INFLUENCE OF TEMPERATURE ON LIFE TABLES PARAMETERS OF SOME *TRICHOGRAMMA* SPECIES REARED ON *PECTINOPHORA GOSSYPIELLA* (SAUNDERS) EGGS.

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Abstract

Laboratory studies were conducted to determine the influence of four different constant temperatures on the life table parameters including the net reproductive rate (R_o), life cycle, the intrinsic (^{r}m) and finite (exp. ^{r}m) rates of increase and population doubling time [(ln2)/ ^{r}m] of *Trichogramma evanescens* Westwood, *Trichogrammatoidea bactrae* Nagaraja , *T. embryophagum* Hartig and *T. brassicae* Bezdenko. Results showed that 25°C is the most favorable temperature for breeding the studied four species of *Trichogramma*. At this temperature, the highest values of net reproductive rates were obtained. Accordingly, it was observed that *T. bactrae* had good qualities, including high intrinsic rate of natural increase (^{r}m = 0.3726), a high finite rate of increase (exp. ^{r}m = 1.451) and the shortest population doubling time (1.860 days). The net reproductive rates were 49.85, 43.72, 38.99 and 36.14 females for *T. embryophagum, T. evanescens, T. brassicae* and *T. bactrae,* respectively. *T. bactrae* is expected to be effective for use in biological control of pink bollworm.

INTRODUCTION

For pest control, establishing of any management program require great knowledge on the effect of the used temperatures on the population growth of the used beneficial organisms. Estimation of population growth can be achieved with life tables, which synthesize data on reproduction and mortality of a population. Under limited conditions Navarro and Marcano (2000) conducted studies of life tables of *Trichogramma pretiosum* Riley and *T. atopovirilia* Oatman Y Platner, grown at constant temperatures of 18,23,28 and 33°C on eggs of corn earworm *Helecoverpa zea* (Boddie)., and stated that there were some indications that the intrinsic rate of natural increase may be a reliable method for differentiating the two species of *Trichogramma*. Also Pratissoli and Parra (2000 [a]) studied the biology and reproductive potential of *Trichogramma pretiosum* reared on eggs of *Phthorimaea operculella* (Zeller) and *Tuta asoluta* (Meyrick) at different temperatures degree (18, 20, 22, 25, 30, 32°C), 70± 10% RH and a photophase of 14 hours, through fertility life tables, with the aim of determining the thermal requirements and the number of

generations during the year. They found that the net reproduction rate (Ro) differed according to the temperature variation for both species. The maximum increase in capacity of *T. pretiosum* on the first host (*T. absoluta*) was reached at 22°C and on the second host (*P. operculella*) between 22 and 25°C. Abd El-Hafez, (2001) found that the different values for life table parameters of four Trichogrammatids (*Trichogramma embryophagum* Hartig, *Trichogramma brassicae* Bezdenko, *Trichogrammatoidea bactrae* Nagaraja and *Trichogramma evanescens* Westwood) when reared on the same host (*Pectinophora gossypiella).*

The aim of this study was to determine the best temperature degree for rearing each of the four *Trichogramma* species that give good qualities. This quality was determined by estimating the net reproductive rates, intrinsic rate of natural increase, finite rate of increase (exp. 'm) and population doubling time

MATERIALS AND METHODS

I. Rearing technique:

1. Host rearing:

Eggs of pink bollworm *Pectinophora gossypiella* (Saund.) were used as a host for rearing four trichogrammatids species. Laboratory rearing of this host was carried out as described by Abd El-Hafez, *et al.* (1982).

2. Parasitoid rearing:

In the present work, four Trichogrammatids belonged to *Trichogramma* and *Trichogrammatoidea* genera were reared on pink bollworm eggs in Bollworms Research Department, Plant Protection Research Institute, ARC according to Abd El-Hafez (1995). These parasitoids are namely *Trichogramma evanescens* Westwood (native strain), *Trichogrammatoidea bactrae* Nagaraja (imported from USA in 1992) and *T. embryophagum* Hartig and *T. brassicae* Bezdenko imported from Iran in 1998. Host egg sheets (2000-2500eggs) were exposed to *Trichogramma* adults (100-150 adults) into glass jars (0.4 - liter) provided with filter paper witted by 10% sucrose solution for nutrition and covered with cloth-wrapped cotton kept in position by rubber band. Egg sheets were renewed daily to avoid super-parasitism..

