Persian J. Acarol., 2019, Vol. 8, No. 3, pp. 225–237.
http://dx.doi.org/10.22073/pja.v8i3.45254
Journal homepage: http://www.biotaxa.org/pja

Article

Comparative biology and growth rate of the two predatory mites, *Cydnoseius negevi* and *Neoseiulus californicus* (Acari: Phytoseiidae), reared on two pea cultivars

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ABSTRACT

Laboratory experiments were conducted to investigate the influence of two pea cultivars, regular and sweet as substrates on biological aspects and life table analysis of two phytoseiid species, *Cydnoseius negevi* (Swirski & Amitai) and *Neoseiulus californicus* (McGregor) fed on nymphs of *Tetranychus urticae* Koch under laboratory conditions of 27 ± 1 °C, 70–80 % RH and 16L:8D h photoperiod. The development was faster and reproduction of *N. californicus* was higher compared with *C. negevi*. The predatory mite *N. californicus* showed the highest fecundity when reared on sweet pea cultivar, while *C. negevi* exhibited the lowest fecundity when reared on regular pea cultivar. Rearing *C. negevi* on the two pea cultivars led to the greatest female longevity than that of *N. californicus*. Feeding capacity of females during oviposition period was the highest for *N. californicus* on sweet pea, but it was the lowest for *C. negevi* on regular pea cultivar. Life table analysis showed that the shortest mean generation time (*T*) for *N. californicus* (13.01 days) compared with *C. negevi* (14.65 days) on sweet pea cultivar. Also, the intrinsic rate of increase (r_m) of *N. californicus* was 0.29 female/female/day, but the r_m value was 0.24 female/female/day for *C. negevi* on sweet pea substrate. Therefore, it can be concluded that the two predatory mites, *C. negevi* and *N. californicus*, are efficient biological control agents against *T. urticae* on the two pea cultivars.

KEY WORDS: Development; intrinsic rate of increase; longevity; phytoseiid mites; *Tetranychus urticae*.

PAPER INFO.: Received: 25 January 2019, Accepted: 9 May 2019, Published: 15 July 2019

INTRODUCTION

Neoseiulus californicus (McGregor) and *Cydnoseius negevi* (Swirski & Amitai) play an important role in the biological control of several pests, feeding on all stages of *Tetranychus urticae* Koch, small insects, and several pollen grains (McMurtry 1977; Abou-Awad *et al*. 1989; Greco *et al*. 2005; Ragusa *et al*. 2009). *Neoseiulus californicus* is a phytoseiid mite that can decrease the population of spider mite under economic threshold in open fields and greenhouses (Schausberger and Walzer 2001; Sato *et al*. 2007; Rezaie *et al*. 2017). In addition, the predatory mite *C. negevi* is a common Middle Eastern species found in different areas of the world. This predator can successfully develop and reproduce on a wide range of preys such as tetranychid and eriophyid mites, small insects, thrips, and on different pollen grains (Abou-Awad *et al*. 1998; Momen *et al*. 2009; McMurtry *et al*. 2013; Negm *et al*. 2014; Hussein *et al*. 2016). Only a few studies have been

How to cite: Abdel-Khalek, A.A., Abou-Elella, G. & El-Saiedy, E. (2019) Comparative biology and growth rate of the two predatory mites, *Cydnoseius negevi* and *Neoseiulus californicus* (Acari: Phytoseiidae), reared on two pea cultivars. *Persian Journal of Acarology*, 8(3): 225–237.

conducted on how plant leaf textures influence the biology of the predatory mite *C. negevi* and *N. californicus*. The leaf surface of the host plant can affect the survival, reproduction and predation rate of the phytoseiid mites, by providing refuge, protecting against biotic factors, and offering pollen grains and fungal spores (Walter 1996; Norton *et al.* 2001; Roda *et al*. 2003).

