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# Biological Aspects, Thermal Requirements and Life Table Parameters of *Tenuipalpus Punicae* Pritchard & Baker, 1958 (Acari: Tenuipalpidae) on Pomegranate Over Different Temperatures in Assiut, Egypt

**Abdelgayed S. Abdelgayed[*], Nazeh M. Abd El-Wahed[*], Abd El-Wahab M Ali[**] and Sayed A. Eraky[**],**

[*]Plant Protec. Res. Inst., Agric. Res. Center, Dokki, Giza, Egypt.

[**]Dept. of Plant Protection, Fac. of Agric., Assiut Univ., 71526 Assiut, Egypt, seraky53@yahoo.com.

## ABSTRACT

Relationships between the biotic potential of pomegranate false spider mite, *Tenuipalpus punicae* Pritchard & Baker, 1958 and temperature was studied at constant temperature conditions of 20 - 35ºC. Optimum temperatures range for *T. punicae* was 30 - 35°C. The shortest Pre-oviposition period, the greatest egg-laying capacity and immature stages development, optimum conditions were noticed at 35ºC followed by 30ºC. Complete age-specific fecundity schedules and life table parameters were computed from these data for each of four temperatures. The shortest developmental duration reached was 12.56 & 9.63 days for female and male at 35ºC. The highest total mean fecundity rate was 13.13 eggs/female with a daily rate of 1.59 eggs/female/day was at 30ºC. The thermal constants (K) were 56.82, 100.80, 83.93, 122.23, 345.97, 419.22, 308.60 and 648.66 (DDs) for the previous stages as physiological times required for this species phenomena. The maximum values of intrinsic rate of increase ($r_m$) and the finite rate of increase (λ) was obtained at 35ºC (i.e. 0.120 and 1.12 individuals/female/day). The gross reproductive rate (GRR) was the highest at 35ºC as 16.4 eggs/female/generation. The shortest time for population density doubling (DT) was 5.77 days at 35ºC.

**Key words:** Acari; Pomegranate; *Tenuipalpus punicae*; Temperature; Life table parameters; Egypt.

## INTRODUCTION

Mites of the family Tenuipalpidae Berlese, 1913 (Trombidiformes: Tetranychoidea) commonly are known as flat mites or false spider mites, as they are generally compressed dorsoventrally and do not produce silk webbing. Mesa *et al*. (2009) reported this family to consist of 891 species belonging to 34 genera. This family has a worldwide distribution with over 1100 valid species belonging to 38 genera (Meyer, 1979; Beard *et al*., 2012). All species are phytophagous and have shown the potential to cause severe economic damage to agricultural crops, ornamentals and timber (Baker and Tuttle, 1972, 1987; Ochoa and Salas, 1989; Bakker *et al*., 1993; Evans *et al*., 1993; Zhang, 2003; Childers *et al*., 2003).

Tenuipalpids are harmful to host plants directly, through their feeding and indirectly, via transmission of plant viruses (Childers and Derrick, 2003; Kitajima *et al*., 2003). They also are known to carry fungal spores and bacteria (Ochoa *et al*., 1994) that may infect the plant. The largest flat mite genera, *Brevipalpus* Donnadieu, 1875 and *Tenuipalpus* Donnadieu, 1875 include the most common species of economic importance.

The pomegranate false spider mite, *Tenuipalpus punicae* is one of the serious mite pest infesting pomegranate trees (Döker *et al*., 2013). The mite pest, *T. punicae* is considered a major economic pest. It reduces the quantity and quality of the production (Al-Jboory *et al*., Al-Mallah and Mohammad, l989; Agrawal, 2000; Amini, 2008).

The importance of this mite pest is not only due to the direct damage of plants including defoliation, leaf burning and even in excessive outbreaks plant death but also to indirect damage of plants due to the decrease of photosynthesis and transpiration (Al-Gboory, 1987; Al-Jboory and El-Haidari, 1989; Al-Jboory and Al-Swuidy, 2006; Ananda, 2007; Ananda *et al*., 2009). For completion of such work for serving yield of pomegranate fruit trees from being decreased year after year attention of the most intersecting research workers as specialists in pest control.

The present work introduces in detail the biology and life table parameters of *T. punicae* when fed on the leaves of pomegranate, *Punica granatum* L. variety Manfaloty under laboratory conditions at constant temperature of 20, 25, 30 and 35°C.

