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# Life history traits and population parameters of the predatory mite *Euseius scutalis* (Acari: Phytoseiidae) fed on *Tetranychus turkestanii* (Acari: Tetranychidae) and pollen from three different plants

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## Original research

### ABSTRACT

Development, reproduction, and demographic parameters of the predatory mite *Euseius scutalis* (Athias-Henriot) (Acari: Phytoseiidae) were determined in the laboratory at 25±1 °C, with a 16L:8D photoperiod and 60 ±5% RH, to evaluate its response to four different diets: *Tetranychus turkestanii* Ugarov and Nikolskii (Acari: Tetranychidae), castor bean pollen, date palm pollen, and hopbush pollen. Male and female mites raised on *T. turkestanii* had a shorter mean pre-adult duration than those grown on date palm, castor, and hopbush pollen. Pre-adult mortality was found to be greater in either the larval stage or protonymphal stage than other stages. The highest and lowest pre-adult mortality rates were recorded on castor bean pollen (31.87%) and *T. turkestanii* (2.94%), respectively. The total pre-oviposition periods (TPOP) on hopbush and castor bean pollen were significantly longer than those on *T. turkestanii* and date palm pollen. The highest egg production and oviposition period were determined when *T. turkestanii* were provided as diet. Overall, the individuals lived considerably longer when provided with *T. turkestanii* and hopbush pollen than the two other diets. The gross reproductive rate (*GRR*) and net reproductive rate (*R*<sub>0</sub>) on *T. turkestanii* were greater than the values attained on other diets. The highest intrinsic (*r*) and finite rates of increase (*λ*) were found to be 0.2537 and 1.2888 on *T. turkestanii*, respectively. However, *R*<sub>0</sub>, *GRR*, *r*, and *λ* were almost similar between all pollen diets tested. In general, all diets tested in this study were adequate for development and oviposition in *E. scutalis*, but *T. turkestanii* was the most favorable diet.

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**Keywords** Acari; Phytoseiidae; pollen; *Tetranychus turkestanii*; mass rearing

## Introduction

Chemical pesticides are often used to control phytophagous mites and insects on different crops worldwide. Adverse influences on the environment and natural enemies may occur through the continued application of chemical pesticides (Sumathi *et al.* 2019). As a result, using non-chemical methods such as biological control of mite pests is essential (Sumathi *et*

*al.* 2019). Phytoseiid mites play an important role in the biological control of plant-dwelling mites, thrips, and whiteflies (McMurtry *et al.* 2013). While approximately 2800 species of this family are currently known, only a limited number have been investigated for their potential as biological control agents (McMurtry *et al.* 2013; Knapp *et al.* 2018).

Life styles or predation patterns of Phytoseiidae members have been categorized into four groups (from type I to IV) as a function of their dietary habits, biological traits, and morphological characteristics (McMurtry *et al.* 2013). *Euseius scutalis* (Athias-Henriot) (Acari: Phytoseiidae) is a pollen-feeding generalist predator from the category type IV (McMurtry & Croft 1997; McMurtry *et al.* 2013). Although the reproductive capacity of this predator is highest on pollen, it can feed on a wide variety of small insects and mites, including eriophyid mites, spider mites, eggs and immature stages of whiteflies, thrips, and scale insects (El-Badry *et al.* 1968; El-Badry & El-Banhawy 1968; Bounfour & McMurtry 1987; Nomikou *et al.* 2001; Kasap & Sekeroglu 2004; Kasap 2005). The species appears suitable for a wide range of botanical families but can be found mainly on trees and bushes (Bounfour & McMurtry 1987). A close association between this species and the flat mites, spider mites, and whiteflies has been reported (El-Badry & El-Banhawy 1968; Wysoki & Cohen 1983; Meyerdirk & Coudriet 1986). In addition, a broad range of environmental tolerances have been demonstrated by this predator, but it appears to be present mostly in hot and dry climates (Bounfour & McMurtry 1987).