It is worth noting that to lay more eggs, some phytoseiid species prefer plants with trichomes or plants with hairy leaves (Overmeer and van Zon 1984; Walter 1996). Moreover, these predators prefer leaves with pubescence and domatia to those, without domatia, perhaps because they are nutritionally important (McMurtry and Croft 1997). Moreover, the morphological characteristics of the leaf textures of the host plant influence the foraging efficiency and predation rate of predatory mites (Walter 1996). Krips *et al*. (1999) and Gnanvossou *et al*. (2005) showed that the biological aspects of phytoseiid mites were inversely related to trichomes density. Pea is an important economic vegetable crop in Egypt for both local consumption and export. In Egypt cultivations of pea are threatened by the two-spotted spider mite which causes economic damage to vegetables crops (Abdallah 2002). There is no knowledge about the suitability of different pea cultivars for rearing the two predatory mites. Therefore, we studied the influence of pea cultivars on biology and life table parameters of the predatory mites, *C. negevi* and *N. californicus*, to manage *T. urticae* population on two pea cultivars, and to reach the suitable leaf surface for rearing and mass production of these predators to be used in biological control programs.

MATERIALS AND METHODS

This study was conducted in the laboratory of Pest and Plant Protection at the National Research Centre, Egypt. All the experiments were carried out in a growth chamber at 27 ± 1 °C and 65 ± 5% R.H.

Spider mite colony

The two-spotted spider mite was collected from regular and sweet pea fields in El-Behaira governorate, Egypt. Mites were reared for three months (several generations) before beginning of the experiments in a growth chamber at 27 ± 1 °C, 65 ± 5% RH.

Leaves were collected from the two acaricides and/or insecticide-free cultivars. Leaves of each cultivar were carefully checked to remove any mite infestation, then, leaf discs (2 cm in diameter) were cut and placed on water-saturated cotton in Petri dish (6 cm diameter) with the underside facing upward. All developmental stages of *T. urticae* were maintained on the leaf discs. The spider mites reared on each cultivar were used in the experiments of the corresponding cultivar. These leaves were replaced every five days or as they became heavily damaged by the mites.

Predatory mite rearing

Neoseiulus californicus and *C. negevi* were obtained from the mass rearing unit of predatory mites of the National Research Centre, Egypt and maintained on leaves of the two pea cultivars, which were previously infested with *T. urticae*. The stock culture of the two predators were maintained in a growth chamber at the same conditions as the prey. Laboratory colonies of the predators were reared in a Petri dish (12 × 2 cm) on water-saturated cotton half-filled with water. The edges of the arenas were covered with moist cotton strand to provide moisture and prevent predators from escaping. Pea leaves infested with surpluses of *T. urticae* were added to the arena three times a week.

Experiments

Gravid females of the predatory mites were transferred from the main culture onto pea leaves (the two cultivars) and left for 24 hours to oviposit. Only one egg was kept on each leaflet and the female mite and additional eggs were removed. The leaflet of each pea culture (2 × 2 cm^2) was placed upside down on top of wet cotton in a Petri dish (3 cm diameters) containing water. The edges of the arenas were surrounded with moistened cotton strand to provide moisture and prevent a predator from escaping. Water was added daily to the tray to maintain moisture. These leaves were replaced every five days or as they became heavily damaged by the mites. Leaves of the pea cultivars were supplied by *T. urticae* nymphs which were replaced daily. After adult emergence, each female was coupled with one male. The duration of developmental stages of the predator was recorded at 12-hour intervals. The number of eggs oviposited by each female was recorded daily. The experiments were continued until the death of all individuals. For each cultivar, 40–50 individuals were tested for the two predatory mites.

Statistical analysis

Before analysis, all data were tested for normality. Differences in the duration of different life stages and fecundity of the predatory mite were analyzed using two-way ANOVA (with predator species and host plant as factor) a significant difference was observed, so we used Tukey test to evaluate statistical differences ($P < 0.05$) (SPSS Inc. 2019).

Life table

The raw data for development, survival rate, longevity and female daily fecundity of *N. californicus* and *C. negevi* were analyzed based on an age-stage, two-sex life table (Chi and Liu 1985; Chi 1988) using the computer program TWOSEX-MSChart (Chi 2015). The following parameters were calculated using methods developed by Chi and Liu (1985): intrinsic rate of natural increase (r), finite rate of increase (e^{rm}), net reproductive rate (R_0) and mean generation time (T) were calculated according to:

$$\sum_{x=0}^{\infty} e^{-r(x+1)} lxmx = 1$$

where lx = age-specific survival rate and mx = age-specific fecundity.

