Persian J. Acarol., 15(2): 150204.

https://www.persianacarology.org

Research Article

https://biotaxa.org/pja

https://doi.org/10.22073/pja.150204

Effect of temperature on the biological parameters of the predatory mite, *Phytoseiulus persimilis* (Acari: Phytoseiidae)

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Received:
14 September, 2025
Accepted:
29 December, 2025
Published:
15 April, 2026

Subject Editor:
A. Farazmand

ABSTRACT

The two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae), is a major agricultural pest, and the predatory mite *Phytoseiulus persimilis* Athias-Henriot is one of its most effective natural enemies. Since temperature strongly influences predator biology, in the present study, the effects of five constant temperatures (21, 23, 25, 27, and 29 °C) on the development, survival, and reproduction of *P. persimilis* using age-stage and two-sex life table analysis were evaluated. Developmental time decreased with increasing temperature, while reproductive onset occurred earlier at warmer conditions. Maximum fecundity, net reproductive rate (R_0 = 14.62), and intrinsic rate of increase (r = 0.35) were recorded at 25–27 °C, indicating an optimal range for population growth. However, adult longevity and reproductive performance sharply declined at 29 °C, suggesting heat stress limitations. These results confirmed that *P. persimilis* exhibits peak biological performance at moderate temperatures (24–27 °C), reinforcing its suitability as a biocontrol agent under controlled environments but highlighting reduced efficiency under extreme heat. The findings provided practical insights for optimizing mass rearing and field release strategies within integrated pest management programs.

KEYWORDS

Life table, predatory mites, survival, temperature, *Tetranychus urticae*

CITE: Sarvi, S.M.-M., Latifi, M. & Sahhafi, S.R. (2026) Effect of temperature on the biological parameters of the predatory mite, *Phytoseiulus persimilis* (Acari: Phytoseiidae). *Persian Journal of Acarology*, 15(2): 150204.
https://doi.org/10.22073/pja.150204

INTRODUCTION

The two-spotted spider mite (*Tetranychus urticae* Koch) is among the most destructive agricultural pests, infesting over 1,100 plant species including vegetables, fruits, ornamentals, and field crops worldwide. Its short developmental time, high fecundity, and remarkable ability to evolve resistance to a wide range of acaricides render chemical control both costly and often unsustainable (Bolland *et al.* 1998; Van Leeuwen *et al.* 2010; Grbić *et al.* 2011). Consequently, biological control has become an essential component of integrated pest management (IPM), with predatory mites playing a central role in suppressing spider mite populations. Among the phytoseiids, *Phytoseiulus persimilis* Athias-Henriotis recognized as one of the most effective natural enemies of *T. urticae*. This specialist predator has been mass-reared and commercially released for decades and is particularly successful in protected cultivation systems such as greenhouses (McMurtry *et al.* 2013). Its high intrinsic rate of increase, rapid developmental cycle, and voracious predation capacity make it a cornerstone of spider mite management strategies (Laing 1968; Kazak *et al.* 1989; Mohamed and Omar 2011). However, the performance of *P. persimilis* is strongly shaped by environmental conditions, especially temperature, due to its poikilothermic physiology. Many experiments have shown that temperature influences the survival, developmental rate, longevity, oviposition, and predation efficiency of predatory mites, thereby determining their effectiveness as a biological control agents (Gotoh and Gomi 2003; Gotoh *et al*. 2004; Kazak 2008; Ganjisaffar *et al*. 2011; Jafari *et al*. 2012; Farazmand *et al*. 2020). Because poikilothermic physiology links metabolic rate to ambient temperature, even small changes in temperature can alter predator-prey interactions and, under extreme conditions, biological control may fail (Skirvin and Fenlon 2003; Walzer and Schausberger 2011). For instance, developmental time is shortened at moderately elevated temperatures, whereas extreme heat can significantly reduce fecundity and increase mortality (Skirvin and Fenlon 2003). Similarly, predation rates have been shown to peak under optimal thermal regimes but decline under both lower and higher extremes (Rojas *et al*. 2013; Bayoumy *et al*. 2022). Life table studies provide deeper insights into how temperature regulates the population growth potential of *P. persimilis*. Parameters such as the net reproductive rate (R_0), intrinsic rate of increase (r), mean generation time (T), and finite rate of increase (λ) have all been shown to vary significantly with temperature (Laing 1968; Gotoh and Gomi 2003; Nawar *et al*. 2014). Optimal ranges (generally 20–30 °C) maximize reproductive output and population growth, while exposure to suboptimal or stressful temperatures leads to reduced longevity, lower fecundity, and suppressed population expansion (Kazak 2008; Papanikolaou *et al*. 2016). Recent studies also indicate that short-term heat stress can disrupt these life table parameters, leading to sharp declines in survival and fertility, which have critical implications under climate change scenarios (Pakyari and Zemek 2025). Given the central role of temperature in regulating the predator-prey dynamics between *P. persimilis* and *T. urticae*, understanding its effects on life history and demographic parameters is crucial for optimizing biological control programs. Even small deviations from the optimal thermal range can tip the balance between successful suppression of *T. urticae* populations and biological control failure (Walzer and Schausberger 2011; Colinet *et al*. 2015; Paaijmans *et al*. 2015). With the added challenge of climate change, which brings increasingly frequent heat stress events, a clear understanding of the thermal limits and optimal range of predatory mites is becoming crucial (Colinet *et al*. 2015; Paaijmans *et al*. 2015). Because the efficiency of predator is greatly affected by temperature, this study aims to quantitatively assess the temperature-dependent life table traits of *P. persimilis* to support effective biocontrol strategy optimization to guide optimal rearing and application strategies. Therefore, in this study the effects of five constant temperatures (21, 23, 25, 27, and 29 °C) on developmental rate, survival and life table parameters of *P. persimilis* using the two-sex life table method were investigated.

