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Source: Systematic and Applied Acarology, 26(2) : 496-508

Published By: Systematic and Applied Acarology Society

URL: https://doi.org/10.11158/saa.26.2.12

Systematic & Applied Acarology 26(2): 496–508 (2021)
https://doi.org/10.11158/saa.26.2.12

ISSN 1362-1971 (print)
ISSN 2056-6069 (online)

Article

Development and life history parameters of *Typhlodromus recki* (Acari: Phytoseiidae) feeding on *Tetranychus urticae* (Acari: Tetranychidae) at different temperatures

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Abstract

Typhlodromus recki (Acari: Phytoseiidae) was collected from aubergines, pepper, black nightshade and jimsonweed plants infested with spider mites from a pesticide-free vegetable garden in Denizli, Turkey. The biology and life table parameters for *T. recki* feeding on *Tetranychus urticae* (Acari: Tetranychidae) at different temperatures (15, 20, 25, 30 and 35 °C) were determined. The results showed that total preadult periods of *T. recki* at 15, 20, 25, 30 and 35 °C were 19.6±0.51, 9.4±0.16, 7.6±0.14, 5.7±0.14 and 4.5±0.08 days, respectively. The longest oviposition period was 23.5 days at 20 °C. Total fecundity of *T. recki* significantly differed between the constant temperatures and the highest was observed at 20 °C (28.6 eggs/female) and 25 °C (23.5 eggs/female). Although females survived for 26 days at 35 °C, only four females laid eggs for 1 day. Thus, 35 °C is not suitable for the reproduction of *T. recki*. Total longevity of female was the longest at 15 °C (59.5 days) and 20 °C (51.3 days) whereas male total longevity was the longest at 15 °C (53.2 days). The intrinsic rate of increase (r) and finite rate of increase (λ) were numerically the highest at 30 °C (0.17 and 1.18 d^{-1}), but there was no statistical difference observed between 25 and 30 °C for both r and λ values. The net productive rate was significantly highest at 20, 25 and 30 °C. The longest mean generation time occurred at 15 °C (42.6 days) and the shortest was at 35 °C (8.0 days). After some field trials, *Typhlodromus recki* could potentially be considered in the biological control agent of *T. urticae.*

Key words: Development, life history, Phytoseiidae, *Tetranychus urticae*, *Typhlodromus (Anthoseius) recki*

Introduction

Tetranychus urticae Koch (Acari: Tetranychidae) is a polyphagous mite pest that can feed and reproduce on a series of plant species including vegetables, fruits, crops and ornamentals, hereby causing serious damage to leaves, stems and fruits and reducing yields (Cakmak *et al.* 2005; Migeon & Dorkeld 2020). In order to manage this mite, chemical pesticides are used, but this mite, due to the short life cycle and high fecundity, easily develops resistance to these pesticides. Also, these pesticides cause environmental pollution and increase health risk to humans and wildlife. Thus, biological control studies have been conducted in many countries to find an alternative to the chemical pesticides used against this pest. Predatory mites (Phytoseiidae), for example, are highly effective and have been widely used in the suppression of *T. urticae* populations (Cakmak *et al.* 2006; 2009). Likewise, many predatory mite species are produced and sold by different companies in the world (Gerson & Weintraub 2007). In addition, there are natural populations in different regions of many predatory mites that are also commercially available for sale. Since different populations of the same species of predatory mites react differently to prey species, host plants and

environmental conditions (e.g., temperature and humidity), efficiency studies on different populations of predatory mites have become increasingly important in recent years. For this reason, studies on the biology of different species and/or populations of predatory mites that indicate their biological control potential against phytophagous insects and mites are of great importance and encouraged.

Typhlodromus recki Wainstein (Acari: Phytoseiidae) is a good example of such predatory mites with biological control potential. It has been reported in several survey studies in European and Middle East countries (Kreiter *et al.* 2020) from a wide variety of plants, especially non-cultivated species; but occasionally it is found on crops such as aubergine, citrus, grapevines, potato, olive, orchard trees, strawberry and tomato. (Swirski & Amitai 1982; Şekeroğlu 1984; Papaioannou-Souliotis *et al.* 1994; Tixier *et al.* 2003; Kumral 2005; Rahmani *et al.* 2010; İnak & Çobanoğlu 2018). However, no information is available about the biology of this predator or its potential as a pest control agent. Therefore, this study was conducted to determine the developmental period, fecundity and longevity of *T. recki* feeding on *T. urticae* at different temperatures. The data obtained from this study will ascertain whether *T. recki* is an effective predator of *T. urticae* as well as provide much-needed information about the developmental period, fecundity and longevity of the predatory mite; as this important information is lacking in the literature.

Materials and Methods

Rearing of mite species

Tetranychus urticae was collected from tomato plants in a greenhouse in Izmir, Turkey and reared on bean plants (*Phaseolus vurgaris* cv. Barbunia supplied by Bursa Seeds, Bursa, Turkey) at 25±1°C, 60±10% RH and 16:8 h L:D photoperiod in a climate room according to the method described by Cakmak *et al.* (2005, 2009).