Doubling time (DT) is defined as the time required for the population to double and is calculated as follows: $DT = \log_e 2/r$ (Birch 1948; Andrewartha and Birch 1954; Southwood 1978). The annual rate of increase (ARI) can be calculated from the intrinsic rate of increase (r) or finite rate of increase (e^{rm}) or doubling time (DT) or the net reproductive rate (R_0) assuming that the rate of increase is constant throughout the year.

$$\text{ARI} = 365 = e^{365r} = 2^{365/DT} = R_0^{365/T}$$

The bootstrap method was used to estimate the variances and standard errors of the population parameters. The differences of the bootstrap-values between treatments were compared using the paired bootstrap test based on the confidence interval of difference (Efron and Tibshirani 1993). Means followed by a different letter are significantly different between treatments using the paired bootstrap test at the 5% significance level (Smucker *et al.* 2007). The bootstrap method is embedded in the computer program TWOSEX-MSChart.

RESULTS

Duration of developmental stages, longevity and fecundity

The predatory mites *N. californicus* and *C. negevi* successfully completed their development on regular and sweet pea cultivars. The survival rate of *N. californicus* was 81 & 86% and 89 & 90% for *C. negevi* on regular and sweet pea cultivars, respectively. Data in Table 1 shows that the duration of the preadult period (egg-adult) of *N. californicus* was shorter than *C. negevi* when reared on regular and sweet pea, but the difference was not significant (Table 1). From two-way ANOVA, there was significant interaction between the predatory species and the host plant for the oviposition periods (Table 2). The oviposition period of *N. californicus* was significantly longer ($p < 0.05$) when reared on regular pea, while for *C. negevi* it was significantly longer on sweet pea ($p < 0.05$). Pre-oviposition and post-oviposition periods of *N. californicus* were shorter than *C. negevi,* but the differences were not significant. The predatory mite, *C. negevi* lived significantly longer ($p < 0.05$) than *N. californicus*.

Data presented in Table 2 show that the total fecundity and daily egg production per females of *C. negevi* and *N. californicus* are significantly higher ($p < 0.05$) when reared on regular and sweet pea cultivars. The maximum number of eggs was 57.50 eggs for *N. californicus* on sweet pea, while the least number of eggs (36.75 eggs) was for *C. negevi* on regular pea. Offspring sex ratio of *N. californicus* and *C. negevi* was female biased sex ratio, the maximum was 83% female in *N. californicus* on sweet pea. The progeny sex ratio was not significantly different between the two predatory mites on the two host plants.

Table 1. Duration of developmental stages (Mean ± SE in days) of *Cydnoseius negevi* and *Neoseiulus californicus* fed on nymphs of *Tetranychus urticae* reared on two pea cultivars at 27 ± 1 °C.

Predator species	***C. negevi***		***N. californicus***	
Host plant	**Regular pea**	**Sweet pea**	**Regular pea**	**Sweet pea**
Egg	3.00 ± 0.21aA	2.75 ± 0.18aA	2.67 ± 0.14aA	2.50 ± 0.15aA
Larva	1.25 ± 0.13aA	1.42 ± 0.15aA	1.42 ± 0.15aA	1.17 ± 0.11aA
Protonymph	1.25 ± 0.13aA	1.33 ± 0.14aA	1.33 ± 0.14aA	1.33 ± 0.14aA
Deutonymph	1.25 ± 0.13aA	1.42 ± 0.15aA	1.25 ± 0.13aA	1.00 ± 0.00aA
Total immature	6.75 ± 0.18aA	6.92 ± 0.19bA	6.67 ± 0.26aA	6.00 ± 0.25bA
No. of replicates	35	37	37	40
% Survival (No. of survivals from egg to adult)	86	81	89	90

The different small letter between host plant and species at one way ANOVA; and the different capital letter between species and host plant at two way ANOVA ($P < 0.05$)

Table 2. Mean (± SE) longevity, reproduction and sex ratio of *Cydnoseius negevi* and *Neoseiulus californicus* fed on nymphs of *Tetranychus urticae* on two pea cultivars at 27± 1 °C.