MATERIAL AND METHODS

Mite culture

Initial colonies of *T. urticae* were obtained from greenhouses in Yazd city, Iran. Initial colony of predatory mite was obtained from the Batab Desert Biomonitoring Company (Zipa Insectarium). Two-spotted spider mites were reared on potted cucumber plants containing a mixture of cocopeat and perlite. The predatory mite was maintained on leaf discs of cucumber plants, containing eggs of *T. urticae* as food. These leaf discs were placed on wet cotton in 9 cm diameter Petri dishes and kept at 25 ± 2 °C, 16L:8D photoperiod and 60 ± 5% RH. Whenever necessary, the leaves were replaced and mites were transferred to fresh leaves with *T. urticae* eggs. Predatory mites were reared for three generations before being used in the experiments.

Experimental units

A cucumber leaf disk (3 cm diameter) with eggs of *T. urticae* was placed upside down at the center of saturated cotton in a Petri dish (9 cm diameter). The leaf disk borders were surrounded with moistened cotton strips as barriers, to provide water for the predatory mites and prevent them from escaping (Rafizadeh Afshar and Latifi 2016). One young (1–2 day old), mated female predatory mite was placed on each leaf disk using a size 4 fine brush. The female mites were given eight hours to lay eggs at the desired temperatures (21, 23, 25, 27, and 29 °C) and 75 ± 5% RH. After this period, the female mites and all eggs except one were removed from each leaf disk. Then the Petri dishes were transferred to controlled conditions (climate chamber) of 21, 23, 25, 27, and 29 °C, 75 ± 5% RH, and a 16L:8D h photoperiod. They were observed every 12 hours until the eggs hatched. After the larvae emerged, sufficient amounts of *T. urticae* eggs (10–50 eggs at 21 and 23 °C, 20–100 eggs at 25, 27 and 29 °C) was added to each leaf disk, daily for feeding. Based on preliminary experiments. The duration of the immature stages including egg, larva, protonymph and deutonymph were separately determined at five temperatures, every 12 hours. Upon reaching adulthood, a male mite was added to each disk for mating. If needed, adult males were transferred from the stock colony. The number of eggs laid by each female was recorded daily. Then these eggs were moved to separate containers under the same environmental conditions and monitored until hatching and sex determination. All individuals were observed until they died. Each treatment was replicated 50 times.

Data analysis

The data obtained from the rearing of the predatory mites *P. persimilis* at different temperatures were analyzed using demographic parameters such as population growth, life table, and reproductive parameters with the TWOSEX-MSChart software (Chi 2020). The standard errors and variances of biological characteristics and population parameters were evaluated using the bootstrap resampling approach with 100,000 replications. Means were compared by using the paired bootstrap test at 5% significance level.

RESULTS

The biological performance of *P. persimilis* was significantly influenced by temperature; the significant effects were observed on developmental time, survival, reproduction and life table parameters. The age-specific survival rate (l_x), age-specific fecundity (m_x), age-specific maternity ($l_x m_x$), and female age-stage-specific fecundity (f_x) of *P. persimilis* at five constant temperatures are shown in Figure 1.