Typhlodromus recki was collected from aubergines, pepper, black nightshade and jimsonweed, where associated with *T. urticae* in a pesticide-free vegetable garden of a small producer in Denizli, Turkey, in 2017. It was reared on plastic plates (80 x 150 mm) placed on a wet sponge in a plastic tray containing water (Overmeer 1985). Wet tissue paper was placed at the edge of plastic plates as a barrier to prevent the escape of the mites. Different life stages of *T. urticae* obtained from the culture and *Typha latifiola* L. (Typhaceae) pollen was supplied as food on the plastic plates with a fine brush every 2 d. Pollen was collected from a pesticide-free area in Denizli, Turkey and was air dried for 24 h under low humidity conditions in the laboratory, then sieved and stored at -20 °C. A small piece of v-shaped plastic (10 x 15 mm) and a cotton thread were placed on the plastic plate as an oviposition site for the predatory mite. The predatory mites were reared in a climate room; 25±1°C, 70±10% RH and 16:8 h L:D photoperiod.

Development period of immature stages

The development period of *T. recki* was monitored using a modified Munger cell (Kustutan & Cakmak 2009; Kamburgil & Cakmak 2014) at five temperatures (15, 20, 25, 30 and 35±1°C), 70% RH and 16:8 h L:D photoperiod in an incubator (Sanyo, MLR 351H). The Munger cell (60 x 45 mm) consisted of a stack containing three plates: base acrylic plate (2 mm thick), moistened filter paper, clean bean leaf; middle acrylic plate (5 mm thick and 23 mm center diameter hole) and top covered with transparent acetate sheet (0.1 mm thick), respectively. Clean bean leaves obtained from the culture was placed abaxial side up on the filter paper. About 100 holes were punched into the transparent acetate sheet with an insect pin for ventilation. All layers were held together with two large binder clips (32 mm). A gravid adult female of *T. recki* obtained from the stock culture was

singly transferred to each Munger cell and allowed to lay eggs for up to 24 h. Only one of the eggs laid by female was left in each cell, and other *T. recki* eggs and female were removed from the cell by a fine hair brush (000). After the eggs hatched, different life stages of *T. urticae* (~25 individuals per cell) obtained from the culture were brushed onto bean leaves as food for the larvae, protonymphs, deutonymphs and adults of *T. recki* at 2-d intervals during the study. Observations were made twice daily (12 h intervals) to determine the period of the immature stages until they reached maturity. When the bean leaves dried, they were replaced with fresh ones. The number of replicates for each temperature varied from 9 to 150 for different development stages (see Table 1).

TABLE 1. Duration (days) of different developmental stages and survival rate (%) of preadult of *Typhlodromus recki* feeding on *Tetranychus urticae* at different temperature.

	Temperatures (°C)									
	15		20		25		30		35	
Stage	n[1]	mean±S.E.[2]	n	mean±S.E.	n	mean±S.E.	n	mean±S.E.	n	mean±S.E.
Egg	143	5.7±0.10 a[3]	124	2.9±0.04 b	86	1.8±0.06 c	72	1.1±0.04 d	89	1.1±0.03 d
Larva	120	1.9±0.04 a	120	1.0±0.02 b	82	0.9±0.02 c	69	0.7±0.03 d	83	0.5±0.01 e
Protonymph	56	8.0±0.40 a	85	3.7±0.14 b	61	2.6±0.11 c	59	1.9±0.09 d	74	1.6±0.06 e
Deutonymph	30	5.0±0.28 a	50	2.5±0.11 b	44	2.5±0.11 b	50	2.1±0.11 c	59	1.4±0.06 d
Total preadult	30	19.6±0.51 a	50	9.4±0.16 b	44	7.6±0.14 c	50	5.7±0.14 d	59	4.5±0.08 e
Adult duration (female)	21	40.1±4.81 a	29	42.2±2.85 a	30	22.0±1.74 b	27	15.9±1.56 c	33	8.4±0.74 d
Adult duration (male)	9	32.9±6.54 a	21	23.1±2.28 a	14	23.6±2.87 a	23	15.1±2.18 b	26	7.4±0.71 c
Preadult survival rate (%)	150	20±0.03 c	125	40±0.04 b	88	50±0.05 b	72	70±0.05 a	91	65±0.05 a

[1] n= number of replicates, [2] The standard errors were calculated using bootstrap procedure with 100,000 bootstraps, [3]Means within a row followed by the same letter are not significantly different between temperatures using the paired bootstrap test at 5% significance level.

Reproduction and adult longevity

Reproduction and longevity of *T. recki* were observed using the Munger cell explained above at five temperatures (15, 20, 25, 30 and 35±1 °C), 70% RH and 16:8 h L:D photoperiod in an incubator (Sanyo, MLR 351H). Newly emerged adult female and an adult male from the above experiment were paired to determine reproduction parameters and longevity. One male was kept with one female for the total duration of the experiment period. If a male died before the female, a new male adult was transferred from the cell. Different life stages of *T. urticae* (~25 individuals per cell) obtained from the culture were brushed onto bean leaves as food for the adults of *T. recki* at 2-d intervals. The eggs laid by female predatory mite were recorded under a stereomicroscope (10x, Leica EZ4) daily (24 h intervals) and then these eggs were removed from the experimental units. The number of replicates for each temperature varied from 9 to 150 for different development stages (Tables 2 and 3).