Some researchers determined the efficiency of immatures of *E. scutalis* on different kinds of food (Meyerdirk & Coudriet 1986; Romeih *et al.* 2004) while very few studies have shown the performance of this predator in both immature and adult stages (Bounfour & McMurtry 1987; Momen & Abdel-Khalek 2008; Abou-Ellella *et al.* 2013; Stathakis *et al.* 2021; Shishehbor *et al.* 2022). Some researchers examined the life history of *E. scutalis* on the pollen of *Maalephora crocea* Jacq. (Bounfour & McMurtry 1987), *Phoenix dactylifera* L. (Al-Shammery 2011; Shishehbor *et al.* 2022), *Ricinus communis* L., (Momen & Abdel-Khalek 2008), *Citrus aurantium* L. (Al-Shammery 2011), and *Typha latifolia* (Shishehbor *et al.* 2022) plants.

The utilization of *E. scutalis* in biological control has been restricted due to inadequate information on its food spectrum and little knowledge of its biology, because of a low number of studies conducted on its full life table on different diets. Therefore, the findings of this study can be helpful in determining its food spectrum and its usefulness in biological control programs.

## Material and methods

### Mite culture

Phytophagous mite: *Tetranychus turkestanii* Ugarov and Nikolskii (Acari: Tetranychidae) was collected from a *Convolvulus vulgaris* weed on the campus of Shahid Chamran University of Ahvaz, Ahvaz, Iran, then transferred to the laboratory and released on the leaves of seedlings of cowpea (*Vigna unguiculata* (L.) Walp.) grown from seeds and transplanted into compost in plastic pots (20 cm diam.). Wood-frame culture cages (120×60×60 cm) surrounded by 210 µm nylon mesh were used for keeping the infested plants under conditions of 25±1°C, 60±10% RH, and 16:8 h (L: D) photoperiod.

Predatory mite: *E. scutalis* was gathered on the leaves of hollyhock (*Althea officinalis* L.) located on the campus of Shahid Chamran University of Ahvaz, Ahvaz, Iran. Each mite-rearing unit was prepared using a Petri dish (9 cm diameter × 3 cm height), a piece of sponge (5 × 5 × 2 cm), a same-size green plastic sheet, a few threads of cotton, and some strips of tissue paper. The sheets kept on the moist sponge in the Petri dish included water. The four sides of the sheet were wrapped in moist tissue papers that formed barriers preventing the mites from escaping. The unit was supplied with a small cotton thread, which made it possible to easily collect eggs laid. The adult mites were transferred and left to lay eggs on the units using a

camel-hair paintbrush. They were fed with *T. turkestanii* as the prey and kept at  $25\pm 1^\circ\text{C}$ ,  $60\pm 5\%$  RH, and 16:8 h (L: D) photoperiod.

### Pollen collection

Date palm tree pollen on mature spadices (*Phoenix dactylifera* L.) were collected from the vicinity of Ahvaz City, Khuzestan province in March. Castor bean pollen (*Ricinus communis* L.) was collected from the mature flower buds of the plants located in the vicinity of Karun River in Ahvaz City, Khuzestan province, between November and early February. The pollen of hopbush (*Dodonaea viscosa* Jacq.) was collected during the spring season from plants grown in the vicinity of Shahid Chamran University of Ahvaz, Khuzestan province, Iran. The flowers were placed on filter paper until pollen grains were released. Pollen grains were left in the laboratory for three to five days to decrease moisture content and prevent the spread of mold. Then they were poured into vials and stored in a refrigerator at  $4^\circ\text{C}$  until the experiment.

### Experiments

Before starting the experiments, the predator colony was divided into four primary groups by transferring the newly deposited eggs of *E. scutalis* from the stock culture to the rearing units. Each group was fed with one of the four following diets for one generation, *T. turkestanii* immatures, date palm pollen, castor bean pollen, and hopbush pollen. Then, 30 newly laid eggs from each group were transferred separately to the units. After egg hatching, the larvae were provided singly by each diet. The diets were immatures of *T. turkestanii*, hopbush pollen, castor bean, and date palm pollen, which were added to the unit *ad libitum*. In the natural prey treatment, a predator was supplied with 40 immatures of *T. turkestanii*. The consumed immatures were replaced daily by new ones to maintain an adequate food supply. In other treatments, a small amount of pollen was added to the units and was replaced at 48–72 h intervals. Experimental unit examination and data recording were performed twice a day to calculate developmental time duration and pre-adult mortality.