Predator species	***C. negevi***		***N. californicus***	
Host plant	**Regular pea**	**Sweet pea**	**Regular pea**	**Sweet pea**
Pre-oviposition	2.00 ± 0.001aA	1.58 ± 0.15bA	1.42 ± 0.15Aa	1.33 ± 0.14Ba
Oviposition	26.25 ± 0.49aA	27.92 ± 0.50bB	26.25 ± 0.22aA	25.00 ± 0.39bB
Post-oviposition	3.92 ± 0.34aA	4.00 ± 0.33bA	2.58 ± 0.15aA	2.67 ± 0.14bA
Longevity	32.17 ± 0.60aA	33.50 ± 0.47bB	30.25 ± 0.37aA	29.00 ± 0.37bB
Total eggs/female	36.75 ± 0.81d	41.67 ± 0.97c	53.75 ± 0.75b	57.50 ± 0.67 a
Daily eggs/female	1.40 ± 0.03d	1.49 ± 0.02c	2.10 ± 0.02b	2.30 ± 0.02 a
Sex ratio	0.75	0.78	0.83	0.85

The different small letter between host plant and species at one way ANOVA; and the different capital letter between species and host plant at two way ANOVA ($P < 0.05$)

Life table parameters

Life table parameters are presented in Table 3. The difference between life table parameters (R_0, r_m, and *GRR*) was significant when *N. californicus* and *C. negevi* were reared on regular and sweet pea. The shortest mean generation time (*T*) was 13.01 days for *N. californicus*, while the highest was 14.65 days for *C. negevi* on sweet pea cultivars and the difference was not significant. The life table parameters (R_0, r_m, λ, and *GRR*) were the highest when *N. californicus* reared on sweet pea (46.03, 0.29, 1.34, and 56.51 respectively) while the lowest when *C. negevi* reared on regular pea. The intrinsic rate of natural increase (r_m) is an important factor for predicting the population growth potential of the predacious mites under environmental conditions, as it reflects an overall effect on duration, egg production and survival rate of females (Southwood and Handerson 2000). The highest intrinsic rate of increase of *N. californicus* was 0.27 and 0.29 female/female/day, but the lowest was 0.24 and 0.24 female/female/day for C. *negevi* on regular and sweet pea cultivars, respectively. In the present study, the (r_m) value of *N. californicus* and *C. negevi* was greater than its prey *T. urticae*. Moreover, the doubling time (*DT*) of *C. negevi* was higher (2.88 days) when reared on regular and sweet pea, while for *N. californicus* it was 2.57, and 2.35 days on regular and sweet pea, respectively. The gross reproductive rate (*GRR*) was significantly different when reared on regular and sweet pea cultivar. Also, in the present study, the cohort generation time (*Tc*) of *C. negevi* and *N. californicus* was 17.59, 18.90 and 18.56, 17.53, while annual rate of increase (ARI) was 1.11×10^{38}, 1.11×10^{38} and 6.31×10^{42}, 5.79×10^{46}, when both predatory mites were maintained on two pea cultivars, respectively. The survival curves of *C. negevi* and *N. californicus* fed on *T. urticae* nymphs and maintained on regular and sweet pea cultivars at 27 °C under laboratory conditions followed a type 1 pattern in which most eggs developed to maturity and death occurred gradually over an extended oviposition period of females (Fig 1). The age-specific fecundity (*mx*) was highest at the early age of females, then gradually decreased and reached its lowest at age 34 days for *N. californicus* reared on regular and sweet pea, and 37–38 days for *C. negevi* on regular and sweet pea, respectively. The highest mean of age-specific fecundity was for *N. californicus* on sweet pea (2.5 egg), while the lowest mean was for *C. negevi* (1.6 egg) on regular pea.

Table 3. The mean of population growth parameters of *Cydnoseius negevi* and *Neoseiulus californicus* fed on *Tetranychus urticae* nymphs on two pea cultivars at 27 ±1°C.

Parameters	*N. californicus*		*C. negevi*	
	Regular pea	Sweet pea	Regular pea	Sweet pea
T	14.10 ± 0.40 a	13.01±0.36 b	14.07±0.25 a	14.65±0.30 a
R_0	43.00 ± 5.61 a b	46.03±5.95 a	29.08±4.16 b	33.40±4.52 b
r_m	0.27 ± 0.01 a	0.29±0.02 a	0.24±0.01 b	0.24±0.01 b
e^{rm}	1.31 ± 0.02 a	1.34±0.02 a	1.27±0.02 a	1.27±0.02 a
GRR	51.43 ± 2.89 b	56.51±3.64 a	35.13±2.76 c	40.20±2.55 c
DT	2.57	2.35	2.88	2.88
ARI	6.31×10^{42}	5.79×10^{46}	1.11×10^{38}	1.11×10^{38}

