# Journal of Entomology

ISSN 1812-5670

Academic Journals Inc.

www.academicjournals.com

Journal of Entomology 8 (6): 557-565, 2011
ISSN 1812-5670 / DOI: 10.3923/je.2011.557.565


# Effect of Temperature on the Biology and Life Tables of *Agistemus exsertus* Fed *Tetranychus urticae* (Acari: Stigmaeidae: Tetranychidae) in Hail, Saudi Arabia

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## ABSTRACT

Because of no previous study on the biology of the predatory mite *Agistemus exsertus* Gonzalez, as a biological control agent of two- spotted spider mite in Saudi Arabia, the effect of temperatures on *A. exsertus* was studied in laboratory. Predator and prey mite individuals were collected from egg plant leaves growing in a private farm at Hail province in 2010. Immature stages and adult predatory mites were divided into four groups and subjected to 20, 25, 30 and 35°C with 70% RH. Predatory mites were provided with immature stages of TSSM as a prey during their whole life span. Results showed that rising temperature shortened the incubation period of eggs and accelerated the development of *A. exsertus*. The highest rate of prey consumption of immature stages was obtained at 25°C and followed by 30, 35 and 20°C. Most of the prey consumption during longevity was obtained in oviposition period. In oviposition period, adult female consumed an average of 90.15, 82.28, 87.01 and 68.72% from the total number of prey individuals during female longevity when predatory mites were kept at 20, 25, 30 and 35°C, respectively. The temperature adversely affected life table parameters, where mean generation time (T) averaged 26.05, 27.23 and 28.46 days when mites were kept at 35, 30 and 25°C, while T increased to 36.66 days at 20°C, respectively. The highest value of net reproductive rate Ro was obtained at 30°C. Temperature also affected the intrinsic rate of increase $r_m$ of *A. exsertus* where it averaged 0.08, 0.11, 0.13 and 0.10 at 20, 25, 30 and 35°C, respectively. Rearing *A. exsertus* individuals at 25 and 30°C gave the best biological aspects represented by short development, high prey consumption and large number of deposited eggs and therefore, *A. exsertus* can be considered as a promising biological control agent against tetranychid mites in Hail, Saudi Arabia.

**Key words:** *Agistemus exsertus*, *Tetranychus urticae*, life tables, prey consumption, fecundity

## INTRODUCTION

Predatory mites belonging to the family Stigmaeidae may play an important role in biological control of a wide range of mite and insect pests (Khan *et al.*, 2010; Fouly *et al.*, 2011). The predaceous mite, *Agistemus exsertus* Gonzalez is the most common stigmaeid mite species collected from fruit trees, vegetables, ornamentals and crops in the mid and mid-west areas of Qassim and Hail regions, Saudi Arabia (Fouly and Al-Rehiayani, 2011). It was found in high or moderate numbers during spring, summer and autumn months in different localities feeding on tetranychid, tenuipalpid and eriophyid mites, some scale insects and pollen grains as well (Childers *et al.*, 2001; Golizadeh *et al.*, 2009; Al-Shammery, 2011; Fouly and Al-Rehiayani, 2011). Temperature has distinct effects on different biological aspects such as development, reproduction and survivorship. Therefore, it is necessary to predict the most suitable climatic conditions for rearing predaceous mites and insects as pest control agents (Arbabi and Singh, 2002; Gorji *et al.*, 2008; De Vis *et al.*, 2006; Rasmy *et al.*, 2011). On the other hand, the two-spotted spider mite Koch *Tetranychus urticae* Koch (TSSP) is known as the most dangerous mite pest infesting a wide range of economic plants and causing serious damages all over the world (Khodayari *et al.*, 2008; Al-Shammery, 2011). There are no previous results with regard to the biology of *A. exsertus* in Saudi Arabia (Fouly and Al-Rehiayani, 2011).

Therefore, the present study aims to check the effect of different temperatures, on biology and life table parameters of *A. exsertus* fed immature stages of *T. urticae*.

## MATERIALS AND METHODS

**Two-Spotted Spider Mite (TSSM) culture:** Mite individuals were collected from castor bean and eggplant leaves growing in Hail region, Saudi Arabia during autumn, 2010. A pure culture of *T. urticae* was maintained on eggplant leaves and left to lay eggs under laboratory conditions.