Life history parameters and statistical analyses

The life history data for *T. recki* were analyzed according to the age-stage, two-sex life table (Chi & Liu 1985) using the TWOSEX-MSChart (Chi 2020). According to the methods of Chi & Liu (1985), the age-stage-specific survival rate (s_{xj}) (where, x is the age and j is the stage); the age-stage-specific fecundity (f_{xj}) of female adults; the age-specific survival rate (l_x); the age-specific fecundity (m_x), adult preoviposition period (APOP), total preoviposition period (TPOP), and the population growth parameters, the net reproductive rate (R_0), intrinsic rate of increase (r), finite rate of increase (λ) and mean generation time (T) were calculated. The standard errors of development period, reproduction, survival rate, fecundity, longevity and population parameters were estimated by the bootstrap method (Meyer *et al.* 1986; Efron & Tibshirani 1993). The differences were compared by Paired bootstrap test (Efron & Tibshirani 1993).

TABLE 2. Adult pre-oviposition (APOP), oviposition period, total pre-oviposition period (TPOP), fecundity and longevity of *Typhlodromus recki* feeding on *Tetranychus urticae* at different temperature.

	Temperatures (°C)									
	15		20		25		30		35	
	n[1]	mean±S.E.[2]	n	mean±S.E.	n	mean±S.E.	n	mean±S.E.	n	mean±S.E.
APOP[3]	21	7.8±0.84 a[4]	29	2.3±0.23 b	30	1.3±0.12 c	27	0.7±1.10 e	33	1.0±0.00 d
Oviposition period	21	12.8±1.70 bc	29	23.5±1.85 a	30	14.0±0.96 b	27	10.4±1.02 c	33	1.1±0.10 d
TPOP[5]	21	27.2±0.97 a	29	11.3±0.25 b	30	8.7±0.19 c	27	6.4±0.15 d	33	5.9±0.10 e
Total Fecundity	21	11.6±3.64 c	29	28.6±2.23 a	30	23.5±1.61 ab	27	18.7±1.96 b	33	0.2±0.08 d
Female total longevity	21	59.5±4.92 a	29	51.3±2.86 a	30	29.4±1.74 b	27	21.6±1.56 c	33	13.0±0.76 d
Male total longevity	9	53.2±6.72 a	21	32.9±2.34 b	14	31.5±2.82 b	23	20.8±2.17 c	26	11.8±0.69 d

[1] n= number of replicates; [2]The standard errors were calculated using bootstrap procedure with 100,000 bootstraps; [3]APOP, Adult pre-oviposition period; [4]The means followed by the same letter within columns are not significantly different between temperatures using the paired bootstrap test at 5% significance level; [5]TPOP, Total pre-oviposition period (from egg to first oviposition).

TABLE 3. Population parameters (*r*, intrinsic rate of increase; λ, finite rate of increase; R_0, net reproductive rate, offspring/individual; and *T*, mean generation time) of *Typhlodromus recki* feeding on *Tetranychus urticae* at different temperature (mean±S.E.[1]).

°C	n[2]	*r* (d^{-1})	λ (d^{-1})	R_0 (offspring/individual)	*T* (d)
15	150	0.01±0.0059 c[3]	1.01±0.0059 c	1.63±0.40 b	42.6±2.19 a
20	125	0.08±0.0087 b	1.08±0.0094 b	6.62±1.20 a	23.5±0.67 b
25	88	0.14±0.0117 a	1.15±0.0134 a	8.00±1.30 a	15.2±0.35 c
30	72	0.17±0.0167 a	1.18±0.0196 a	7.01±1.29 a	11.7±0.30 d
35	91	-0.36±0.0415 d	0.69±0.0298 d	0.05±0.03 c	8.0±0.05 e

[1]The standard errors were calculated using bootstrap procedure with 100,000 bootstraps; [2] n= number of replicates; [3]The means followed by the same letter within columns are not significantly different between temperatures using the paired bootstrap test at 5% significance level.

Results

Development period of immature stages

Typhlodromus recki males and females successfully completed their development from egg to adult at five constant temperatures (15, 20, 25, 30 and 35 °C) (Table 1). Development periods of eggs, larvae, protonymphs, deutonymphs and total preadults were the longest at 15 °C and the shortest at 30 and 35 °C for eggs, at 35 °C for larvae, protonymphs, deutonymphs and total preadults. The period for total preadults at 15, 20, 25, 30 and 35 °C was 19.6, 9.4, 7.6, 5.7 and 4.5 d, respectively. The developmental periods of immature stages and total preadults decreased significantly with increasing temperatures and the difference in temperatures was statistically significant (Table 1, $P < 0.05$). The shortest female and male adult longevity were 8.4 and 7.4 d at 15 °C, respectively. The highest preadult survival was 70% and 65% at 30 and 35 °C, respectively, and the lowest was 20% at 15 °C (Table 1, $P < 0.05$).