Means followed by different letters in the same row are significantly different at 5% ($p < 0.05$) by using paired bootstrap test

Feeding capacity

Predation of *N. californicus* and *C. negevi* immature stages and adult females is shown in Table 4. Feeding capacity of *C. negevi* and *N. californicus* fed on *T. urticae* nymphs was highly affected by the plant texture and rearing substrates. Individuals of *N. californicus* attacked significantly more prey during immature stages than *C. negevi* on both pea cultivars ($p < 0.01$). Moreover, the feeding capacity during oviposition period was significantly high ($p < 0.01$) (349.67 and 382.83 individuals/

female) for *N. californicus*, than (286.25 and 315.83 individuals/female) for *C. negevi* on regular and sweet pea cultivars, respectively.

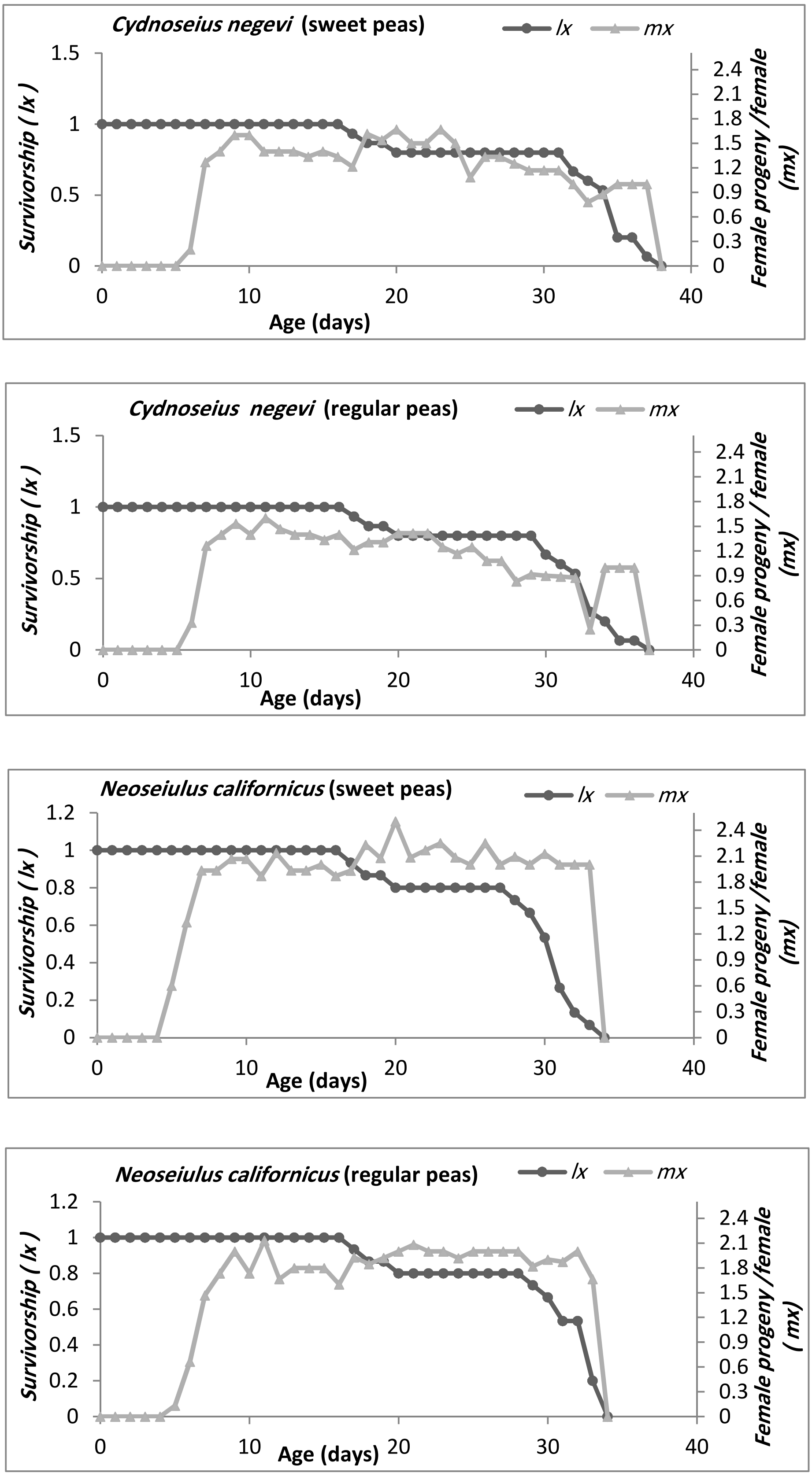

Figure 1. Age-specific fecundity (m_x) and survivorship (l_x) of *Cydnoseius negevi* and *Neoseiulus californicus* reared on two pea cultivars fed on nymphal stages of *Tetranychus urticae* at 27 ± 1°C.