***Agistemus exserus* culture:** Predatory mite individuals were collected from eggplant leaves growing in a private farm in Hail province, KSA in 2010. A pure culture of the predatory mite was maintained on immature stages of TSSM as a prey and reared on eggplant leaves under laboratory conditions. Adult males and females of *A. exsertus* were left together where the deposited eggs were daily extracted for seven days and singly transferred into small discs of eggplant leaves (2 cm in diameter) and surrounded with tangle foot of a mixture of Canada balsam, citronella oil and castor bean oil to prevent mites from escaping. Leaf discs were placed on a layer of cotton wool soaked in water in a Petri-dish (10 cm in diameter). Suitable moisture was daily maintained to the cotton layer. The collected eggs were divided into four groups of 30-40 eggs each, where the first group was kept at 20°C and 70% RH while the second, third and fourth groups were kept at 25, 30 and 35°C. In all cases, eggs were left to hatch where the percentages of hatchability and incubation period were counted daily. Approximately of 25 newly hatched larvae of nearly the same age were provided immature stages of *T. urticae* as food source during their whole life span. Devoured prey individuals were replaced with new ones and the duration of immature stages, life cycle, adult longevity, life span and total consumed prey individuals were counted. Total and mean egg productions of *A. exsertus*, survivorship and sex ratio for the new generation were also determined in order to calculate life table parameters as affected by thermal factor.

**Collection of life table parameters of *A. exsertus*:** Duration of immature stages, mortality, sex ratio and total number of deposited eggs/females of *A. exsertus* were counted daily and used in calculation of life table parameters. Life table parameters of *A. exsertus* were calculated according to Birch (1948), Laing (1968) and by using the Basic Computer Program (Abou-Setta *et al.*, 1986), where:

- $r_m$ the intrinsic rate of natural increase was estimated from the equation: $\Sigma e^{-r_m} l_x m_x = 1$, where: x is the age in days, $l_x$ the age-specific survival rate (proportion of females alive at age x)× (survival rate during the immature stage) X (hatchability%) and $m_x$ the oviposition rate at age ×{(age-specific oviposition)×(proportion of females)} (Howe, 1953)
- $R_o$ the net reproductive rate is given as $Ro = \Sigma l_x m_x$
- T the mean generation time (days), is given by $T = \ln Ro / r_m$

The hatchability and developmental rate at lab conditions of 20, 25, 30 and 35°C with 70% RH were used for $l_x$. The proportions of females (number of females/females+males) were used for calculating the $m_x$ values.

**Statistical analysis:** Data was statistically analyzed by ANOVA test to compare means of each treatment (LSD test, where p>0.05) using Costat Software (1990).

## RESULTS

**The effect of temperatures on duration (in days) and feeding capacity of *A. exsertus*:** Under laboratory conditions of four different temperatures and a constant RH of 70%, female and male larvae of *A. exsertus* emerged after 5.5, 3.7, 2.8 and 2.7 days and 4.8, 3.4, 2.8 and 2.4 days, respectively (Table 1). That means there is a negative correlation between the duration of egg hatchability and temperature where duration decreased by increasing temperature (p>0.05 1.42; 1.24). In general, temperature accelerated development of the predatory immature stages where life cycle lasted 21.3, 17.0, 13.7 and 12.4 days and 25.5, 19.2, 16.3 and 15.0 days for males and female immature stages of *A. exsertus* at 20, 25, 30 and 35°C, respectively (Table 1). From these results, it was noticed that there were no significant differences between the effect of 25, 30 and 35°C on the duration of *A. exsertus* life cycle but they significantly shortened the development of immature stages in comparison with 20°C (p>0.05 3.24 and 2.82 for female and male), respectively.