Reproduction and Adult Longevity

Adult pre-oviposition period (APOP), oviposition period, total pre-oviposition period (TPOP), female/male adult longevity of *T. recki* were significantly affected by temperature (Table 2). APOP was shorter at 30 °C (0.70 d) and significantly different compared with other temperatures (Table 2, $P < 0.05$). TPOP of *T. recki* varied between the temperatures from 5.9 d at 35 °C to 27.2 d at 15 °C

(Table 2). The highest oviposition period was 23.5 d at 20 °C. Total fecundity of *T. recki* significantly differed between the constant temperatures and the highest was observed at 20 °C (28.6 eggs) and 25 °C (23.5 eggs). Female total longevity was the longest at 15 °C (59.5 d) and at 20 °C (51.3 d) whereas male total fecundity was the longest at 15 °C (53.2 d) (Table 2).

Life history parameters

Intrinsic rate of increase (r) and finite rate of increase (λ) were numerically the highest at 30 °C (0.17 and 1.18 d^{-1}), but there was no statistical difference observed between 25 and 30 °C for both r and λ (Table 3). The net productive rate (R_0) significantly highest at 20, 25 and 30 °C. The longest mean generation time (T) occurred at 15 °C (42.6 d) and the shortest at 35 °C (8.0 d) (Table 3).

The age-stage survival rate (s_{xj}) indicating the rate of surviving individuals to age x and stage j is shown in Figure 1. The s_{xj} curves differed greatly at various temperatures and overlaps were found in the s_{xj} curves, which showed variable individual developmental rates. The mean generation time of *T. recki* decreased from 103 d at 15 °C to 26 d at 35 °C. The highest survival rate for adults was recorded at 30 °C, with 0.38 for females and 0.32 for males (Figure 1).

The age-specific survival rate (l_x), the age-specific fecundity (m_x) and the age-stage-specific maternity ($l_x m_x$) of *T. recki* at different temperatures are shown in Figure 2. The age-specific survival rate (l_x) at 15, 20, 25, 30 and 35 °C showed the same pattern of gradual decline from early stages of development to the end of development. First oviposition occurred on days 22.0, 8.5, 7.0, 5.0 and 5.5 at 15, 20, 25, 30 and 35 °C, respectively. The highest peaks of m_x and $l_x m_x$ were observed at 25 °C (Figure 2). Although females survived for 26 d at 35 °C, only four females laid eggs for 1 d. Thus, 35 °C is not appropriate for reproduction of *T. recki* (Figure 2).

The age-stage-specific life expectancy (e_{xj}) values of female adults of *T. recki* at 15, 20 and 35 °C were higher than those of male adults except for the ages of 57–67, 69–85 d at 15 °C and 15–17 d at 35 °C (Figure 3). Adult males e_{xj} values were higher than female adults at 25 and 30 °C, with the exception of ages 16–17 d at 25 °C and 4–15 d at 30 °C. The e_{xj} at 15 °C was higher than the other temperatures and decreased with increasing the temperatures. The e_{xj} values of the initial reproducing *T. recki* were 22.2, 22.9, 17.9, 16.0 and 9.2 at 15, 20, 25, 30, 35 °C, respectively (Figure 3).

The age-stage reproductive value (v_{xj}) of *T. recki* fed on *T. urticae* at the five temperatures is shown in Figure 4. The highest v_{xj} value was 10.7 on day 12 at 20 °C and the lowest at 35 °C (0.67 on day 3) (Figure 4).

Discussion

As there are no data in the literature regarding the developmental periods and reproductive parameters for *T. recki* at different temperatures, the data obtained in this study were compared with the data of different predatory mite species in the Phytoseiidae family. Our results showed that *T. recki* eggs hatched and developed successfully between 15 and 35 °C. Eggs of some phytoseiid species may not hatch at extreme temperatures such as 15 and 35 °C, or they cannot complete their development even if the eggs hatch. Kustutan & Cakmak (2009) reported that the eggs of *Neoseiulus californicus* hatched and became adult at 15 °C, but at 35 °C, 20% of the eggs that hatched and did not complete the development. Likewise, 73% of *Neoseiulus longispinosus* eggs (Rahman *et al.* 2013) and 30% of *Phytoseiulus persimilis* eggs (Hamamura *et al.* 1976) that hatched at 35 °C, did not develop into adult. Li *et al.* (2019) found that *Amblyseius andersoni* eggs did not hatch at 16 °C. The ability of predatory mites such as *T. recki* to develop at such wide temperature ranges increases their potential as biological control agents.