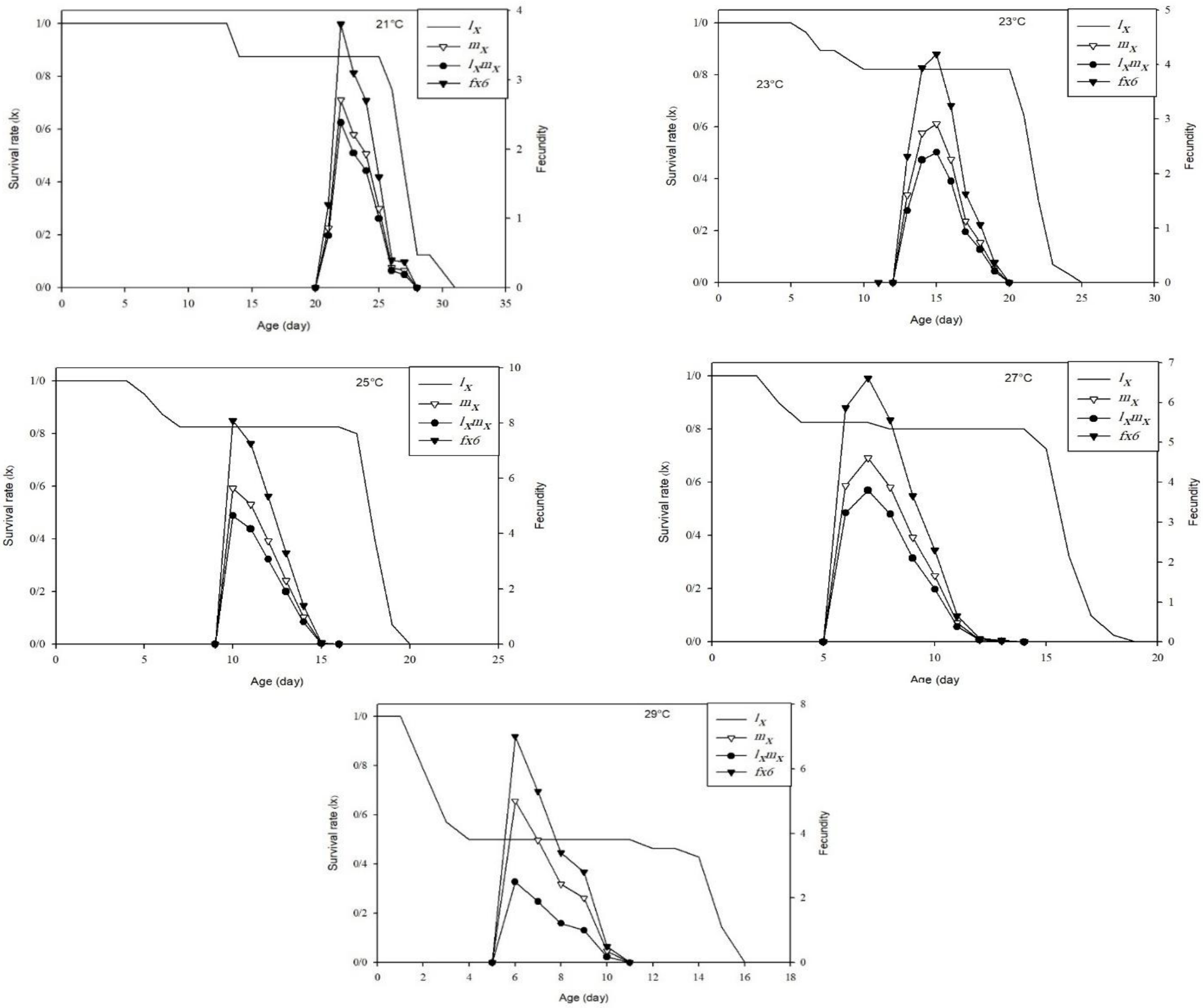

Figure 1. Age-specific survival rates (l_x), fecundities (m_x), maternities ($l_x m_x$), and age-stage-specific fecundities (f_x) of *Phytoseiulus persimilis* at five constant temperatures.