After adult emergence, each female was paired with a male from the same food group listed before. The couples were provided with sufficient amounts of the specific food until their death. Adult survival was documented daily until all individuals died. After recording the number of eggs laid, adults were discarded from the unit daily. *Euseius scutalis*, which feeds on four different diets under conditions of  $25\pm 1^\circ\text{C}$  temperature,  $60\pm 5\%$  relative humidity, and 16:8 h (L: D) photoperiod, was the subject of a life table study. Adult pre-oviposition (APOP), total pre-oviposition period (TPOP), adults' longevity, oviposition period, fecundity, and sex ratio were calculated.

### Life table construction

Data analysis was performed using the method defined by Chi (Chi 1988) and the theory named the age-stage, two-sex life table (Chi & Liu 1985). The data from four diet experiments were subjected to a user-friendly software, namely TWSEX-MSChart (Chi 2021), available at <http://140.120.197.173/Ecology/prod02.htm>. All parameters, including the age-stage-specific survival rate ( $s_{xj}$ ) (where  $x$  and  $j$  are age and stage, respectively), the age-stage specific fecundity ( $f_{xj}$ ) of adult females; the age-specific survival rate ( $l_x$ ); the age-specific fecundity ( $m_x$ ), APOP, TPOP, the net reproductive rate ( $R_0$ ), intrinsic rate of increase ( $r$ ), finite rate of increase ( $\lambda$ ), gross reproductive rate ( $GRR$ ), and mean generation time ( $T$ ) were calculated using the software. The standard error of each parameter was identified by bootstrapping with 100,000 replicates. The statistical significance of the observed differences was estimated by TWSEX-MSChart software (Chi 2021). Group differences were assessed using paired bootstrapping,  $P < 0.05$  being considered statistically significant.

Results

The results showed that the type of food had an important effect on the length of different developmental stages of *E. scutalis*. Generally, the duration of the pre-adult stages attained at each diet was substantially different for both sexes, except for the larval duration. The longest protonymphal duration of females was observed when the predator fed on hopbush pollen, and the shortest duration was recorded when it fed on *T. turkestanii*, while it was not significantly different from date palm pollen (Table 1). For males, it was the longest when *E. scutalis* fed on hopbush pollen (1.94 d), while it did not differ significantly between other diets (Table 1). The shortest deutonymphal duration was recorded when *E. scutalis* was reared on *T. turkestanii*, and it showed no significant difference from date palm pollen for both sexes. Male and female *E. scutalis* reared on *T. turkestanii* had a shorter mean pre-adult duration than those grown on date palm, castor, and hopbush pollen (Table 1).

**Table 1** Developmental time, adult longevity and total life span of females and males of *Euseius scutalis* fed on different diets.

Parameter	Hopbush pollen	Castor bean pollen	Date palm pollen	<i>T. turkestanii</i>
<b>Female</b>				
Egg (day)	2.27 ±0.05 a	2.20 ±0.06 ab	2.05 ±0.08 b	1.82 ±0.04 c
Larva (day)	1.07 ±0.08 a	1.90 ±0.06 a	1.02 ±0.07 a	1.07 ±0.04 a
Protonymph (day)	1.66 ±0.16 a	1.31 ±0.07 b	1.13 ±0.08 bc	1.07 ±0.04 c
Deutonymph (day)	1.44 ±0.10 a	1.43 ±0.08 a	1.34 ±0.08 ab	1.17 ±0.05 b
Pre-adult (day)	6.44 ±0.25 a	6.02 ±0.15 a	5.53 ±0.16 b	5.12 ±0.07 c
Adult longevity (day)	13.69 ±0.97 b	9.60 ±0.46 c	11.03 ±0.57 c	16.84 ±0.88 a
Total life span (day)	20.13 ±0.95 b	15.62 ±0.44 c	16.56 ±0.57 c	21.97 ±0.87 a
<b>Male</b>				
Egg (day)	2.12 ±0.08 a	2.33 ±0.19 a	2.15 ±0.09 a	1.75 ±0.05 b
Larva (day)	1.18 ±0.10 a	0.97 ±0.09 a	1.02 ±0.07 a	1.14 ±0.06 a
Protonymph (day)	1.94 ±0.25 a	1.30 ±0.08 b	1.09 ±0.09 b	1.20 ±0.05 b
Deutonymph (day)	1.62 ±0.19 a	1.33 ±0.13 a	1.26 ±0.13 ab	1.00 ±0.06 b
Pre-adult (day)	6.85 ±0.39 a	5.93 ±0.15 b	5.52 ±0.18 b	5.09 ±0.09 c
Adult longevity (day)	9.71 ±0.90 b	8.70 ±0.61 b	7.02 ±0.51 c	12.70 ±0.95 a
Total life span (day)	16.56 ±0.85 a	14.63 ±0.66 b	12.54 ±0.54 c	17.80 ±0.98 a