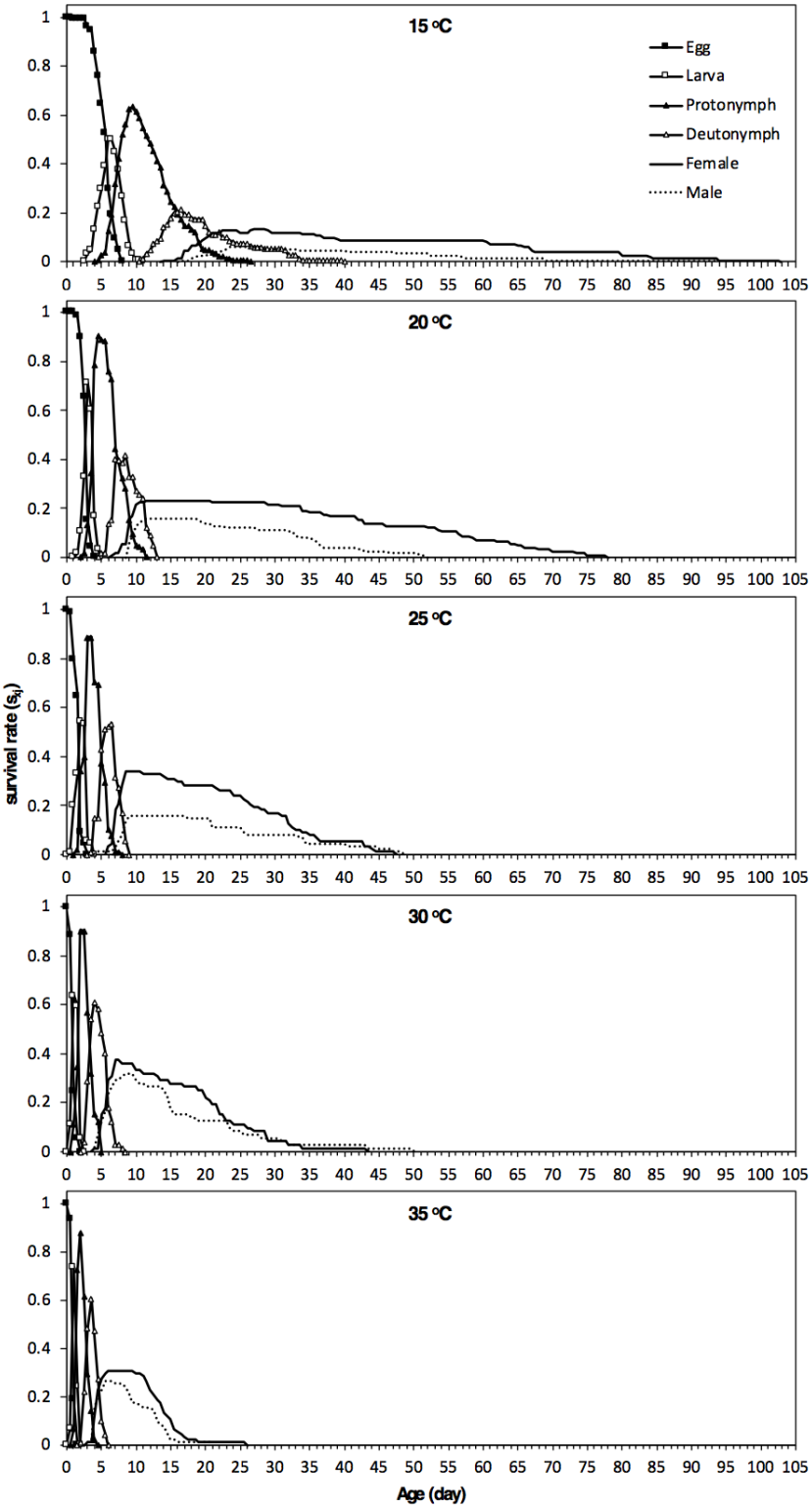

FIGURE 1. Age-stage survival rate (s_{xj}) of *Typhlodromus recki* feeding on *Tetranychus urticae* at different temperature.