Table 4. Feeding capacity (Mean ± SE) of immature stages and adult female of *Cydnoseius negevi* and *Neoseiulus californicus* fed on *Tetranychus urticae* nymphs and reared on two pea cultivars at 27 ± 1 °C.

Stages	*N. californicus*		*C. negevi*		F-TEST
	Regular pea	Sweet pea	Regular pea	Sweet pea	
Larva	3.50 ± 0.42a	4.17 ± 0.47a	0.00	0.00	49.85**
Protonymph	6.25 ± 0.71b	8.60 ± 0.89a	4.75 ± 0.52b	6.00 ± 0.65 b	5.18**
Deutonymph	11.92 ±1.30ab	14.33 ± 0.23a	7.08 ± 0.81c	10.00 ± 0.97 b	11.27**
Pre-adult	21.67 ± 1.38b	26.46 ± 0.92a	11.83 ± 0.96d	16.00 ± 0.95 c	39.14**
Pre-oviposition	17.25 ± 1.68a	20.00 ± 2.09a	15.92 ± 0.26a	19.42 ± 1.55 a	1.5^{ns}
Oviposition	349.67 ± 6.60b	382.83 ± 5.95a	286.25 ± 4.13d	315.83 ± 2.75c	67.42**
Post-oviposition	33.67 ± 2.05a	35.92 ± 1.46 a	27.17 ± 1.42b	34.58 ± 1.36 a	5.92**
Longevity	400.58 ± 5.76b	437.75 ± 5.93a	329.33 ± 4.24d	369.833 ± 3.05c	61.76**
Life span	422.25 ± 9.16b	464.21 ± 6.18a	341.17 ± 4.71d	385.83 ± 3.03 c	73.15**

Means in the same row having different letters are significantly different based on Tukey's test (P < 0.01), df = 3,44.