During the development, larvae consumed the highest rate of preys (3.14 and 4.31 prey/day) when they were kept at 25 and 30°C, respectively. The prey consumption declined significantly to 3.44 and 1.45 prey/day at 35 and 20°C (Table 2). The same trend was observed on the feeding

Table 1: Duration (in days) of developmental stages of *Agistemus exsertus* fed on immature stages of *Tetranychus urticae* under 4 different degrees of temperatures

| | | Temperature (°C) | | | | |
|---|---|---|---|---|---|---|
| Stage | Sex | 20 | 25 | 30 | 35 | LSD (p≥0.05) |
| Egg | ♀ | 5.5±0.8a | 3.7±0.4b | 2.8±0.4b | 2.7±0.4b | 1.42 |
| | ♂ | 4.8±0.6a | 3.4±0.6b | 2.8±0.5b | 2.4±0.4b | 1.24 |
| Larva | ♀ | 3.7±0.6a | 2.8±0.4b | 1.9±0.3c | 1.8±0.3c | 0.86 |
| | ♂ | 2.8±0.8a | 2.6±0.6a | 1.6±0.4b | 1.6±0.6b | 0.64 |
| Protocrysalis | ♀ | 2.8±0.7a | 1.8±0.4b | 1.6±0.4b | 1.5±0.4b | 0.82 |
| | ♂ | 2.4±0.6a | 1.4±0.6b | 0.8±0.6b | 1.2±0.6b | 0.84 |
| Protonymph | ♀ | 3.8±0.6a | 2.4±0.4b | 2.2±0.5b | 2.2±0.4b | 1.20 |
| | ♂ | 2.9±0.8a | 1.8±0.2b | 1.8±0.6bc | 1.2±0.6b | 0.88 |
| Deutochrysalis | ♀ | 2.9±0.6a | 2.1±0.8ab | 2.0±0.6bc | 1.8±0.6bc | 0.82 |
| | ♂ | 2.4±0.6a | 1.8±0.6ab | 1.6±0.2b | 1.4±0.2b | 0.68 |
| Deutonymph | ♀ | 3.9±0.8a | 3.6±0.6a | 3.2±0.8ab | 2.6±0.8b | 0.88 |
| | ♂ | 3.8±0.6a | 3.6±0.4a | 3.2±0.6ab | 2.8±0.6b | 0.84 |
| Tritochrysalis | ♀ | 2.9±0.8a | 2.8±0.7a | 2.6±0.8a | 2.4±0.7a | --- |
| | ♂ | 2.2±0.6a | 2.4±0.8a | 1.9±0.6a | 1.8±0.8a | --- |
| Life cycle | ♀ | 25.5±1.2a | 19.2±1.4b | 16.3±1.6bc | 15.0±1.8c | 3.24 |
| | ♂ | 21.3±1.2a | 17.0±1.2b | 13.7±1.2c | 12.4±1.1c | 2.82 |
| Adult | ♀ | 40.2±3.6a | 32.4±3.2b | 28.6±3.4b | 22.8±3.8c | 4.64 |
| | ♂ | 36.4±3.2a | 26.6±2.8b | 24.8±2.8b | 16.2±2.6c | 3.62 |

Means±SE. Data were subjected to the Micro-Computer Program COSTAT, one way ANOVA using Student-Newman Keuls Test, where means within each raw having the same letter aren't significantly different (p>0.05)

Table 2: Number of consumed immature stage of *Tetranychus urticae* by females of *Agistemus exsertus* under 4 different temperatures

| | Temperature (°C) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 20 | | 25 | | 30 | | 35 | | |
| Stage | T | D | T | D | T | D | T | D | LSD (p≥0.05) |
| Larva | 5.4±0.8c | 1.45 | 8.8±0.6a | 3.14 | 8.2±0.4a | 4.31 | 6.2±0.4b | 3.44 | 0.56 |
| Protonymph | 12.8±1.6b | 3.36 | 14.6±1.4a | 6.08 | 12.6±1.2b | 5.72 | 8.8±0.6c | 4.00 | 1.24 |
| Deutonymph | 20.4±1.8b | 5.23 | 26.2±2.8a | 7.27 | 18.4±1.4b | 5.75 | 12.6±0.8c | 4.84 | 3.82 |
| Adult ♀ | 387.8±22.4b | 9.64 | 488.2±32.2a | 15.0 | 380.4±21.4b | 13.3 | 238.2±14.6c | 10.44 | 28.64 |

T: Total number of consumed preys, D: daily number of consumed preys. Data were subjected to the Micro-Computer Program COSTAT, one way ANOVA using Student-Newman Keuls Test, where means within each raw having the same letter aren't significantly different (p>0.05)