## MATERIALS AND METHODS

### (1) Rearing of *T. punicae*:

A pure culture of *T. punicae* was propagated on Manfaloty pomegranate variety. Mite eggs on leaf of the pomegranate variety manfaloty. Were leased the biology of *T. punicae*, The method proposed by Amini (2008) was used with some modifications. One leaflet from the first fully expanding leaf at the top per plant was taken, then washed with running water to remove any possible residuals or mites which may be found on these leaves. Leaf discs of about one-inch in diameter were made and surrounded by tangle foot, which acts as a barrier to prevent mite individuals from escaping. These discs were placed on pieces of moisten cotton wool in Petri dishes (10 cm diameter) and a couple mite (male and female) was placed on each disc, on the lower surface of the leaf. These Petri dishes were kept at four different constant temperatures (i.e. 20, 25, 30 and 35°C±2°C and 70±5% R.H.), for 24 hours to allow mating process. Thereafter, males were removed, while females served as a source for known-age eggs, which in turn produced known-age larvae. The moisture was kept constant by adding few drops of water to the cotton wool. About 60 hatching larvae were transferred and kept singly and left to continue their life span. Newly emerged females were copulated and left to deposit their eggs. Examination was made twice daily, early in the morning and before sunset. Essential records were noted. To examine sex ratio of *T. punicae*, ten newly emerged females and males were transferred and kept under the same conditions of temperature and R.H. %. From the eggs of each female, 50 eggs (25 eggs after two days and 25 eggs after one week) were deposited during female oviposition period. Eggs were left to develop until the second generation, then the number of males and females were counted for each constant temperature.

**(2) Life table parameters of the *Tenuipalpus punicae* Pritchard & Baker, 1958:**

During developmental period duration, mortalities of different stages and sex ratio of progeny were determined. Oviposition period of each female was recorded daily. Life table parameters were estimated using the Life 48, BASIC Computer programmed (Abou-Setta *et al*., 1986). Parameters were determined by the following formula: $\Sigma_0^{max} L_x\ m_x$ / exp. $r_m$ X = 1, the definitions of the abbreviations were presented by Birch (1948).

**(3) Statistical analysis:**

Obtained duration data for different biological aspects were analyzed as linear regression for developmental rates (i. e. 1/time) using EXCEL spread sheet.

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±b1*Temperature±b2* relative humidity), where a is the intercept and b is the slope. These analyses were conducted using SAS statistical software (SAS Institute, 2010).

## RESULTS AND DISCUSSION

The effect of the four constant temperature degrees (20, 25, 30 and 35°C) on the biological aspects and demographic parameters ($R_o$, G, $r_m$ and exp. $r_m$) of *T. punicae* was studied in the laboratory under controlled conditions ±2°C and 70±5% RH.

**Developmental times:**

Developmental times for all stages of the constant temperatures and relative humidity are presented in Tables (1 and 2). Developmental periods were generally decreased as temperature increase. *T. punicae* larvae hatched after a shortest egg incubation period of 2.47 and 2.50 days at 35ºC for females and males, respectively. The shortest duration of larval, protonymphal, deutonymphal stages female and male were (3.59 & 3.75), (3.12 & 1.13) and (3.47 & 2.25) days at 35°C, respectively, while the longest duration periods as (7.71 & 8.3), (7.53 & 4.3) and (6.00 & 2.00) days were at 20ºC, respectively. The longest life cycles were 28.53 & 21.70 days at 20ºC, while the shortest periods were 12.65 and 9.63 days at 35ºC for female and male, respectively. Generation time and longevity decreased as temperature increased. The shortest generation time was 14.76 days at 35ºC, while the longest one was 31.59 days at 20ºC. The shortest female longevity was observed at 35ºC (9.94 days), while the longest was 19.06 days at 20ºC. The highest mean number of eggs laid per female was 13.13 eggs/female with a daily rate of 1.59 eggs/female/day at 30ºC. The lowest fecundity was 9.12 eggs/female with a daily rate of 0.73 eggs/female/day at 20ºC.

It was found that the life cycle of *Oligonychus punicae* (Hirst, 1924) differed among cultivars with average values ranged between 8.2 days on Tucupita leaves and 9.1 days on Sirah (Vàsquez *et al*., 2008). Relatively high fecundity was found on Tucupita leaves (2.8 eggs/female/day) during (11.4 oviposition day), while low fecundity values occurred on Sirah and Villanuera leaves, with 0.9 day and 1.8 eggs/female/day during 7.9 and 6.7 days (Al-Mallah and Mohammed, 1989).

