conclusion that the maximum and minimum temperatures had a significant impact of the insect population outdoors more than the average temperature. Therefore the maximum temperature during the fall was an optimum temperature for the insect physiological activity. This may be explain the outbreaks and huge numbers of the insect in September, October and November each year.

Shishehbor and Brennan (1996 a) studied the effect of host plant species in terms of life history of *T. ricini* on eight host plant species. The highest number of eggs was deposited on aubergine, intermediate on potato, cotton and French bean, and lowest on melon, cucumber and tomato. Meanwhile, the three host plants used in the present study showed that *T. ricini* deposited the higher number of eggs on costar, intermediate on papaya and the lower number on the sweet potato. Moreover, egg hatchability percentage and nymphal survival were higher on costar followed by papaya and were lower on the sweet potato. Shishehbor and Brennan (1996 a) who ranked the survival on hosts as follows :aubergine > cotton > pumpkin > French bean > potato. They also mentioned that no individuals survived to adults eclosion on melon, cucumber or tomato. In field studies, Abd-Rabou, *et al.* (2000) recorded the highest population of *T. ricini* between September and December on *R. communis, Bidens bipinnata, Cichorium endivia* and *Sonchus oleraceus* which appeared to be the major host plants. According to David, *et al.* (1973) a perennial type (variety OSS 23/61) of castor (*R. communis*) was susceptible to *T. ricini* attack. This was in harmony with the present results in Figure (2). The data showed that castor bean was the preferred host under natural infestation. This may be attributed to the total free amino acid content in the resistant types which was lower than in the susceptible ones (David and Paul, 1973).

In conclusion, this obtained results proved that *T. ricini* can persist and increase in numbers within the range of 20-30 °C. Therefore, the pest is well adapted to high temperatures and may extend its distribution if the mean world temperatures increase due to global warming. The host plant species also had a significant effect on the developmental time, egg hatchability, nymphal survival, female fecundity and the duration of life cycle of *T. ricini*. Further studies on *T. ricini* host range, distribution, natural enemies, and viral disease transmission are required.

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تأثير كل مِنْ درجاتِ الحرارة ونوع العائل النباتى على بَعْض الخصائص البيولوجية لذبابة الخروع البيضاء (Himeptera: Alyrodidae) *Trialeurodes ricini* Misra.

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أجريت دراسات معملية بغرض تحديد تأثير درجةِ الحرارة ونوع العائل النباتى علىالخصائص البيولوجية لذبابة الخروع البيضاء. حيث استخدمت أربعة درجات حرارة هى، ١٥، ٢٠، ٢٥ و ٣٠ م، بالإضافة إلى، ثلاثة عوائل نباتية هى الخروع، البابائظ، والبطاطا. وقد أجريت التجارب تحت درجة رطوبه نسبية ثابتة هى ٧٥±٥%.

وقد أثر إختلاف درجاتِ الحرارة بدرجة واضحة على معدل نمو الحشرة، وضع البيض، مدة الجيل ودورة حياة الحشرة عند التربية على نبات الخروع. وعند التربية على ٣٠م، فإن فترة حضانة البيض، مدة أعمار الحوريات، فترة حياة الحشرة الكاملة كانت أقصر وكذلك على درجة ٢٥م. بينما استغرقت فترات أطول عند التربية على درجة ١٥ م. كما أن نسبة hatchability وخصوبة الأنثى كانتا أعلى على درجةِ الحرارة الأعلى ٣٠ و ٢٥ م، وانخفضت بانخفاض درجة الحرارة إلى ١٥م. كذلك تم حساب صفر النمو للبيض والحوريات ومدة الجيل وكذلك درجات الحرارة التراكمية. وتم تدعيم الدراسة المعملية بدراسة حقلية لتأكيد تأثير درجات الحرارة على تعداد الحرة فى المواسم الجغرافية المختلفة. أوضحت الدراسة أن الدرجة المناسبة لنمو الحشرة تترواح بين ٢٥-٣٠ م.

و بخصوص نوع العائل النباتى، فإن نبات الخروع كان أفضل العوائل لنمو وتكاثر الحشرة يليه البابائظ بينما كانت البطاطا أقل العوائل الثلاثة تفضيلا. مما يبين أنّ لنوعَ العائل النباتى تأثير هامّ على الخصائص البيولوجية للحشرة تحت ظروف المعمل أو الحقل.