Table 3: Duration and number of consumed immature stages of *Tetranychus urticae* during oviposition period and fecundity of *Agistemus exsertus* under 4 different temperatures

| Temperature (°C) | Oviposition period (days) | Total No. of consumed preys | Daily prey consumption | Total deposited eggs | Daily rate of deposited eggs |
|---|---|---|---|---|---|
| 20 | 28.2±1.8a | 349.6±22.6b | 12.4 | 26.72±2.4d | 1.02 |
| 25 | 22.8±1.4a | 401.7±20.6a | 16.2 | 60.0±8.2a | 2.42 |
| 30 | 18.6±1.2b | 331.0±18.6b | 17.8 | 47.7±4.8b | 2.84 |
| 35 | 13.2±1.2c | 163.7±8.4c | 12.8 | 31.6±3.8c | 2.40 |
| L.S.D (P≥0.05) | 3.42 | 48.42 | --- | 4.22 | --- |

Data were subjected to the Micro-Computer Program COSTAT, one way ANOVA using Student-Newman Keuls Test, where means within each column having the same letter aren't significantly different (p>0.05)

capacity of protonymph and deutonymph of *A. exsertus*, where it was noticed that the highest rate of prey consumption was obtained at 25°C and followed by 30, 35 and 20°C. In general, developmental stages consumed 11.77, 12.15, 9.32 and 9.25% prey individuals from the total percentages of prey of TSSM consumed during life span when developmental stages were kept at 20, 25, 30 and 35°C respectively (Table 2).

With regard to adults of *A. exsertus*, female mite consumed an average of 349.6 prey individuals of TSSM with a daily rate of 12.4 preys and these values significantly increased to 401.7 preys (p>0.05 48.42) with a daily rate of 16.2 preys when the adult female of *A. exsertus* was kept at 20 and 25°C, respectively (Table 3). Data also showed that there were no significant differences between the effect of 20 and 30°C on the feeding capacity of *A. exsertus*, while the highest rate of feeding capacity was obtained when the predatory mite was kept at 25°C and the lowest rate was at 35°C. In other word, feeding capacity increased by increasing temperature. The lowest rate of prey consumption was obtained at 35°C and that may be due to the shortest oviposition period. During this period, adult female laid an average of 26.72, 60.0, 47.7 and 31.6 eggs with a daily rate of 1.02, 2.42, 2.84 and 2.40 eggs/day when *A. exsertus* female fed TSSM and kept at 20, 25, 30 and 35°C, respectively. These results showed that the differences between the effect of temperature on the fecundity and egg production of *A. exsertus* were significant (p>0.05 4.22) (Table 3).

**Life table parameters of *A. exsertus*:** Sex ratio was not significantly affected by temperature, where females percentages (females/females+males) averaged 58, 62, 64 and 56% when predatory mites were kept at 20, 25, 30 and 35°C, respectively. These values were subsequently used in