The life 48-computer program (Abou- Setta *et al.* 1986) was used to compare reproductive output of the four parasitoid species on the different temperatures. Life table parameters were calculated using the following formula:

$$\sum_{0}^{x} exp\,(-r_m{}^x)\, L_x M_x = 1$$

The net reproductive rates (R_0) and intrinsic rates of increase ('m) were calculated according to the method of Birch (1948). R_0 was estimated by $\Sigma\ L_x\ M_x$, where L_x is the proportion of females surviving to day x and M_x is the mean number

of female progeny produced per female during the day x. The value of ^{r}m was estimated from the formula. The finite rate of increase ($_{exp}{}^{r}m$) is the natural antilogarithm of the intrinsic rate of increase and gives the number of times of the population multiplies in a unit time. T is the mean length of generation time expressed in days. The age specific female fecundity (M_x) and the rate of survival (L_x) were graphically illustrated.

RESULTS AND DISCUSSION

Data illustrated in Figs (1-4) showed that, fecundity reached to the highest value in the first day of emergence for all temperatures degree used. This phenomenon was strongly correlated with the shortness of adult longevity. For example, *T. embryophagum* lived the shortest periods at 15 & 30°C and put 95.16 and 93.39% of their eggs immediately after emergence. After that, the number of progeny per female declined in the subsequent days until females' death. Also, *T. evanescens* and *T. brassicae* produced 87.73 and 85.67% of their progeny in the first day at 30°C and from 38.68-55.26% and 41.83-43.45% in the same day at the other three temperatures, respectively. The percentages of progeny for *T. bactrae* in the first day of its life-span were 68.10 & 65.12%, respectively, while they produced 37.49 and 34.09% of their progeny in the first day at 15 and 20°C, respectively. From these results it could be concluded that females of these four parasitoids followed the group of pro-ovigenic females i. e, these females reach the adult stage with ripen eggs, deposit them within a brief period. In this group most of their eggs produced from nutrients carried over from the larval stage, this is in accordance with that found by Garcia and Tavares (1995) for *T. cordubensis* at 15, 20 and 25 °C as they mentioned that, a faster oviposition at higher temperatures will allow this pro-oviginic parasitoid to lay most of its available eggs in a short lifetime period.

Net reproductive rate (R_o):

The net reproductive rate (R_o) varied according to the parasitoid species and the rearing temperature (Table 1). For all species, R_o reached to its highest values at 25°C and it was estimated by 43.72, 36.144, 49.851 and 38.994 female/ for *T. evanescens, T. bactrae, T .embryophagum* and *T. brassicae*. These values decreased to 18.41, 26.797, 29.928 and 19.509 female/ at 30°C for these species, respectively. The corresponding figures at 15 and 20°C were 26.92& 30.682, 18.608& 35.226, 20.242 & 29.928 and 24.674 & 19.509 female/ , respectively.