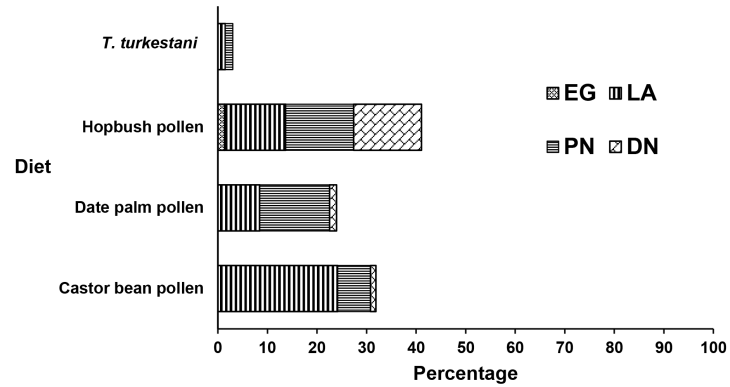
Means (± SE) within rows followed by different letters are significantly different (P < 0.05). Differences between parameters were examined using paired bootstrap test.

A significant difference was found between pre-adult mortality rates of different stages of *E. scutalis* on different diets (Figure 1). Mortality was greatest in either the larval stage (in the populations fed on date palm and hopbush pollen) or protonymphal stage. The highest mortality rates were recorded when castor bean pollen (31.87%) was the diet followed by hopbush pollen (28.77%), whereas it was lowest on *T. turkestanii* (2.94%) (Figure 1).

Values of the age-stage survival rate ( $s_{xy}$ ) presented in Figure 2 varied with developmental stages, due to different growth rates in individuals. The results reflected that it was not significantly delayed for the development of female and male *E. scutalis* on date palm pollen, *T. turkestanii*, and castor bean pollen. However, the males fed hopbush pollen completed their immature development one day later than females (Figure 2).

The longest adult pre-oviposition period (APOP) was detected on hopbush pollen (2.25 d) which was not significantly different from that obtained on castor bean pollen (1.85 d) (Table 2). Similarly, the total pre-oviposition periods (TPOP) on hopbush and castor bean pollen were significantly longer than those on *T. turkestanii* and date palm pollen (Table 2). Females laid 31.14, 17.39, 12.64, and 17.20 eggs in the duration of 11.62, 5.98, 4.79, and 7.38 days on *T. turkestanii*, date palm, castor bean, and hopbush pollen, respectively. The highest fecundity and oviposition period were determined when *T. turkestanii* were provided as diet (Table 2). Male *E. scutalis* lived for 12.70, 7.02, 8.75, and 9.70 days while females survived for 16.84, 11.03, 9.60, and 13.69 days after rearing on *T. turkestanii*, date palm, castor bean, and hopbush pollen,