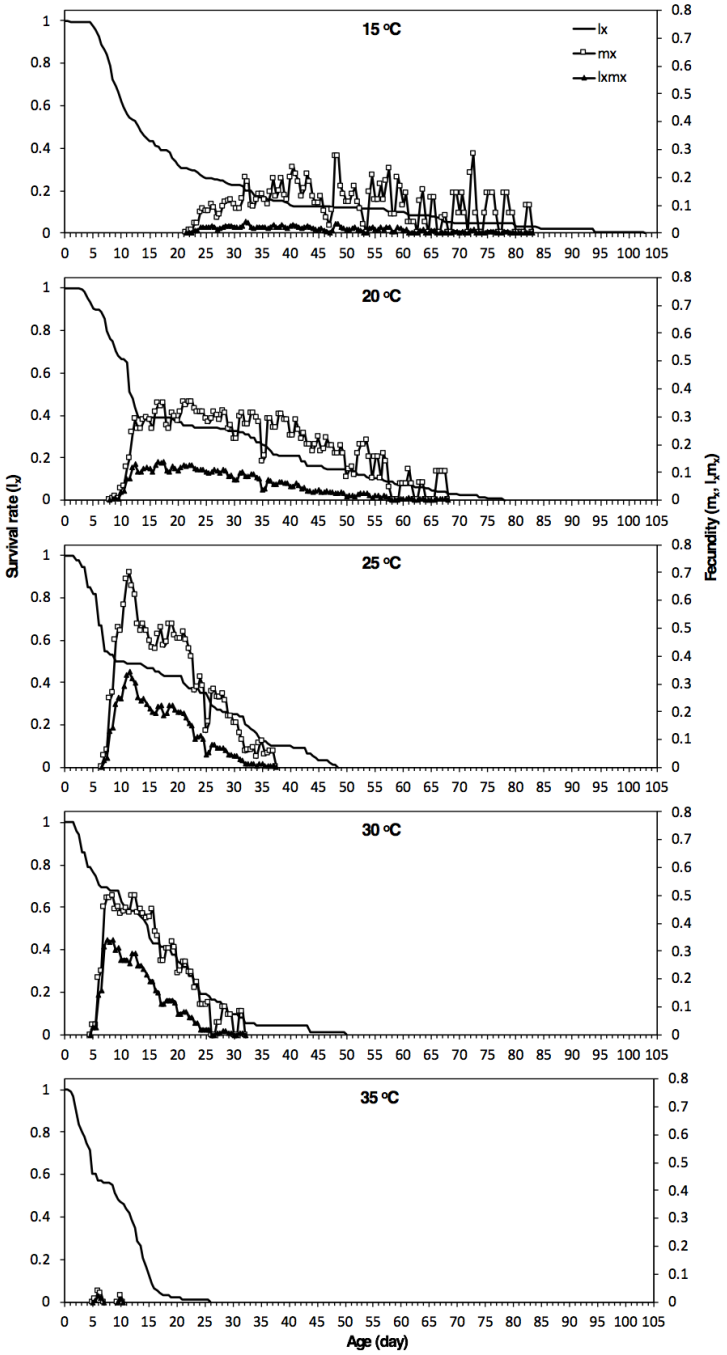

FIGURE 2. Age-specific survival rate (l_x), age-specific fecundity (m_x), and age-specific maternity (l_xm_x) of *Typhlodromus recki* feeding on *Tetranychus urticae* at different temperature.

The present study showed that the total developmental periods of *T. recki* at 15, 20, 25, 30 and 35 °C were 19.6, 9.4, 7.6, 5.7 and 4.5 d, respectively. Considering the results of all temperatures tested, the total development period of *T. recki* was lower than those of *Amblyseius swirskii* (Farazmand *et al.* 2020), *Neoseiulus cucumeris* (Al-Azzazy *et al.* 2018), *Phytoseius plumifer* (Gorji *et al.* 2008), *Typhlodromus bagdasarjani* (Ganjisaffar *et al.* 2011), *T. pyri* (Genini *et al.* 1991), but

higher than those of *Neoseiulus fallacis* (Genini *et al.* 1991), *Euseius finlandicus* (Broufas & Koveos 2001), *Iphiseius degenerans* (Tsoukanas *et al.* 2006), *Neoseiulus californicus* (Kustutan & Cakmak 2009), *Phytoseiulus persimilis* (Moghadasi *et al.* 2016), *P. fragariae* (de Vasconcelos *et al.* 2008), *P. macropilis* (Ali 1998). These results reported in literature show that the developmental period of predatory mites at certain temperature regimes differ if they are reared on different prey species. The developmental period of predatory mites may differ even when they feed on different biological stages of their prey. Kazak (2008) showed that the total development period of *P. persimilis* changed only when they were fed with *T. urticae* larvae or protonymphs.

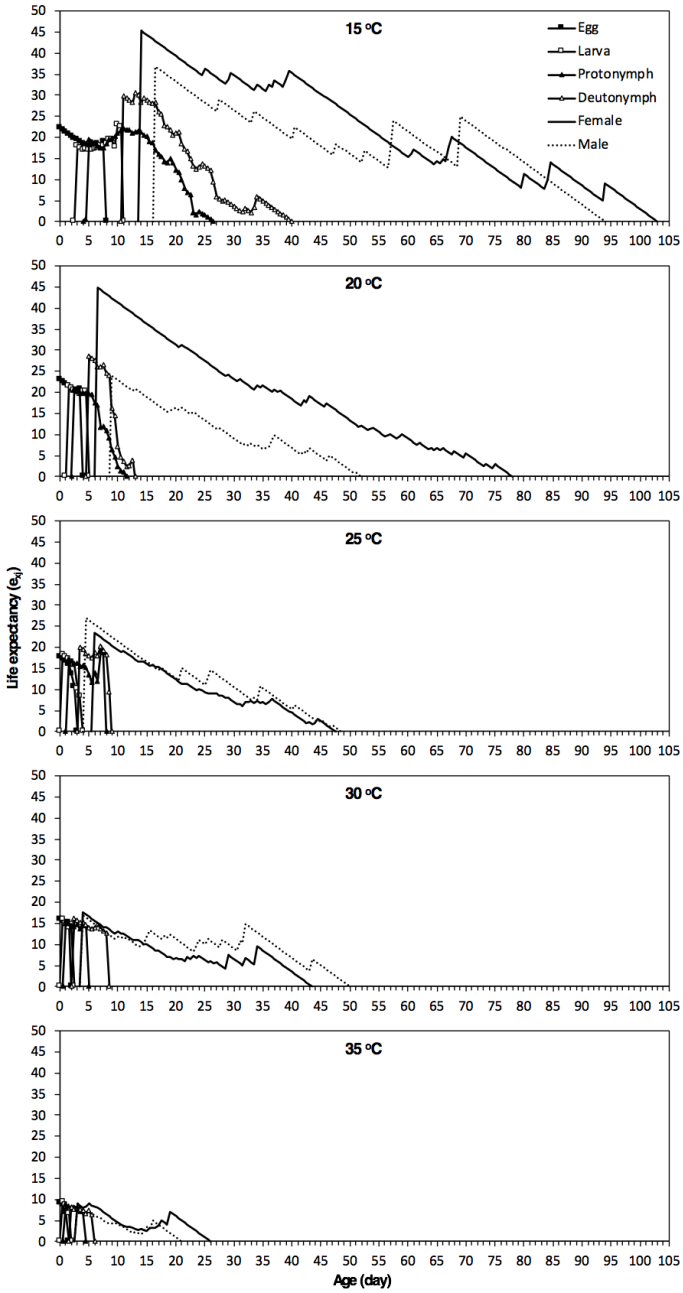

FIGURE 3. Age-stage-specific life expectancy (e_{xj}) of *Typhlodromus recki* feeding on *Tetranychus urticae* at different temperature.