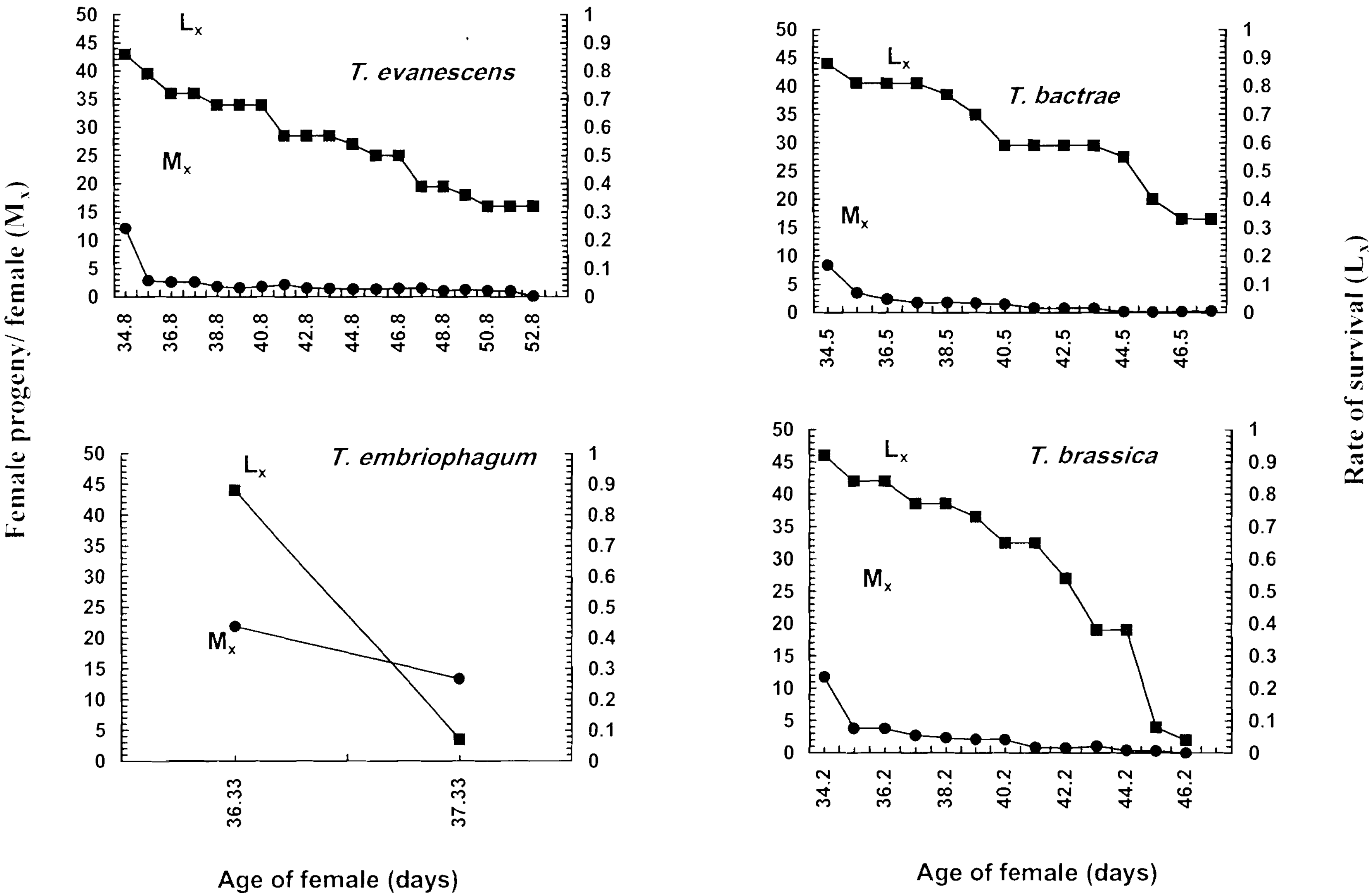

Fig.(1): Age-specific fecundity (M_x) and survival (L_x) of four Trichogrammatids reared on *P. gossypiella* eggs at 15°C.