DISCUSSION

The host plant can affect the development and reproduction of the predatory mites. In this study, the survival rate ranged from 81–90% for the two predatory mites on sweet pea, and from 86–89% on regular pea. *Neosieulus californicus* and *C. negevi* are effective control agents of *T. urticae* on sweet and regular pea. Gotoh *et al*. (2004) showed that the survival rate of *N. californicus* reared on apple leaves and fed on different immature stages of *T. urticae* during seven days was 72%, but the survival rate of immature stages and its incubation period were 97.5 and 98.9%, respectively. This difference may be due to differences in rearing method, type of host plant, environmental conditions and kind of prey species. *Neosieulus californicus* and *C. negevi* successfully developed when reread on the two pea cultivars but the differences were not significant. Our results showed that the duration of egg incubation, larval, protonymphal and deutonymphal periods of *N. californicus* ranged from 2.5 to 2.67, 1.17 to 1.42, 1.33 and 1.00 to 1.25 days respectively. The developmental duration of *N. californicus* reared on Lima bean leaves when fed on *T. urticae* was shorter (1.5, 0.4, 0.9, 0.9 days) for the above-mentioned stages, respectively (Gotoh *et al*. 2004). The total developmental times for *N. californicus* ranged from 6.00 to 6.67 days were higher than that obtained by Toldi *et al*. (2013) who reported that the average is 5.69 days. On the contrary, data obtained by Rezaie *et al*. (2017) showed that egg incubation and developmental duration were significantly different when *N. californicus* is reared on different strawberry cultivars. Most of phytoseiid species usually lay their eggs on leaf surface substrates which can provide enough prey for egg production (Ragusa and Tsolakis 1995). In this study, the highest egg production of *N. californicus* ranged from 53.75 to 57.50 eggs/ female, but the lowest in case of *C. negevi* ranged from 36.75 to 41.67 eggs/female on regular and sweet pea cultivar, respectively. This was close to that reported by Momen (1997) who recorded that the total fecundity of *C. negevi* fed on *T.urticae* at 28 °C was 39.7 egg/female and the oviposition rate was 1.6 egg/female/day. The fecundity of *C. negevi* was 25.64 eggs/female at 27 °C when fed on *T. urticae* and the oviposition rate was 1.4 egg/female/day (Abou-Awad *et al.* 1998). *Neosieulus californicus* gave the lowest fecundity on seven strawberry cultivars, whereas the number of egg production ranged from 6.90 to 13.29 eggs/female (Rezaie *et al*. 2017). The reported daily oviposition rate of *N. californicus* fed on *P. ulmi* by Gotoh *et al*. (2006) was 3.0–3.2 eggs/female/day at 25 °C, while we found a lower number 2.10 and 2.30 eggs/female/day for *N. californicus*, where the oviposition rate for *C. negevi* was 1.40 &1.49 eggs/female/day when reared on regular and sweet pea, respectively. Also, Castagnoli *et al.* (1999) who reported that, when *N. californicus* was maintained on two strawberry cultivars and fed on *T. urticae* for two generations, the average number of eggs varied from 2.87 to 3.18 eggs/female/ day. While fecundity of *N. californicus* averaged 3.45 eggs/day when fed on *T. urticae* (Croft *et al*. 1998). Ali *et al*. (2013) found that the ovipositon rate of *N. californicus* was 1.92 eggs /female/day on Aswan watermelon cultivar at 25 °C, while the lowest was 1.40 eggs/female/day on Giza-1 cultivar at 30 °C. Nassar *et al*. (2010) found that the *P. persimilis* Athias-Henriot female preferred leaves of fig, apple, and bean to lay its eggs. In addition, the egg production was significantly decreased when this predator was reared on squash and cucumber leaves, also the lowest egg production was obtained on cotton and mango leaf surface. Pesa have smooth leaves with no hairs or trichomes or domita. The host plant affects the development and reproduction of the predatory mites. Predatory mites have different responses to leaf structure of the tested host plants. Rasmy and El-Banhawy (1974) reported that smooth glabrous orange leaf surface lead to faster development and higher egg production for *Euseius scutalis* (Athias-Henriot). Moreover, the developmental time and oviposition rate for *N. californicus* were affected by trichome density, whereas the survival rate and sex ratio of the progeny were not influenced, when reared on tomato leaves (Koller *et al*. 2007). These results agree with the finding of Fouly (1982) who found that *E. scutalis* had a faster development and laid more eggs when it fed on nymphs of *T. urticae* and maintained on ficus leaves rather than *Lantana camara* leaves. Also, Rasmy *et al*. (1990) reported that cucumber leaves were inadequate as a rearing substrate for *E. scutalis* but, it was suitable for rearing *Phytoseius finitimus* Ribbaga. On the other hand, influence of different host plant species had a significant effect on egg production and movement of *T. urticae*, but no effect on the movement of *P. persimilis* (Skirvin and William 1999).

The biotic potential (r_m) of most phytoseiid mites ranged from 0.18 to 0.334; maximal values of the predatory mite *P. persimilis* are 0.219 to 0.334 at optimal environmental conditions (Laing 1968; Popov and Kondryakov 2008). On the other hand, if the predatory mite has a population growth rate (r_m) equal or greater than its prey, it could be able to regulate or control the population of its prey (Sabelis 1992). The *rm*-value of *N. californicus* in the present study was 0.27 and 0.29 day $^{-1}$ on regular and sweet pea, respectively. The *rm*-value of *C. negevi* was 0.24 day^{-1} on regular and sweet pea, respectively. On the contrary, the highest intrinsic rate of increase was (r_m = 0.20) as well as net reproductive rate (R_0 = 6.13) when *N. californicus* was maintained on Chandler strawberry cultivar, but the lowest rate (r_m = 0.10 and R_0 = 2.18) was on Gaviota strawberry cultivar (Rezaie *et al*. 2017). Results obtained by Saber (2012) found that r_m was 0.17 and 0.23 for *N. californicus* when fed on *T. urticae* eggs and maize pollen grains, respectively. Also, the r_m value was 0.15, 0.23 and 0.18 individuals/female/day, when *N. californicus* was reared on *T. urticae* immature, almond pollen and maize pollen grains, respectively (Khanamani *et al*. 2017). In another work, the r_m value ranged from 0.16 to 0.23 for *N. californicus* when maintained on leaves of kidney bean (Canlas *et al*. 2006). Moreover, the r_m value recorded 0.27 when *N. californicus was* reared on leaves of lima bean (Gotoh *et al.* 2004). Ali *et al*. (2013) showed that the highest r_m value was 0.21 on Giza-1 watermelon at 30 °C, but the lowest r_m was 0.17 on Aswan watermelon at 25 °C when *N. californicus* was reared on the two cultivars. In addition, these results agree with Momen (1997), Abou-Elella (1998), Rasmy *et al*. (2003), Abou-Elella *et al*. (2014) and Osman *et al*. 2016). There is a large variation in the *rm*-values among predatory mite species (Gotoh *et al*. 2004). It is speculated that this is because there are interspecific differences in the population growth parameters (Gotoh *et al*. 2004). A wide difference in *rm*-values is sometimes found between populations of the same species.