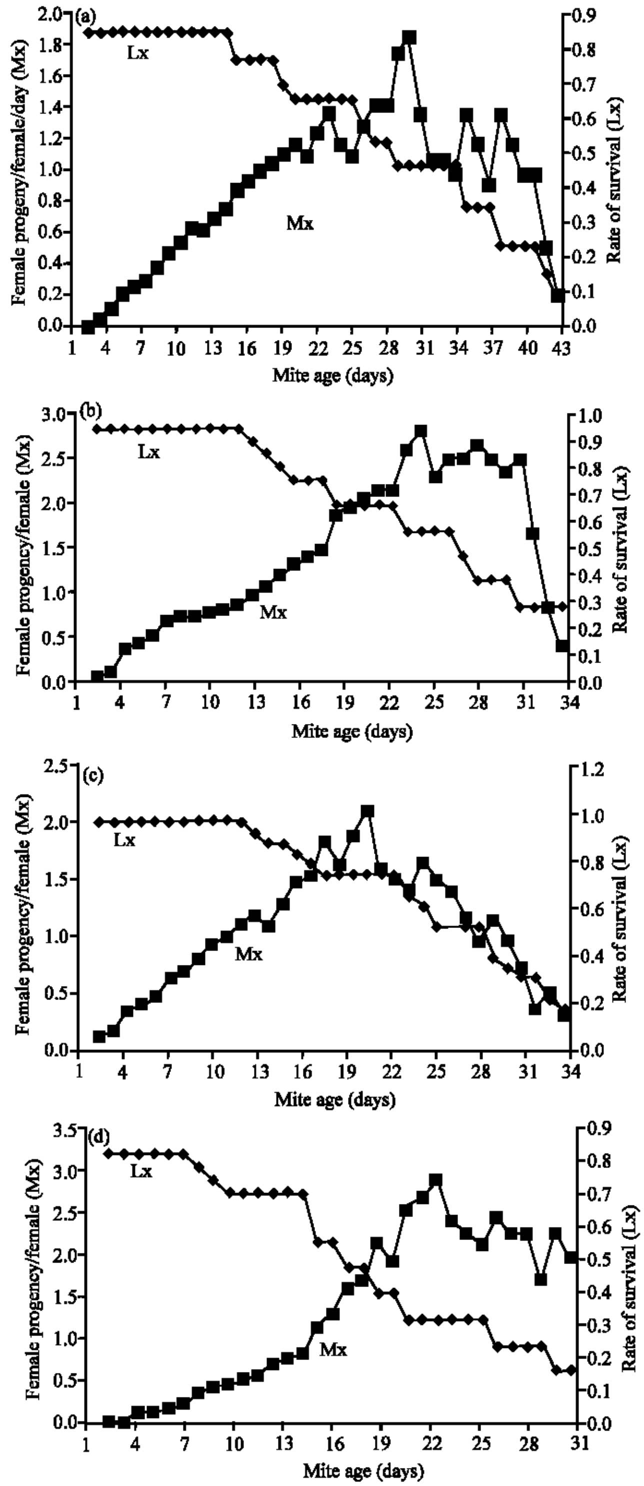


Fig. 1(a-d): Age-specific fecundity (Mx) and rate of survival (Lx) of *Agistemus exsertus* fed immature stages of *Tetranychus urticae* under four temperatures and 70% Rhs; (a) 20°C, (b) 25°C, (c) 30°C and (d) 35°C

calculation the specific rate of fecundity (Mx) as shown in Fig. 1a-d. Survival curves (Lx) of *A. exsertus* followed a type I in which 84, 94, 96 and 82% of deposited eggs reached maturity when

Table 4: Life table parameters of *Agistemus exsertus* fed on immature stages of *Tetranychus urticae* under 4 different temperatures

| Temperature (°C) | Eggs reached maturity (%) | Mean generation time (T) | Net reproductive rate (Ro) | Intrinsic rate of increase ($r_m$) | Finite rate of increase ($e^{rm}$) | Sex ratio (♀/♂) |
|---|---|---|---|---|---|---|
| 20 | 84 | 36.66 | 20.94 | 0.08 | 1.08 | 0.58 |
| 25 | 94 | 28.46 | 29.46 | 0.11 | 1.12 | 0.62 |
| 30 | 96 | 27.23 | 36.97 | 0.13 | 1.14 | 0.64 |
| 35 | 82 | 26.05 | 15.37 | 0.10 | 1.11 | 0.56 |

eggs were kept at the aforementioned temperatures, respectively (Table 4) (Fig. 1a-d). These results indicated that most female death occurred gradually after extended ovipositional period. Table 4 also showed that increasing temperature obviously decreased the mean generation time (T) which averaged 26.05, 27.23 and 28.46 days when mites were kept at 35, 30 and 25°C, while it significantly prolonged to 36.66 days at 20°C, respectively. As shown in Table 4 and Fig. 1a-d, it was clear that 30°C caused the highest value of net reproductive rates (Ro = ΣLx Mx) of 36.97. This value clearly declined by 29.46, 20.94 and 15.37 multiplication times/T time when the predatory mite fed immature stages of TSSM and kept at 25, 20 and 35°C, respectively. Concerning the intrinsic rate of increase ($r_m$) (female/female/day), Birch (1948) stated that $r_m$ is the rate of increase of an insect or mite species under specific physical conditions, in unlimited environment where the effects of increasing density don't need to be considered. Accordingly, tested temperatures obviously affected the intrinsic rate of increase of *A. exsertus* where it was 0.08 female progeny/female/day when predatory mite was kept at 20°C and then increased to 0.11, 0.13 and 0.10 when mites were kept at 25,30 and 35°C, as shown in Table 4.