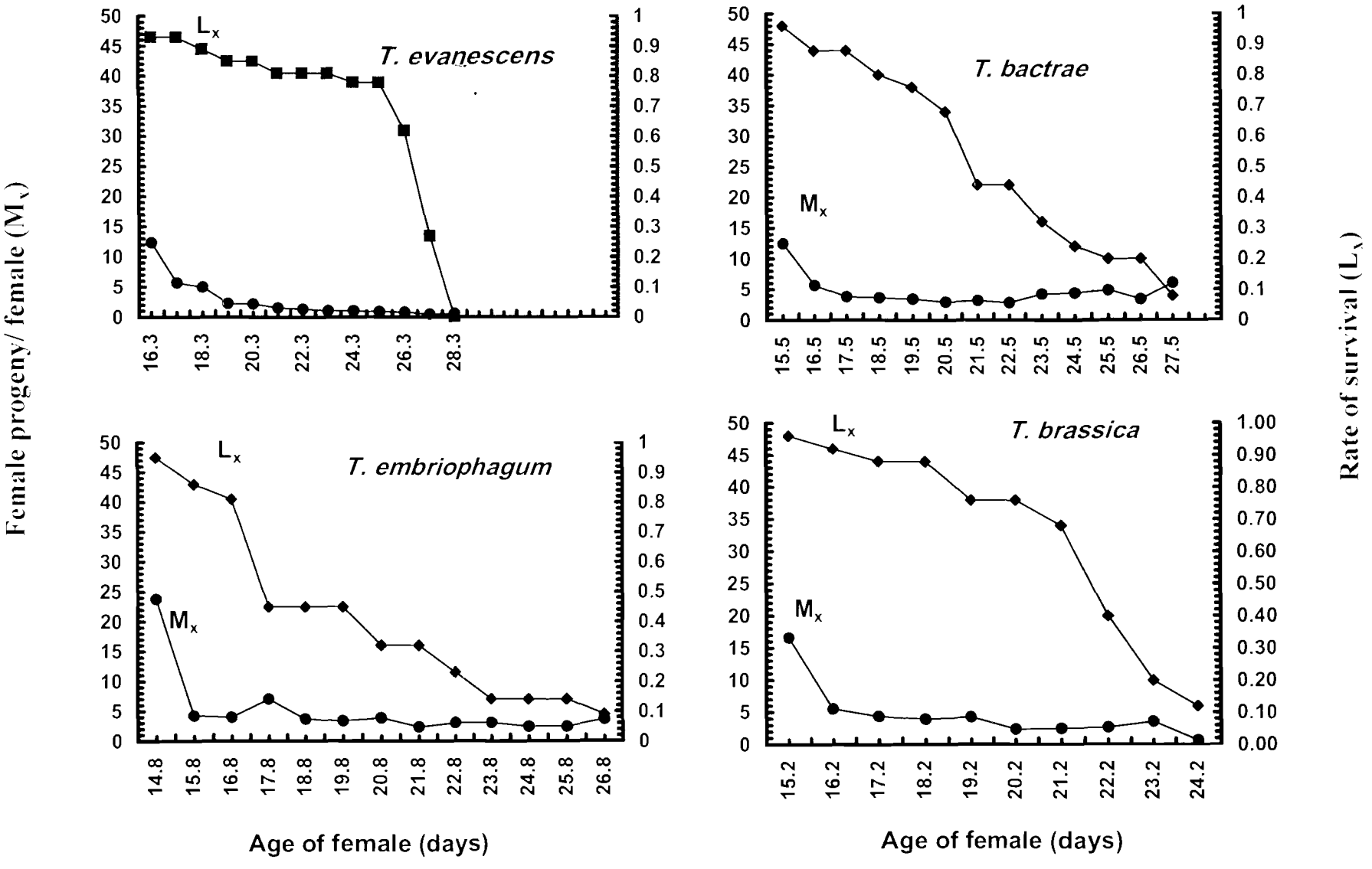

Fig.(2): Age-specific fecundity (M_x) and survival (L_x) of four trichogrammatids reared on *P. gossypiella* eggs at 20°C.