Biological study under laboratory conditions indicated that the number of eggs laid by a single female found to be 12-15 eggs, and the incubation periods of larva and nymph and adult life span were 7.85, 8, 13.11 and 20.7 days, respectively.

These results are in agreement with Zaher *et al.* (1970), whom was studied the biology of the *Brevipalpus phoenicis* (Geijskes, 1939) and found that the developmental time from egg to adult took 23.8 – 29.9 days at 23 – 27ºC. The fecundity was greatly influenced by temperature, more eggs are produced during summer (27 eggs) than winter (16 eggs).

Abid and El-Haidari (1972) studied some aspects of the biology and control of *Tenuipalpus punicae* on pomegranate. The generation time changed from 17.8 days at average temperature of 27.3ºC to 44.8 days at average temperature of 18.0ºC. (Zaher and Yousef, 1972) Showed that females may live for 1-2 months, for instance, *T. granati*, the number of deposited eggs

Table (1): Mean developmental times in days (±SD) of *T. punicae* females reared on *P. granatum* at constant temperatures

| Stages | Developmental duration Temperature (°C) | | | |
|---|---|---|---|---|
| | 20 | 25 | 30 | 35 |
| Egg | 7.29±0.69 | 5.85±0.80 | 4.06±0.57 | 2.47±0.62 |
| Larva | 7.71±1.16 | 5.69±0.48 | 4.44±0.75 | 3.59±0.62 |
| Protonymph | 7.53±1.12 | 5.62±1.45 | 4.75±1.53 | 3.12±1.11 |
| Deutonymph | 6.00±0.94 | 5.15±0.90 | 4.19±0.75 | 3.47±0.62 |
| Immature stages | 21.24±1.56 | 16.46±1.66 | 13.38±1.50 | 10.18±1.52 |
| Life cycle | 28.53±1.81 | 22.31±1.70 | 17.44±1.50 | 12.65±1.62 |
| Generation | 31.59±1.97 | 24.62±1.94 | 19.38±1.96 | 14.76±2.09 |
| Pre-oviposition | 3.06±0.56 | 2.31±0.75 | 1.94±0.44 | 1.53±0.80 |
| Oviposition | 13.0±2.4 | 11.85±2.76 | 9.25±3.0 | 7.0±1.54 |
| Post-oviposition | 3.0±0.71 | 2.38±0.65 | 1.88±0.50 | 1.41±0.71 |
| Longevity | 19.06±2.33 | 16.54±3.07 | 12.81±3.2 | 9.94±1.82 |
| Fecundity | 9.12±3.62 | 12.69±3.15 | 13.13±3.12 | 13.12±4.73 |
| Daily rate | 0.73±0.32 | 1.13±0.42 | 1.59±0.69 | 1.93±0.74 |
| Life span | 47.59±3.37 | 38.85±3.54 | 30.25±3.86 | 22.59±2.62 |

The means are followed by different letters in the same rows are significantly divergent ($P< 0.05$, Duncan).

Table (2): Mean developmental durations in days (±SD) of *T. punicae* males reared on *P. granatum* at constant temperatures

| Stages | Developmental duration Temperature (°C) | | | |
|---|---|---|---|---|
| | 20 | 25 | 30 | 35 |
| Egg | 7.0±1.0 | 5.6±0.55 | 3.86±.68 | 2.50±0.58 |
| Larva | 8.3±1.53 | 5.20±1.30 | 4.71±1.38 | 3.75±0.96 |
| Protonymph | 4.3±3.51 | 2.20±1.10 | 3.57±2.30 | 1.13±0.25 |
| Deutonymph | 2.0±1.0 | 2.80±1.30 | 3.29±1.11 | 2.25±0.50 |
| Immature stages | 14.7±5.13 | 10.20±3.70 | 11.57±4.28 | 7.13±0.63 |
| Life cycle | 21.7±5.86 | 15.8±4.25 | 15.43±4.65 | 9.63±0.48 |
| Longevity | 13.7±1.53 | 14.17±1.47 | 12.14±1.35 | 11.50±1.29 |
| Life span | 35.3±5.51 | 30.50±3.08 | 27.57±4.58 | 21.13±1.18 |

The means are followed by different letters in the same rows are significantly divergent ($P< 0.05$, Duncan).