It was also noticed that the finite rate of increase $e^{rm}(\lambda)$ (population multiplications in a unit of time) was at its highest level (1.30) when *A. exsertus* was kept at 30°C and decreased to 1.12, 1.11 and 1.08. at 25, 35 and 20°C, respectively.

## DISCUSSION

**The effect of temperatures on duration (in days) and feeding capacity of *A. exsertus*:** The present results showed a negative correlation between egg hatchability duration of *A. exsertus* and incubation temperature. In general, temperature accelerated development of the predatory immature stages. An approximately 84, 94, 96 and 82% of immature stages succeeded to reach adulthood. These results showed that a range of 25-30°C was the most suitable temperatures because of its acceleration the development and immature stages survivorship of *A. exsertus* and followed by 20 and 35°C. From these results, it was noticed that there were no significant differences between the effect of 25, 30 and 35°C on the duration of *A. exsertus* life cycle but they significantly shortened the development in comparison with 20°C (LSD 3.24 and 2.82 for female and male, respectively). On the other hand, developmental stages consumed about 11.77, 12.15, 9.32 and 9.25% from the total prey individuals of TSSM consumed during life span when developmental stages were kept at 20, 25, 30 and 35°C, respectively. That means 25°C was the most suitable temperature to obtain the highest rate of prey consumption of *A. exsertus*. However, the lowest rate of prey consumption obtained at 35°C and that may be due to the shortest oviposition period. Similarly, Matioli and de Oliveira (2007) found that development and survivorship of *A. brasiliensis* Malitoli, Ukermann and Oliveira fed the tenuipalpid mite *Brevipalpus phoenicis* (Geijskes) were better at 25-30°C in comparison with 15, 20 and 35°C. On the other hand, Abou-Awad and Elsawi (1993) tested food rang of *A. exsertus* and noticed that *T. urticae* was the most preferable diet over *Eutetranychus orientalis* Klein, *Brevipalpus pulcher* (C. and F.) and whitefly *Bemicia tabaci* (Genn.) when it was reared at 25°C.

The present results clearly showed that the differences between the effect of tested temperatures on the fecundity and egg production of *A. exsertus* were generally significant. In other words, it was clear that female mite of *A. exsertus* raised its total egg production by 124.55, 78.51 and 18.46% when temperature raised from 20°C to 25, 30 and 35°C, respectively. The present results are in harmony with those of Khan and Afzal (2005) who obtained an average of 40 eggs/female when *A. buntex* Chaudhri fed TSSM and kept at 25°C. These findings also agree with the observations of Nguyen and Amano (2009) who found that females of *Neoseiulus californicus* produced an approximately 46.1 eggs/female at 25°C while this value decreased to 13.9, 26.6 and 23.9 eggs/female when they were kept at 18, 30 and 35°C, respectively. Moreover, Abou-Awad *et al.* (2010) found that the rise of temperature from 20°C to 25 and 30°C shortened development and increased the fecundity and prey consumption of *A. olive* Abou-Awad, Hassan and Romeih fed two eriophyid mites. Similar results were also obtained by Rasmy *et al.* (2011) who found that 59.33 eggs were deposited by each female of *A. exsertus* at 25°C and then decreased to 32.27, 33.34 and 24.27 eggs/female when predatory mite was reared at 20, 30 and 35°C, respectively.