At lower temperatures, oviposition begins later, whereas with increasing temperature, oviposition starts significantly earlier, starting on days 20, 12, 9, 5, and 5 at 21, 23, 25, 27 and 29 °C, respectively. The corresponding peak oviposition occurred on days 21, 14, 9, 6, and 5, respectively. This pattern reflects the well-documented acceleration of development and reproductive onset under warmer conditions. The synchronization of f_x, m_x, and l_xm_x, with overlapping peaks, indicates that survival, fecundity, and maternity are closely linked. The highest values of f_x were 3.8, 4.18, 8.08, 6.6, and 7 offspring, while mx values were 2.71, 2.91, 5.64, 4.61, and 3.79 offspring, and l_xm_x values were 2.38, 2.39, 4.65, 3.8, and 1.89 offspring at 21, 23, 25, 27, and 29°C, respectively.

Age-specific survival (l_x) was 100% until days 13, 5, 4, 2, and 1 at 21, 23, 25, 27, and 29 °C, respectively, then gradually declined to near zero at 30, 24, 19, 18, and 16 days.

The age-stage-specific survival rate (S_{xj}) of the different stages are presented in Figure 2. The graphs illustrated the survival rate of different life stages of predatory mites (eggs, larvae, protonymphs, deutonymphs, females, and males), providing insight into how temperature influences their life cycle. The age-stage specific survival rate (S_{xj}) is the probability that a new born will survive to age x and stage j (Chi and Liu 1985). Overlaps were observed between different developmental stages across temperatures, a pattern also reported by Pakyari and Zemek (2025), who showed substantial stage overlaps in *P. persimilis* under short-term heat stress. The highest female survival rates were 0.625, 0.571, 0.575, 0.575, 0.357 on days 19–25, 12–21, 8–17, 6–14, 4–14 while the highest male survival rates were 0.25, 0.25, 0.25, 0.22, 0.14 on days 19–26, 11–20, 7–16, 5–14, 4–11 in 21, 23, 25, 27 and 29 °C respectively. The survival rate of female and male gradually decreased with increasing temperature but remained relatively constant at intermediate temperatures. In these conditions, mites required approximately 17, 10, 7, 4 and 4 days to complete the egg, larva, protonymph and deutonymph stages before adulthood.