The higher fecundity and R_0 value, short generation time, and moderate *rm* of the population of *N. californicus* and *C. negevi*, when reared on regular and sweet peas, indicate significant potential as an effective biological control agent. Moreover, they can be used in integrated pest management (IPM). Therefore, our data suggest that both predatory species *N. californicus* and *C. negevi* are promising biological control agents in spider mite control on pea cultivars.

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زیست‌شناسی مقایسه‌ای و میزان رشد دو کنهٔ شکارگر، *Cydnoseius negevi* و *Neoseiulus californicus* (Acari: Phytoseiidae)، پرورش داده شده روی دو رقم نخود

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چکیده

آزمایش‌هایی برای بررسی اثر دو رقم نخود، معمولی و شیرین به عنوان بسترهایی برای تجزیه و تحلیل جنبه‌های زیستی و جدول زندگی دو گونه فیتوزئید، *Cydnoseius negevi* (Swirski & Amitai) و *Neoseiulus californicus* (McGregor) با تغذیه از پوره‌های *Tetranychus urticae* Koch در شرایط آزمایشگاهی ۲۷ ± ۱ درجهٔ سلسیوس، ۷۰–۸۰ درصد رطوبت نسبی و دورهٔ نوری: تاریکی ۸:۱۶ ساعت انجام شد. گونهٔ *N. californicus* در مقایسه با *C. negevi* رشدی سریع‌تر و تولیدمثلی بیشتر داشت. کنهٔ شکارگر *N. californicus* وقتی روی رقم نخود شیرین پرورش داده شد بیشترین بارآوری را داشت در حالی‌که کنهٔ *C. negevi* کم‌ترین بارآوری را روی رقم نخود معمولی نشان داد. پرورش گونهٔ *C. negevi* روی دو رقم نخود به بیشترین طول عمر ماده‌ها نسبت به *N. californicus* منجر شد. ظرفیت تغذیه‌ای ماده‌های *N. californicus* در دورهٔ تخمگذاری روی رقم نخود شیرین بیشترین بود اما روی رقم نخود معمولی برای گونهٔ *C. negevi* کم‌ترین بود. تجزیه و تحلیل جدول زندگی نشان داد که کم‌ترین میانگین طول دورهٔ نسل (*T*) روی رقم نخود شیرین برای *N. californicus* (۱۳/۰۱ روز) در مقایسه با *C. negevi* (۱۴/۶۵ روز) اتفاق افتاد. همچنین میزان ذاتی افزایش (r_m) کنهٔ *N. californicus* روی بستر نخود شیرین ۰/۲۹ ماده/ماده/روز بود اما این میزان برای کنهٔ *C. negevi* ۰/۲۴ بود. بنابراین می‌توان نتیجه گرفت که دو کنهٔ شکارگر *C. negevi* و *N. californicus* برای *T. urticae* روی دو رقم نخود عوامل مهار زیستی مؤثری‌اند.

واژگان کلیدی: رشد؛ میزان ذاتی افزایش؛ طول عمر؛ کنه‌های فیتوزئید؛ *Tetranychus urticae*.

اطلاعات مقاله: تاریخ دریافت: ۱۳۹۷/۱۱/۵، تاریخ پذیرش: ۱۳۹۸/۲/۱۹، تاریخ چاپ: ۱۳۹۸/۴/۲۴