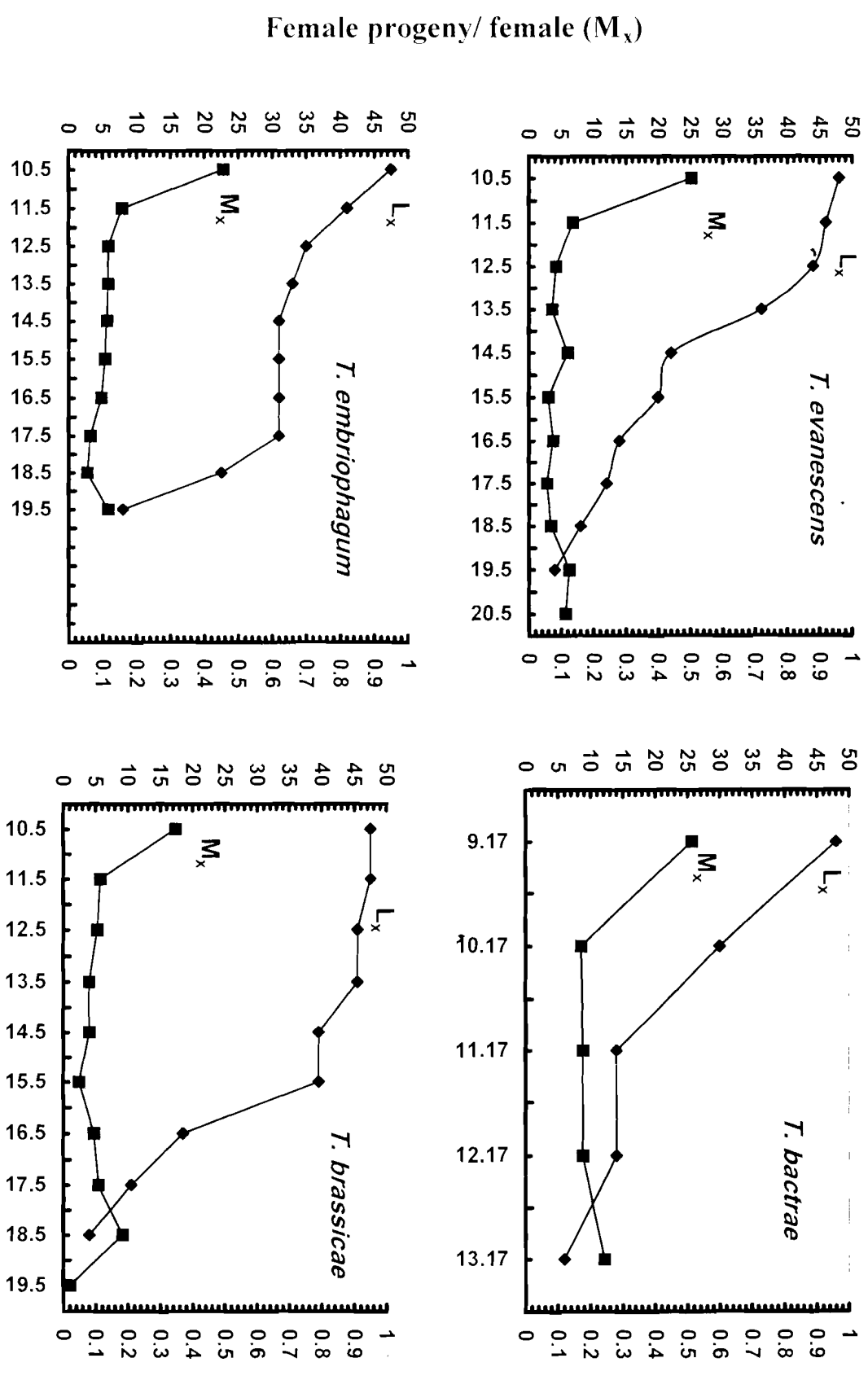

Fig.(3): Age-specific fecundity (M_x) and survival (L_x) of four Trichogrammatids reared on *P. gossypiella* eggs at 25°C.