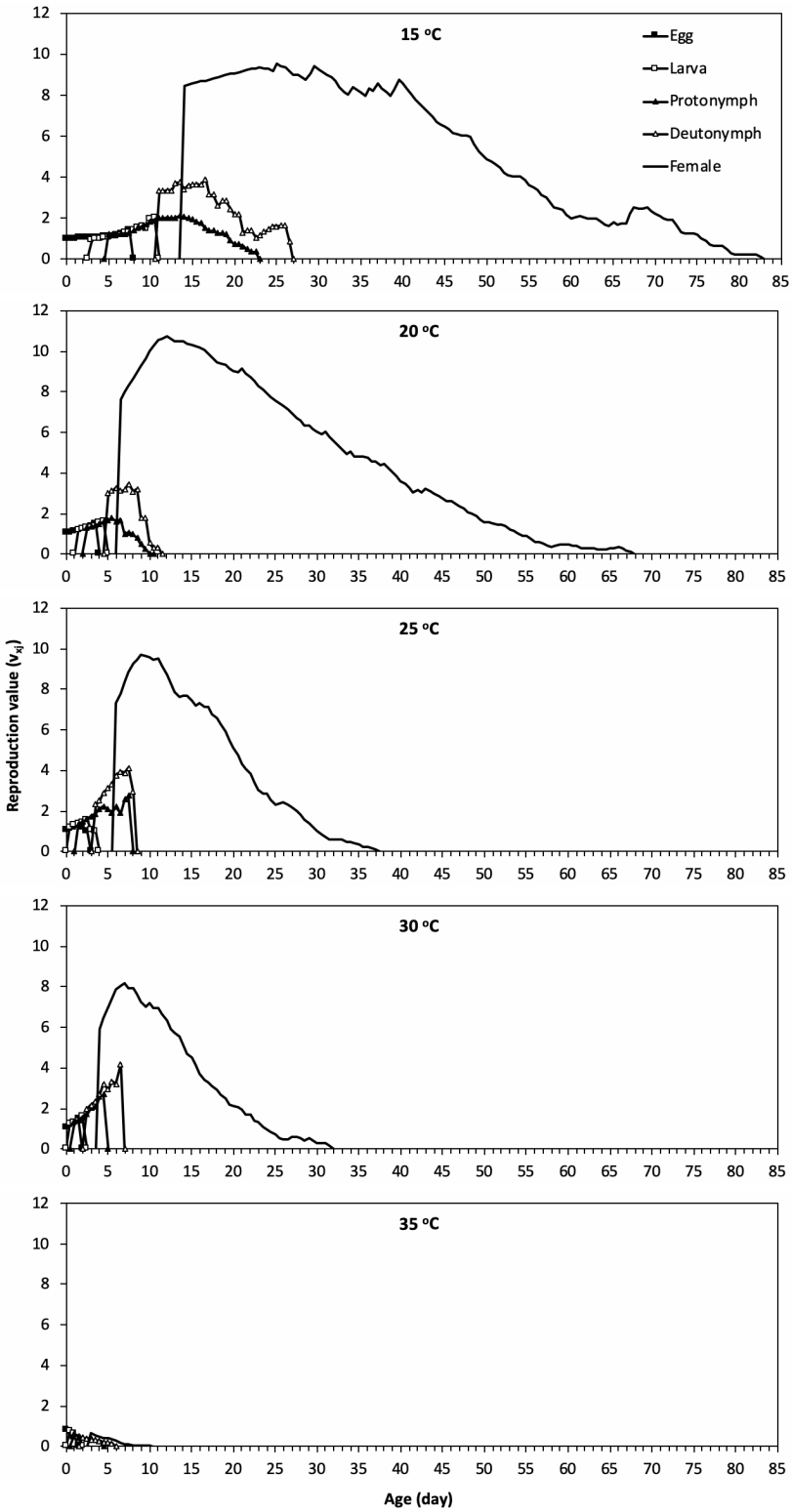

FIGURE 4. Age-stage-specific reproductive value (v_{xj}) of *Typhlodromus recki* feeding on *Tetranychus urticae* at different temperature.