Table (3): Linear regression analysis values for the effect of temperature on *T. punicae* developmental rates

| Stages | A | B | To | K | R | $R_2$ |
|---|---|---|---|---|---|---|
| Egg | -0.2433 | 0.0175 | 13.84 | 56.92 | 0.95 | 0.90 |
| Larva | -0.0705 | 0.0099 | 7.107 | 100.80 | 0.99 | 0.99 |
| Protonymph | -0.1172 | 0.0119 | 9.837 | 83.93 | 0.96 | 0.92 |
| Deutonymph | -0.0030 | 0.0081 | 0.3729 | 122.23 | 0.99 | 0.98 |
| Life cycle | -0.0254 | 0.0028 | 8.794 | 345.97 | 0.98 | 0.96 |
| Generation | -0.0176 | 0.0023 | 7.416 | 419.22 | 0.99 | 0.98 |
| Longevity | -0.0162 | 0.0032 | 5.002 | 308.60 | 0.98 | 0.96 |
| Life span | -0.0113 | 0.0015 | 7.378 | 648.66 | 0.98 | 0.96 |

a = Intercept, b = slope of developmental rate, $t_0$ = (-a/b) K= DDUs (1/b).

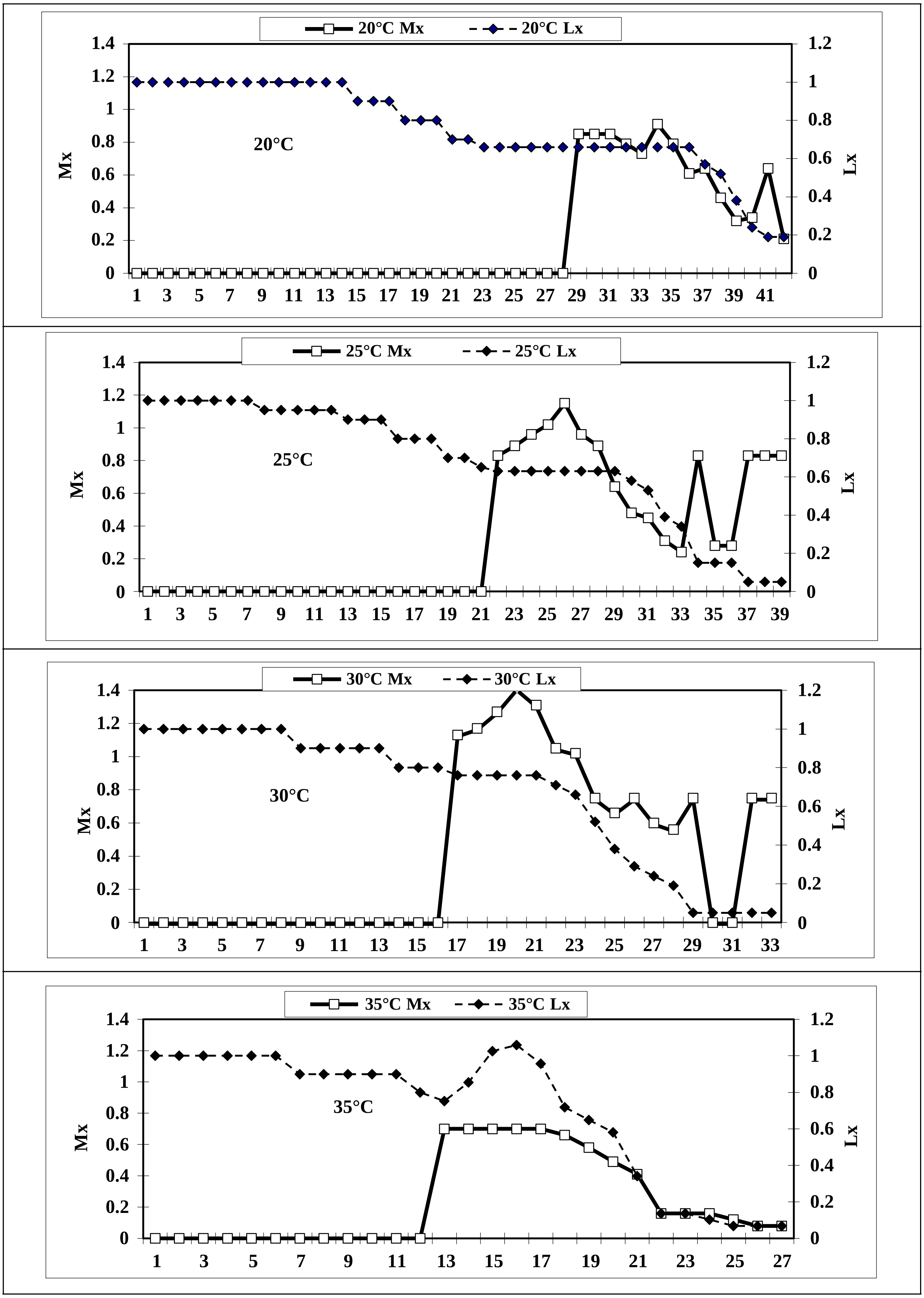


Fig. (1). Age specific survivorship ($L_x$) and age specific fecundity ($M_x$) for *T. punicae* reared on *P. granatum* at four constant temperatures.