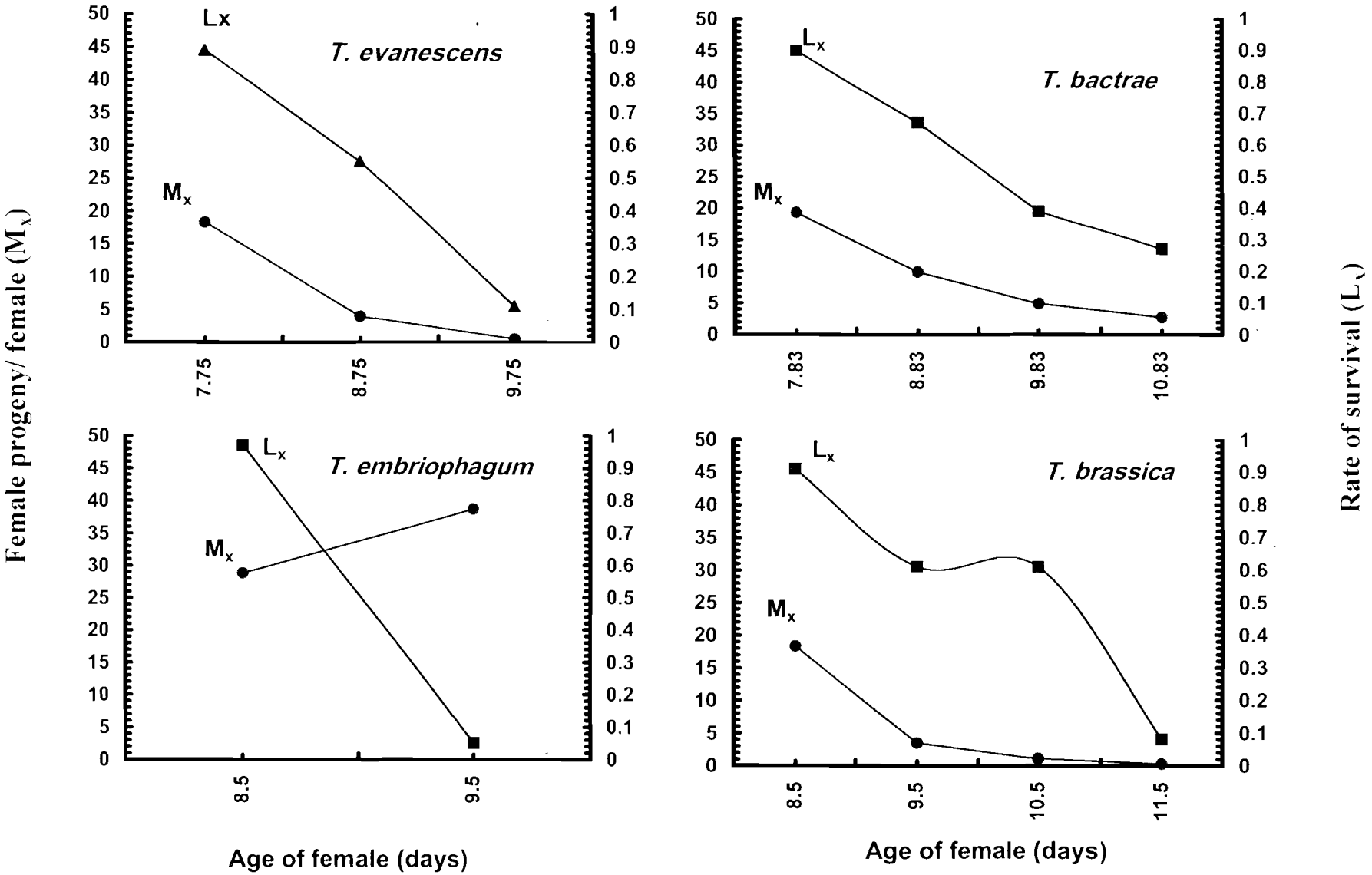

Fig.(4): Age-specific fecundity (M_x) and survival (L_x) of four trichogrammatids reared on *P. gossypiella* eggs at 30°C.

Table 1. Changes in Life Table parameters of four Trichogrammatids reared on *P. gossypiella* eggs at different constant temperatures.

Parameter	*T. evanescens*				*T. bactrae*				*T. embryophagum*				*T. brassicae*			
	15°C	20°C	25°C	30°C	15°C	20°C	25°C	30°C	15°C	20°C	25°C	30°C	15°C	20°C	25°C	30°C
Survival to maturity (%)	86.1	93.07	96.21	88.60	88.00	96.36	95.93	90.34	88.00	95.10	94.80	97.20	91.90	95.75	95.05	91.20
Sex ratio (% female)	60.47	57.50	59.50	51.40	54.16	67.75	62.84	54.71	62.10	61.00	59.20	57.75	61.02	66.78	67.59	54.50
Maximum fecundity/ day	38.68	37.50	55.26	87.73	37.49	34.09	68.10	65.12	95.16	56.75	43.27	93.39	41.83	43.45	42.19	85.67
(Ro) =The net reproductive rate	26.92	30.682	43.72	18.41	18.608	35.226	36.144	26.797	20.242	39.917	49.851	29.928	24.674	36.846	38.994	19.509
Mean generation time (T)	37.913	17.891	11.376	7.856	36.489	17.546	9.629	8.211	36.378	15.845	11.839	8.555	35.862	16.590	11.782	8.647
The intrinsic rate of natural increase (rm)	0.0869	0.1914	0.3321	0.371	0.0801	0.2030	0.3726	0.4005	0.0827	0.2327	0.3302	0.3973	0.0894	0.2174	0.3109	0.3436
The finite rate of increase (exp. rm)	1.091	1.211	1.394	1.449	1.083	1.225	1.451	1.493	1.086	1.262	1.391	1.488	1.0935	1.2429	1.3647	1.4100
Time of generation doubling [(ln2)/ rm]	7.976	3.621	2.087	1.869	8.652	3.414	1.860	1.730	8.380	2.978	2.099	1.744	7.752	3.188	2.229	2.017

From these results, it is indicated that 25°C is the most favorable temperature for the reproduction of the aforementioned species. Also, *T. embryophagum* has the highest value of the net reproductive rate Abd El-Hafez, Alia (2001). The present results for *Trichogramma evanescens* and *T. brassicae* are in accordance with those found by Arun Baitha & Atma Ram (1998[a]) as they found that the net reproductive rate (R_0) for *Trichogrammatoidea* sp. nr. *armigera* was highest at 25°C and 30% R.H. Also, Naranjo (1993) found that net reproductive rates (R_0) for *T. bactrae* reared on the same host (pink bollworm) under the same conditions were highest (27.86 & 26.93 female/ female) at 20& 25°C and declined rapidly with increasing temperature.