**The effect of temperature on life table parameters of *A. exsertus*:** Data showed that sex ratio averaged 58, 62, 64 and 56% when *A. exsertus* individuals fed immature stages of TSSM and kept at 20, 25, 30 and 35°C, respectively. The mean generation time T averaged 28.46, 27.23 and 26.05 days when *A. exsertus* individuals were kept at 25, 30 and 35°C while it sharply increased to 36.66 days when the temperature declined to 20°C. Similar results were obtained by Abou-Awad and Elsawi, 1993 who found that *A. exsertus* had a mean generation time of 26.21 days at 25°C. The present results were Contradictory with Yue and Childers (1994) who found that the mean length of a generation (T) was 35.9, 18.1, 14.5, 11.4 and 12.6 days when *A. exsertus* fed *Panonychus citri* (McGregor) eggs and kept at 15, 20, 25, 30 and 35°C., respectively. Ferla and de Moraes (2003) also noticed that *A. floridans* Gonzalez fed *Tenuipalpus heveae* Baker showed a lower T time of 19.2 days at the same temperature, while Goldarazena *et al.* (2004) noticed that T averaged a higher mean generation period of 35.2 and 37.8 days when both stigmaeid mites *A. cyprius* Gonzalez and *A. industani* Gonzalez were kept at 25°C, respectively. From these notices, it may be concluded that the mean generation time as one of the life table parameters depends mainly on either temperature variability or mite species and prey kinds when they were kept at the same temperature. On the other hand, the present study also proved that as T time decreased, the net reproductive rate Ro increased by increasing temperature. In other words, Ro averaged 20.94, 28.46, 27.23 and 26.05 when mite individuals were kept at 20, 25, 30 and 35°C, respectively. That means, rearing at 20°C resulted in increase in multiplication times of *A. exsertus* population in one generation (Ro) to 40.69, 76.55 and 26.59% after increasing the temperature to 25, 30 and 35°C, respectively. The results of Yue and Childers (1994) are in agreement with the previous results where they noticed that *A. exsertus* fed *P. citri* eggs and kept at 15, 20, 25, 30 and 35°C, had the highest net reproductive rate (Ro = 25.30) at 25°C. Similar values of Ro were obtained by Rasmy *et al.* (1987) who found that Ro of *A. exsertus* averaged 16.13, 29.67, 16.60 and 12.10 times in one generation when the mite individuals were kept at 20, 25, 30 and 35°C, respectively. These findings don't agree with those of Abou-Awad and Elsawi (1993) who found that Ro was much higher where the population of *A. exsertus*, fed TSSM eggs and kept at 25°C, multiplied 57.91 times in one generation. While Ferla and de Moraes (2003) obtained a significant lower Ro values of 13.2 times in each generation when *A. floridanus* fed *T. heveae* and kept at 25°C. Also, Goldarazena *et al.* (2004) found that Ro was lower than the present values where the populations of *A. cyprius* and *A. industani* multiplied 6.36 and 18.70 times in comparison with 29.46 times of

*A. exsertus* fed the same preys and kept at the same temperature, respectively. The previous discussion proved that T period and Ro rate mainly affected by mite species, preys provided to the predatory mites and climatic conditions especially temperature.

Concerning the intrinsic rate of natural increase $r_m$, the recent results showed that $r_m$ averaged 0.08, 0.11, 0.13 and 0.10 when *A. exsertus* was kept at 20, 25, 30 and 35°C, respectively. With regard to the expected numbers of new females which added daily to the population as represented by the finite rate of increase $e^{rm}$ ($\lambda$), the present data showed that temperature affected this parameter where $\lambda$ averaged 1.08, 1.12, 1.14 and 1.1 new females/female/day when *A. exsertus* fed TSSM and kept at 20, 25, 30 and 35°C, respectively. Similar results were obtained by Ferla and de Moraes (2003) who noticed that 25°C was the most suitable temperature for *A. floridanus* to get 1.1 new females which added daily to mite population. Moreover, Saber and Rasmy (2010) found that $e^{rm}$ averaged 1.20, 1.27, 1.29, 1.15 and 1.25 when *A. exsertus* fed TSSM eggs and reared on apple, pear, acalypha, lantana and mulberry leaves at 26°C, respectively. Also, Rasmy *et al.* (2011) mentioned that $\lambda$ values of *A. exsertus* increased gradually from 1.07 to 1.12, 1.13 and 1.14 by increasing temperature from 25 to 30 and 35°C, respectively.

## CONCLUSION

From the previous results it can be concluded that development and feeding capacity of developmental stages and adults of the predatory stigmaeid mite *A. exsertus* increased by increasing temperatures. The most suitable temperatures required to obtain better biological aspects of *A. exsertus* were 25 and 30°C. The total egg production peaked at 25°C and decreased lower and higher degrees of temperature. Data also showed that *A. exsertus* can be considered a promising biological control agent to minimize the populations of tetranychid mites in Hail region, Saudi Arabia.

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