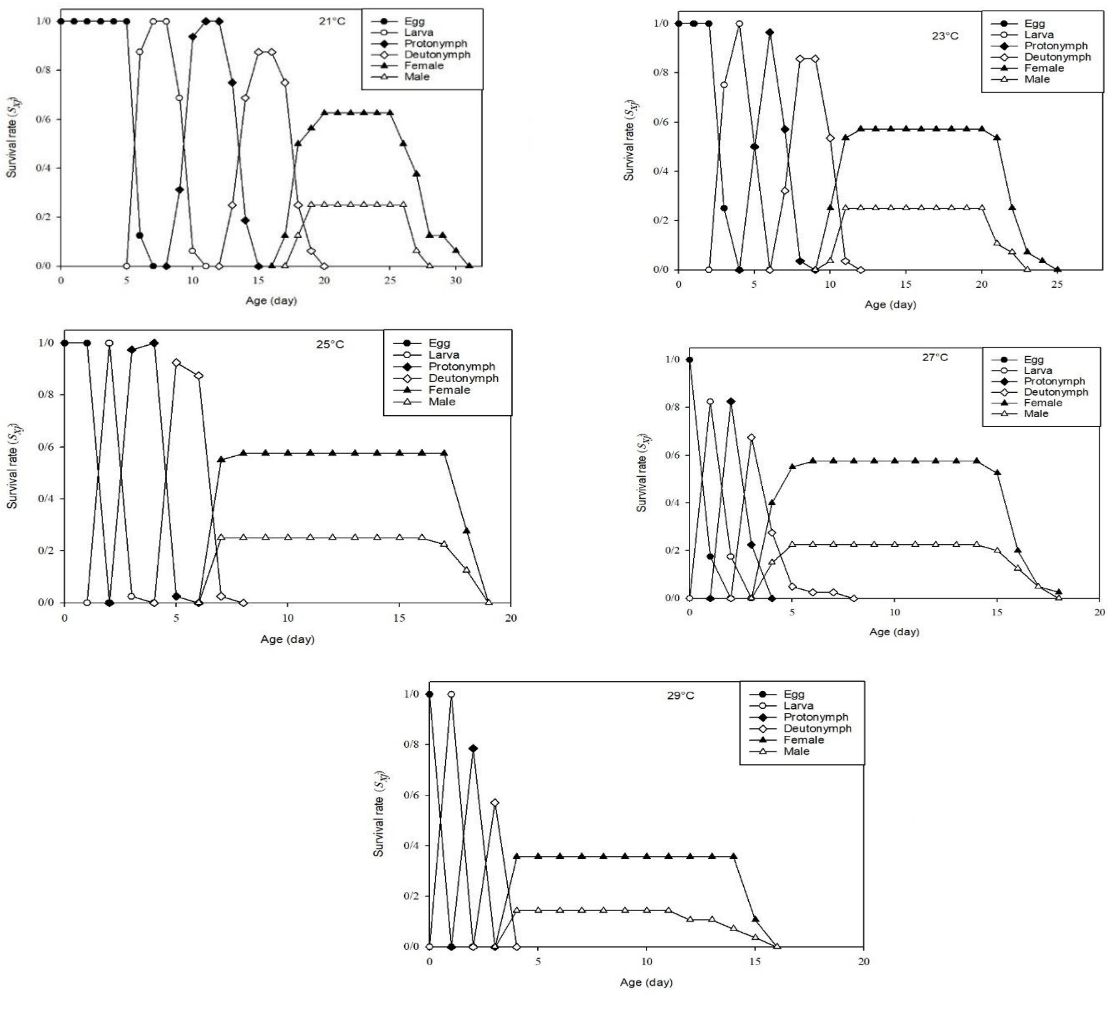

Figure 2. The age-stage-specific survival rates (S_{xj}) of *Phytoseiulus persimilis* at five constant temperatures.

Mean developmental time, adult preoviposition period (APOP) and total preoviposition period (TPOP) of *P. persimilis* at five constant temperatures are presented in Table 1. The duration of immature stages decreased with increasing temperature. At 21 °C, mite development required 17 days, whereas at 23, 25, 27, and 29 °C, it required approximately 10, 7, 4, and 4 days, respectively.

Table 1. Means (± SE) comparison of the developmental time, adult preoviposition period (APOP) and total preoviposition period (TPOP) of *Phytoseiulus persimilis* at five constant temperatures.

Developmental stages	Temperature				
	21 °C	23 °C	25 °C	27 °C	29 °C
Egg (days)	6.12 ± 0.09a	3.25 ± 0.08b	2.00 ± 0.00c	1.18 ± 0.38d	1.00 ± 0.00d
Larva (days)	3.12 ± 0.69a	2.25 ± 0.08b	1.02 ± 0.02c	1.00 ± 0.00c	1.00 ± 0.00c
Protonymph (days)	4.29 ± 0.13a	2.16 ± 0.07b	2 ± 0c	1.06 ± 0.04d	1.00 ± 0.00d
Deutonymph (days)	4.29 ± 0.13a	3.00 ± 0.00b	2.00 ± 0.00c	1.09 ± 0.09d	1.00 ± 0.00d
Male (days)	8.75 ± 0.25c	10.86 ± 0.34b	11.7 ± 0.33a	12.33 ± 0.29a	10.351 ± 01.35b
Female (days)	9.8 ± 0.39b	11.94 ± 0.19a	11.43 ± 0.12a	12.04 ± 0.77a	11.51 ± 0.27a
Total developmental time (days)	26 ± 1.18a	19 ± 71.07b	16.35 ± 0.76c	13.97 ± 0.8d	08.96 ± 1.2e
APOP (days)	3.00 ± 0.00a	2.31 ± 0.11a	2.00 ± 0.00a	1.00 ± 0.00b	1.00 ± 0.00b
TPOP (days)	21.1 ± 0.26a	12.93 ± 0.22b	9.04 ± 0.04c	5.34 ± 0.11d	5.00 ± 0.00e

Means followed by the different letters in each row are significantly different (Paired bootstrap test, $P < 0.05$).

Population parameters of *P. persimilis* at five constant temperatures are shown in Table 2. Analysis of life table parameters showed that intrinsic rate of increase (r), finite rate of increase (λ), net reproductive rate (R_0), and gross reproductive rate (*GRR*) increased with rising temperature up to 27 °C, then declined at 29 °C. The highest r (0.35) and λ (1.43) were observed at 27 °C, while the highest R_0 (14.62) and *GRR* (17.73) were recorded at 25 °C, without significant difference from 27 °C. The mean generation time (T) decreased significantly with increasing temperature. Our analysis of intrinsic and finite rates of increase (r and λ) and life table parameters further confirmed that population growth was optimal between 25 and 27 °C. The sharp decline in r and R_0 at 29 °C confirmed that this upper threshold is unsuitable for long-term population maintenance, although the species performed well within 25–27 °C, its efficiency declined rapidly under thermal stress, limiting its use in hotter environments (Walzer and Schausberger 2011; Colinet *et al.* 2015; Papanikolaou *et al.* 2016).