Life-cycle:

For the mean generation time (T), evident differences were observed between the four temperatures (Table 1). The mean generation period decreased by increase of temperature. The average values were 37.91, 17.891, 11.376 and 7.856 days for *T. evanescens* when reared at 15, 20, 25 and 30°C, respectively, opposed to 36.49, 17.55, 9.63 and 8.21 days in the case of *T. bactrae*, respectively. The generation time values for *T. embryophagum* were 36.38, 15.85, 11.84 and 8.56 days, and for *T. brassicae* and 35.86, 16.59, 11.78 and 8.65 days at the same temperatures, respectively. This inverse relationship between the duration of life cycle and temperature was previously reported by Arun Baitha and Atma Ram (1998[b]) as they stated that, the cohort generation time (T_c) values of *Trichogrammatoidea* sp. nr. *armigera*, an egg parasitoid of *Helicoverpa armigera* showed decreasing trend from 18 to 30°C. Pratissoli and Parra (2000 [a & b]) also mentioned that there was an inverse correlation between the duration of the cycle for *T. pretiosum* reared on eggs of *Phthorimaea operculella* (Zeller) and *Tuta asoluta* and the increase of temperature in the thermal zone studies.

The intrinsic (r_m) and the finite (exp. r_m) rates of increase:

Daily intrinsic rate of increase r_m varied in relation to rearing temperature and parasitoid species. There was a positive relationship between the intrinsic rate of increase and the rearing temperature (Table 1). When *T. evanescens, T. bactrae, T. brassicae* and *T. embryophagum* were reared at 15°C, their intrinsic rates of increase were 0.0869, 0.0801, 0.0827 and 0.0894, respectively. By increasing the rearing temperature degree to 20°C, these values increased to 0.1914, 0.2030, 0.2327 and 0.2174, respectively. Therefore, more increase occurred in these values at 25°C to become 0.3321, 0.3726, 0.3302 and 0.3109, respectively, and 0.3707, 0.4005, 0.3973 and 0.3436, respectively, by rearing at 30°C.

When the values of intrinsic rates of increase r_m were converted into finite rates of increase (exp. r_m), the population of *T. evanescens, T. bactrae, T. brassicae* and *T.*

embryophagum had the capacity to increase by 1.091, 1.083, 1.086 and 1.094 times/female/day at 15°C, respectively. At 20°C, the four parasitoid species had the capacity to increase by 1.211, 1.225, 1.262 and1.243, respectively. Moreover, when rearing temperature was increased to 25°C their capacity to increase reached to 1.394, 1.451, 1.391 and1.365, respectively while all species had the highest capacity to increase at 30°C (1.46, 1.52, 1.39 and 1.45, respectively).

Generally, intrinsic rates of increase (r_m) and finite rates of increase (exp. r_m) had a positive relationship with the increase of temperature ranging from 15 to 30°C and the highest value occurred at 30°C., while these values varied between the four parasitoid species. The present results, which obtained at 25& 30°C are higher than those were estimated by Naranjo (1993) who found that, daily intrinsic rates of increase (r_m) varied in relation to temperatures, with maximum rates (0.3269 and 0.3250) at temperatures between 25 and 30°C and the lowest rate (0.2405) at 32.5°C. Also, Arun Baitha and Atma Ram (1998[b]) found that the r_m for *Trichogrammatoidea* sp. nr. armigera, an egg parasitoid of *Helicoverpa armigera* was highest at 27°C and 45% R. H., also, Navarro & Marcano (2000) and Pratissoli and Parra (2000 [a & b]) reported that the maximum increase in capacity of *T. pretiosum* was reached between 22 and 25°C according to the rearing host. They revealed that the infinitesimal increase rate (r_m) and the finite increase rate had a relationship with the increase of temperature ranging from 18 to 30°C and the highest value occurred at 30 and 32°C according to the lesser duration of a generation. Scholler and Hassan (2001) found that the intrinsic rate of natural increase were higher in *T. evanescens* than in *T. cacoeciae* when reared with and without hosts (*Ephestia elutella*) at 20, 26, 30 and 35 °C and 75 ±5% relative humidity.

Population doubling Time [(ln2)/ r_m].

Results 1n Table (1) indicated that the time of population doubling decreased as the rearing temperature increased. The population of *T. evanesces, T. bactrae, T. brassicae* and *T. embryophagum* had the capacity to double every 7.976, 8.652, 8.380, and 7.752 days, respectively when they were reared at 15°C. As the rearing temperature was increased to 20 °C, the generation duplicating time decreased to 3.621, 3.414, 2.978 and 3.188 days, respectively. While another decrease in generation duplicating time was achieved at 25°C to reach 2.087, 1.860, 2.099 and 2.229 days, respectively. At 30°C, the parasitoid populations had the higher capacity to multiply, so the generation duplicating times were 1.869, 1.730, 1.744 and 2.017 days for the aforementioned species, respectively.