Our study showed that the highest total fecundity of *T. recki* was at 20 °C (28.6 eggs) and 25 °C (23.5 eggs), but there was no significant difference between these temperatures. Total fecundity of *T. recki* increased with increasing temperature from 15 to 20 °C and then decreased from 25 to 35 °C. The total fecundity of *T. recki* at 25 °C is higher than those of *T. bagdasarjani* (21.5 eggs) (Riahi *et al.* 2016), *A. swirskii* (25.0 eggs) (Lee & Gillespie 2011), *T. pyri* (19.9 eggs) and *E. finladicus* (12.2 eggs) (Puchalska & Kozak 2015), but lower than those of *N. californicus* (54.3 eggs) (Kustutan & Cakmak 2009), *Iphiseius degenerans* (53.7 eggs) (Tsoukanas *et al.* 2006), *N. longispinosus* (47.9 eggs) (Sugawara *et al.* 2017), *A. andersoni* (45.6 eggs) (Li *et al.* 2019), *N. womersleyi* (42.1 eggs) (Sugawara *et al.* 2017), This is expected as various species of predatory mites reared at different temperatures and/or fed different prey have different total fecundity (Helle & Sabelis 1985).

The (R_0) value for *T. recki* was 8.0 offspring/individual at 25 °C. However, there was no significant difference at 20, 25 and 30 °C. The R_0 value for *T. recki* at 25 °C was considerably higher than the values obtained for *Euseius concordis* (1.7 offspring/individual), *Galendromus annectens* (7.3 offspring/individual) (Mesa *et al.* 1990), *Neoseiulus idaeus* (5.5 offspring/individual) (Collier *et al.* 2007), but lower than those for *P. persimilis* (45.6 offspring/individual) (Escudero & Ferragut 2005), *N. californicus* (42.9 offspring/individual) (Kustutan & Cakmak 2009), *N. womersleyi* (32.2 offspring/individual) (Saito & Mori 1981). The optimum (*T*) value of *T. recki* was 15.2 d at 25 °C. Similar results were obtained by de Vasconcelos *et al.* (2008) for *P. fragariae* (15.6 d). The (*r*) value of *T. recki* was positively affected as temperature increased. The *r* for *T. recki* feeding on *T. urticae* was numerically the highest at 30 °C (0.17 d^{-1}), but it was not significantly different from those obtained at 25 °C (0.14 d^{-1}). Similar *r* values were obtained for *T. bagdasarjani* (0.12 d^{-1}), *A. swirskii* (0.13 d^{-1}) and *N. cucumeris* (0.13 d^{-1}) at 25 °C (Ganjisaffar *et al.* 2011; Lee & Gillespie 2011; Al-Azzazy *et al.* 2018). The *r* values of *T. recki* in the present study are lower than those of *N. californicus* (0.33 d^{-1}), *N. womersleyi* and *N. longispinosus* (0.30 d^{-1}), *P. persimilis* (0.29 d^{-1}), *N. longispinosus* (0.18 d^{-1}) *A. andersoni* (0.16 d^{-1}) (Kustutan & Cakmak 2009; Sugawara *et al.* 2017; Moghadasi *et al.* 2016; Tung *et al.* 2017; *Li et al.* 2019), but higher than those of *T. pyri* and *E. finlandicus, E. concordis* (0.11, 0.09 and 0.03 d^{-1}) (Mesa *et al.* 1990; Puchalska & Kozak 2015). In the present study, the temperature-dependent increase in *r* was negatively affected at 35 °C (-0.36 d^{-1}). Although females survived for 26 d at 35 °C, only four females laid eggs for 1 d. Thus, 35 °C is not suitable for reproduction of *T. recki.* Similar results were obtained for *r* values for *A. swirskii* at 15°C (-0.002 d^{-1}) and *Kampimodromus aberrans* (-0.07 d^{-1}) at 33 °C (Lee & Gillespie 2011; Broufas *et al.* 2007). McMurtry & Croft (1997) reported that *r* for generalist predatory mites as *Typhlodromus* was sometimes below 0.1 but increased to 0.25 when fed on spider mites or pollen. The life history parameters, such as *Ro*, *T* and *r,* depend on many factors and are particularly influenced by the species and the different biological stages of the prey (Zhang *et al.* 2015). Low *T*, high *Ro* and *r* are very important for the success of phytoseiid predators in biological control of spider mites (Helle & Sabelis 1985).

Results of this laboratory study showed that *T. recki* feeding on *T. urticae* could complete its development and reproduce at a wide range of temperatures. The fact that this predator also feeds on pollen indicates that it is a generalist predator. McMurtry *et al.* (2013) similarly reported that *Typhylodromus* species are generalist predator and they can survive on pollen as well as on a wide range of prey species in families Acaridae, Eriophyidae, Tarsonemidae, Tetranychidae and Tenuipalpidae. The ability to develop on pollen is an advantage in the mass rearing of *T. recki* under laboratory conditions and for long persistence of the mite in the field environments when prey is scarce. However, further studies should be conducted to determine the prey range, food types and different prey species of *T. recki* as well as its functional and numerical response. In this regard, *T. recki* is considered to be one of the most promising candidates for control of *T. urticae* as well as other mite pests in IPM programs of many agricultural systems.

Acknowledgements

This study was supported by the Scientific and Technological Research Council of Turkey (TUBITAK-project number: 118O666). We are grateful to Ian T. Riley for editing the manuscript, Hsin Chi and Remzi Atlihan for analyzing of life history parameters.

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Submitted: 15 Sep. 2020; accepted by Rostislav Zemek: 3 Jan. 2021; published: 1 Feb. 2021