Table 2. Mean (± SE) comparison of population parameters of *Phytoseiulus persimilis* at five constant temperatures.

Population parameters	Temperature				
	21 °C	23 °C	25 °C	27 °C	29 °C
r (d^{-1})	0.09 ± 0.00d	0.15 ± 0.01c	0.24 ± 0.01b	0.35 ± 0.02a	0.27 ± 0.04b
λ (d^{-1})	1.09 ± 0.01c	1.16 ± 0.01c	1.27 ± 0.01b	1.43 ± 0.02a	1.31 ± 0.05b
R_0 **(offspring/individual)**	8.18 ± 1.69b	9.57 ± 1.58b	14.62 ± 2.00a	14.01 ± 1.93a	6.78 ± 1.74c
GRR **(offspring)**	9.39 ± 1.66bc	11.65 ± 1.63bc	17.73 ± 2.06a	17.24 ± 1.99a	13.57 ± 2.43ab
T **(day)**	23.07 ± 0.3a	14.99 ± 0.25b	11.15 ± 0.04c	7.39 ± 0.11d	7.01 ± 0.07d

R = Intrinsic rate of increase; λ = Finite rate of increase; R_0 = Net reproductive rate; *GRR* = Gross reproductive rate; T = Mean generation time.
Means followed by the different letters in each row are significantly different (Paired bootstrap test, $P < 0.05$).

DISCUSSION

This study indicates that temperature strongly influences life history, development, survival, and reproduction of *P. persimilis*, consistent with its poikilothermic physiology. The results of this study clearly align with the well-established thermal tolerance pattern of *P. persimilis*. The significant decline in population growth rate, survival, and fecundity at 29 °C is fully consistent with previous findings indicating that this species possesses a narrow thermal window with optimal performance around 24–27