Sex ratio:

Regardless of temperature or species, female progeny always dominated the male one. Higher percentages of females in progeny were obtained when parasitoids were reared at temperature up to 25°C, while the lower percentages were indicated at 30°C (Table 1). Percentage of females in *T. evanescens* progeny varied insignificantly when reared at 15, 20 and 25°C, those were 60.47, 57.50 and 59.50%, respectively. While an obvious reduction occurred (51.40%) when rearing took place at 30°C. As for *T. bactrae* progeny, the highest percentage of females (67.75%) was produced at 25°C, while lower percentages were produced at the lower (15°C) and higher (30°C) rearing temperatures (54.16 and 54.71%, respectively). At 20°C, moderate percentage of females was obtained in *T. bactrae* progeny. On the other hand, the percentage of females in *T. embryophagum* progeny averaged 62.10, 61.00, 59.20 and 57.75% when reared at the four temperatures, respectively. In case of *T. brassicae*, rearing at 20 and 25°C led to obtain, approximately, the same percentages of females in progeny (66.78 and 67.59% respectively). However, production of females in progeny decreased to 61.02, 54.50% when rearing temperature was changed to 15 or 30°C, respectively. In the present study, the reduction in percentage of females in progeny at high temperature was in agreement with those reported by Hutchison *et al.* (1990), Abd-El Hafez (1995) and Berti and Marcano (1997) as they stated that sex ratio was affected by temperatures of 30°C and higher. On the other hand, Cynthia and Chiang (1982) stated that, *T. ostriniae* females in progeny were not affected significantly at low temperatures. Pratissoli and Parra (2000 [a & b]) found that temperature did not affect the sexual ratio of *T. pretiosum* reared on eggs of *Tuta asoluta* (Meyrick). Hutchison *et al.* (1990) recorded lower percentage of female in *T. bactrae* progeny when reared at 15°C.

From the foregoing results it could be concluded that 25°C is the most favorable temperature for breeding the four aforementioned species of *Trichogramma*. Also, the highest values of net reproductive rates were obtained. At this temperature, it was observed that *T. bactrae* has good qualities, including high intrinsic rate of natural increase (r_m = 0.3726), a high finite rate of increase (exp. r_m = 1.451) and a shortest population doubling time (1.860 days). Thus this parasitoid is expected to be more effective for use in biological control of pink bollworm.

According to the intrinsic rate of natural increase (r_m) which considered the reliable method for differentiating two species of *Trichogramma* (Navarro and Marcano 2000), the studied species of *Trichogramma* could be arranged descendengly as follows: *T. bactrae* > *T. evanescens* > *T. embryophagum* > *T. brassicae*.

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* c. f. computer search.

تأثير درجات الحرارة على قياسات جدول الحياة لأربعة أنواع من طفيل الترايكوجراماوالمرباه على بيض دودة اللوز القزنفلية

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تشتمل قياسات جدول الحياة على معدل التناسل الصافي (R_0) و معدل الزيادة الحقيقي (r_m) و معدل التزايد النهائي ($\exp.r_m$) والفترة اللازمة لتضاعف التعداد [$(\ln 2)/r_m$] لأربعة أنواع من الترايكوجراما وهى ترايكوجراماتويدا باكترى وترايكوجراما افانسنس و ترايكوجراما امبريوفاجم وترايكوجراما براسيكا على بيض دودة اللوز القرنفلية وهذه القياسات تمت دراستها تحت أربعة درجات حرارة وهى ١٥و٢٠و ٢٥و ٣٠ م من النتائج المتحصل عليها وجد أن درجة ٢٥م° هي أفضل درجة حرارة لتربية الأربعة أنواع من الترايكوجراما تحت الدراسة، حيث أنه تحت هذه الدرجة تم الحصول على أعلى معدلات للتناسل، وعند هذه الدرجة أظهر طفيل ترايكوجراماتويديا باكترى خصائص جيدة تشمل معدل زيادة حقيقي عالي (r_m) = ٠،٣٧٢٦ و معدل تزايد نهائي عالي ($\exp.r_m$)= ١،٤٥١ ومدة قصيرة لتضاعف الجيل مرتين [$(\ln 2)/r_m$]=١،٨٦٠ يوم.