changed according to seasons. It averaged 10.5, 15.0 and 13.0 eggs per female during spring, summer and autumn, respectively with a daily number ranging from zero to 4 eggs. (Yousef *et al.,* 1980; Wahba *et al.,* 1982) *Tenuipalpus granati* reared on three different varieties of grape namely Cabernait, Farawla and Banaty the pre-oviposition period and the incubation period one were about 3 and 8 days. The life cycle lasted about 19 days on Cabernait, 24 days on Farawla and 30 days on Banaty.

**Thermal requirements**

Linear model to the relation between temperature and rate of development was calculated. Results are presented in Table (3). Results showed that ($R^2$) values of *T. punicae* ranged between 0.90 and 0.99 of larva, protonymph, deutonymph, life cycle, generation, longevity and life span on (*P. granatum*). Using the equation resulted in determination of low thresholds ($t_0$) as 13.84, 7.11, 9.84, 0.37, 8.79, 7.42, 5.00 and 7.38°C for egg, larva, protonymph, deutonymph, life cycle, generation, longevity and life span, respectively. The thermal constants (K) were 56.92, 100.80, 83.93, 122.23, 345.97, 419.22, 308.60 and 648.66 (DDs) for the previous stages as physiological times required for this species phenomena. These results is agreement with finding by Elhalawany and Abdel-Wahed (2013) who reared *Tetranychus urticae* Koch, 1836 on Kostata and Hachiya Persimmon cultivars under laboratory conditions of 15, 20, 25 and 30ºC. The thermal constants (K) were 64.10 & 68.02, 78.12 & 56.49, 71.42 & 61.34, 54.34 & 41.49, 312.5 & 256.4 and 666.6 & 526.3 (DDs) and lower thresholds ($t_0$) as 11.63 & 11.17, 5.55 & 7.64, 5.35 & 6.63, 8.32 & 9.49, 7.93 & 9.25 and 3.8 & 5.57°C on egg, larva, protonymph, deutonymph, generation and life span on Kostata and Hachiya persimmon varieties, respectively.

**Life table parameters:**

All major life table parameters are shown in Table (4). The mean generation time (T) decreased as temperature increase, while the net reproductive rate ($R_0$) increased as temperature increased. The mean generation time decreased from 33.27 to 16.72 days at 20ºC and 35ºC. The peak net reproduction rate ($R_0$) occurred at 35ºC as 7.51 individuals/female, also the gross reproductive rate (GRR) was the highest at 35ºC as (16.4 egg/female/generation), while the lowest one was 8.99 at 20°C eggs/female /generation. The shortest time for population density to double (DT) 65.77 days at 35ºC, while the longest period was 14.14 days at 20ºC. The intrinsic rate of increase values ($r_m$) ranged from 0.049 (at 20ºC) to 0.120 (at 35ºC). The daily age specific survival rate of female (Lx) and age specific fecundity (Mx) were illustrated in Fig. (1). The daily age specific survival rate was the highest at 35ºC.

The maximum population growth rate ($r_m$) values increased from 0.04 at (20ºC) to 0.17 at (29ºC) (Quan *et al.,* 2019), Then decreased 0.12 at (32ºC). The finite rates of increase (λ) were over 1.00 at all 5 constant temperatures. Temperature had a great effect on the development and reproduction of *Oligonychus litchi* Lo and Ho, 1989 and the optimal temperature for the mite was around 26ºC (Childers *et al.,* 1991). The intrinsic rates of increase ($r_m$) were 0.066, 0.123, 0.179, 0.210, 0.224 and 0.190 at 15°, 20°, 25°, 28°, 30° and 32ºC. for the *Eutetranychus banksi* (McGregor, 1935), respectively while, Ali *et al*. (2019) found that, the generation times (GT) were 18.31 and 12.19 days, the reproductive potential rats (Ro) were 51.47 and 28.50 individuals/females, population doubling times (DT) were 3.22 and 2.52 days, intrinsic rats ($r_m$) were 0.2152 and 0.2748 and the finite rates of increase (λ) were 1.2401 and 1.3163 at 25 and 30ºC.

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