°C (Gotoh and Gomi 2003; Walzer and Schausberger 2011). Numerous earlier studies have shown that exposure to higher temperatures leads to reduced egg size, increased juvenile mortality, and shortened adult longevity—an exact pattern that is also evident in our results. Moreover, the accelerated development and earlier sexual maturity observed at 25–27 °C in our study closely correspond with physiological models of thermal tolerance in highly specialized predators. Species such as *P. persimilis* typically exhibit lower adaptive capacity to elevated temperatures compared with generalist predators such as *Neoseiulus californicus* (McGregor). Overall, this connection between our findings and previous studies highlights that even small but sustained increases in temperature can rapidly disrupt the balance between metabolism, development, and reproduction in this predator, ultimately reducing its biocontrol efficiency under conditions that exceed its optimal thermal range. Survival analyses revealed that females generally outlive males, but adult survival declines sharply after reaching adult stage, suggesting that reproductive activity and thermal stress influence longevity. These findings corroborate previous life-table studies (Laing 1968; Gotoh aand Gomi 2003; Mohamed and Omar 2011) and confirm that *P. persimilis* performs best under intermediate thermal conditions. The peak $l_x m_x$ values were recorded at 25–27 °C, reflecting the interdependence of survival and reproduction, in line with previous life-table findings (Walzer and Schausberger 2011; Nawar *et al.* 2014). Our results on age specific survival showed that the mites are primarily fertile during a short period of their lives, with reproduction almost concentrated in the middle of their life cycle. This confirms that higher temperatures shorten lifespan but accelerate development, as observed in Laing (1968) and Gotoh and Gomi (2003). The survival rates of both female and male mites showed a more stable pattern compared to earlier life stages. Female survival was consistently higher than male survival, but there was a notable decrease in survival after reaching adult stage. This could indicate that adult mites may be less resilient to extreme temperatures or that their reproductive activities impact their longevity. The fluctuating survival rates across different stages suggest that temperature plays a crucial role in mite development and population dynamics, in agreement with multiple life-table studies showing that *P. persimilis* has a narrow thermal optimum compared to generalist phytoseiids such as *N. californicus* (Gotoh and Gomi 2003; Paaijmans *et al.* 2015), suggesting that mixed-species release strategies could exploit complementary thermal niches for pest suppression. A longer immature period reduced the growth rate of predator population growth, which may weaken its ability to suppress pest populations (*e.g.*, spider mites). In contrast, at optimal temperatures, predators reach adulthood faster, reproduce more quickly, and control pests more effectively. Accelerated development of *P. persimilis* at higher temperatures have been reported in previous life-table studies (Laing 1968; Elmoghazy 2012; Vangansbeke *et al.* 2013; Farazmand *et al.* 2015). APOP and TPOP values followed similar trends, confirming that warming accelerates pre-oviposition and generation turnover, consistent with earlier reports (Laing 1968; Chi and Su 2006; Bayoumy *et al.* 2022). Developmental time for both males and females increased with rising temperature up to 27 °C, then slightly declined at 29 °C, suggesting that this upper threshold imposes physiological stress on adults. This trend suggests that 29 °C represents a suboptimal threshold for development, a finding consistent with earlier reports that *P. persimilis* performs best at intermediate temperatures but suffers reduced survival and reproduction under heat stress (Gotoh and Gomi 2003; Walzer and Schausberger, 2011; Colinet *et al.* 2015). For example, while the mean generation time sharply decreased with temperature in our study, adult longevity was shortened considerably at 29 °C, reflecting the well-documented trade-off between accelerated reproduction and reduced lifespan under thermal stress (Paaijmans *et al.* 2015; Papanikolaou *et al.* 2016). Such temperature-dependent acceleration of life history traits has been widely reported in mites and other poikilotherms, where faster metabolism at warmer temperatures reduces stage duration but eventually impairs performance at extremes (Sabelis 1981). Our analysis of intrinsic and finite rates of increase (r and λ) and life table parameters further confirmed that population growth was optimal between 25 and 27 °C. The sharp decline in r and R_0 at 29 °C confirmed that this upper threshold is unsuitable for long-term population maintenance, although the species performed well within 25–27 °C, its efficiency declined rapidly under thermal stress, limiting its use in warmer environments (Walzer and Schausberger 2011; Colinet *et al.* 2015; Papanikolaou *et al.* 2016). Kazak *et al.* (1989) and Mohamed and Omar (2011) reported higher R_0 values for *P. persimilis* (26.05 and 30.99, respectively) compared to those obtained in our study. Conversely, the r value for *P. persimilis* in our research was found to be lower than those (0.338 and 0.334, respectively) presented by Kazak *et al.* (1989) and Abad Moyano *et al.* (2009), but higher than the value (0.12) reported by Mohamed and Omar (2011). These findings on population parameters corroborated earlier reports that *P. persimilis* achieves maximum reproductive output around 24–27 °C for population growth and biocontrol performance (Skirvin and Fenlon 2003; Rojas *et al.* 2013), but declined rapidly under warmer conditions, where increased temperatures reduced egg size, increased juvenile mortality and shortened adult lifespan (Gotoh and Gomi 2003; Walzer and Schausberger 2011; Colinet *et al.* 2015; Papanikolaou *et al.* 2016). Although differences existed in the reported r and R_0 values among studies, most reports indicated a similar thermal optimum for *P. persimilis* (Gotoh *et al.* 2004; Abad-Moyano *et al.* 2009; Mohamed and Omar 2011). Such discrepancies may reflect differences in prey quality, experimental design, and geographic strain. Gotoh *et al.* (2004) indicated that the r value can fluctuate considerably based on factors such as the plant that the prey consumes, the species and developmental stage of the prey, environmental conditions like temperature and humidity, and the methods used for data analysis. In general, demographic parameters reported in different studies are not easy to compare, since observed differences may result from strain variation as well as differences in experimental methodologies, such as arena size and type, food sources, relative humidity, photoperiod, and calculation methods. Overall, temperature shapes population growth and predator-prey dynamics by affecting development, reproduction, and survival. The decline in population parameters at 29 °C highlights the importance of maintaining rearing and release conditions within the optimal thermal range for effective biological control. Such information is essential for improving biological control strategies and ensuring the sustainable management of *T. urticae* under diverse environmental conditions. These findings underscore the practical importance of understanding the thermal biology of *P. persimilis* for effective management of *T. urticae*. The predator performs optimally at 25–27 °C, while temperatures beyond this range reduce survival, reproduction, and population growth, potentially compromising pest suppression. Under natural conditions with daily and seasonal temperature fluctuations, and in the context of climate change with rising temperatures and more frequent heat waves, even moderately thermotolerant predators may fail to control *T. urticae* populations effectively. Therefore, timing releases, optimizing rearing conditions, and implementing complementary strategies such as mixed-species releases or environmental management are essential to maintain sustainable biocontrol (Skirvin and Fenlon 2003; Colinet *et al.* 2015; Paaijmans *et al.* 2015). Future studies comparing specialist and generalist predatory mites under fluctuating, field-like temperature regimes can provide valuable insights into how thermal stress affects predator-prey dynamics and help design complementary release strategies that exploit differences in thermal niches.

Author contributions: Methodology: M.L., S.R.S.; Sampling, collection and preparation of specimens: S.M.M. S.; Analyses and data curation: M.L., S.R.S., S.M.M.S.; writing-original draft preparation: M.L. writing-revisions and editing: M.L., S.R.S.; supervision: M.L., S.R.S. All authors have read and agreed to the published version of the manuscript.

Funding: NA.

Availability of data and materials: Data are available upon request from the authors.

Ethics approval and consent to participate: This study only included arthropod material, and all required ethical guidelines for the treatment and use of animals were strictly adhered to in accordance with international, national, and institutional regulations. No human participants were involved in any studies conducted by the authors for this article.

Conflict of interest: The authors declare no conflict of interest.

Generative AI statement: The authors declare no use of Gen AI in the creation of this manuscript.

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تـــاثیر دمـــا بـــر پراســـنجه‌های زیســـتی هِرنـــای شـــکارگر *Phytoseiulus persimilis* (Acari: Phytoseiidae)

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دریافت
۲۳ شهریور ۱۴۰۴
پذیرش
۸ دی ۱۴۰۴
انتشار
۲۶ فروردین ۱۴۰۵
دبیر تخصصی
آ. فرازمند

چکیده

هرنای تارتن دولکه‌ای *Tetranychus urticae* Koch (Acari: Tetranychidae) یکی از آفات مهم کشاورزی است و هرنای شکارگر *Phytoseiulus persimilis* Athias-Henriot یکی از مؤثرترین دشمنان طبیعی آن به شمار می‌رود. از آنجا که دما تأثیر زیادی بر زیست‌شناسی هرنای شکارگر دارد، در این پژوهش اثر پنج دمای ثابت (۲۱، ۲۳، ۲۵، ۲۷ و ۲۹ درجهٔ سلسیوس) بر رشد، زنده‌مانی و تولیدمثل *P. persimilis* با استفاده از تحلیل جدول زندگی سن-مرحله و دوجنسی بررسی شد. زمان رشد با افزایش دما کاهش یافت، در حالی که آغاز تولیدمثل در شرایط دمایی بیشتر، زودتر رخ داد. بیشترین باروری، میزان خالص تولیدمثل (R_0 = 14.62) و میزان ذاتی افزایش جمعیت (r = 0.35) در دماهای ۲۵ تا ۲۷ درجهٔ سلسیوس ثبت شد که نشان‌دهنده دامنه بهینه برای رشد جمعیت است. با این حال، طول عمر حشرات کامل و عملکرد تولیدمثلی در دمای ۲۹ درجهٔ سلسیوس به میزان زیادی کاهش یافت که بیانگر محدودیت‌های ناشی از تنش گرمایی است. این نتایج تأیید می‌کند که *P. persimilis* در دماهای معتدل (۲۴ تا ۲۷ درجه سلسیوس) بیشترین کارایی زیستی را دارد و این امر مناسب‌بودن آن را به‌عنوان عامل مهار زیستی در شرایط کنترل‌شده تقویت می‌کند، هرچند کارایی آن در دماهای بسیار زیاد کاهش می‌یابد. یافته‌های این مطالعه بینش‌های کاربردی برای بهینه‌سازی راهبردهای پرورش انبوه و رهاسازی در مزرعه در چارچوب برنامه‌های مدیریت تلفیقی آفات فراهم می‌کند.

واژگان کلیدی: جدول زندگی، هرنای شکارگر، زنده‌مانی، دما، *Tetranychus urticae*

CITE: Sarvi, S.M.-M., Latifi, M. & Sahhafi, S.R. (2026) Effect of temperature on the biological parameters of the predatory mite, *Phytoseiulus persimilis* (Acari: Phytoseiidae). *Persian Journal of Acarology*, 15(2): 150204.
https://doi.org/10.22073/pja.150204