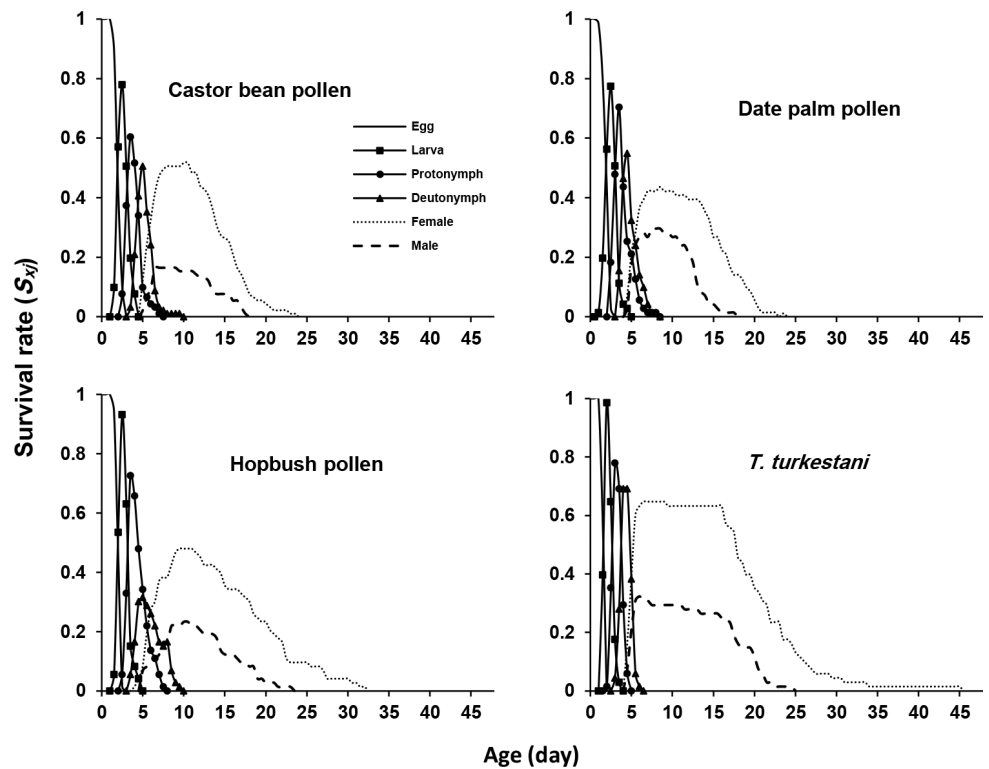




**Figure 1** Total pre-adult mortality and the contribution of each stage to total mortality of *Euseius scutalis* reared on different diets. EG: egg, LV: larva, PN: protonymph, and DN: deutonymph.

respectively (Table 2). The total life span of both males and females was significantly different between treatments (Table 2). Overall, the individuals lived considerably longer when feeding the spider mites and hopbush pollen than the two other diets (Table 3).

On date palm pollen, most of the daily egg laying occurred between the 7th to 12th day, and the highest daily fecundity was 1.57 eggs per female on the 9th day (Figure 3). The individuals reared on *T. turkestanii* showed a fertile age-range between the 7th and 16th day, with the highest daily egg production being 1.49 eggs per female per day (on the 10th day).  $F_x$  and  $m_x$  reached maximum values (1 egg) at 19 days, on castor bean pollen (Figure 3). The highest value of  $f_x$



**Figure 2** Age-stage survival rate ( $s_{xj}$ ) of *Euseius scutalis* reared with different diets.

**Table 2** Reproductive parameters of *Euseius scutalis* fed on different diets.

Parameter	Hopbush pollen	Castor bean pollen	Date palm pollen	<i>T. turkestani</i>
APOP (day)	2.52 ± 0.35 a	1.85 ± 0.14 ab	1.47 ± 0.12 c	1.72 ± 0.11 bc
TPOP (day)	8.83 ± 0.45 a	7.87 ± 2.00 a	6.98 ± 0.21 b	6.84 ± 0.13 b
Oviposition days (day)	7.38 ± 0.93 b	4.79 ± 0.37 c	5.98 ± 0.48 b	11.62 ± 0.64 a
Fecundity (eggs/fem)	17.20 ± 2.63 bc	12.64 ± 1.08 c	17.39 ± 1.85 b	31.14 ± 1.92 a
Sex ratio (Nf/N)	0.48 ± 0.06 b	0.52 ± 0.05 ab	0.44 ± 0.07 b	0.65 ± 0.06 a

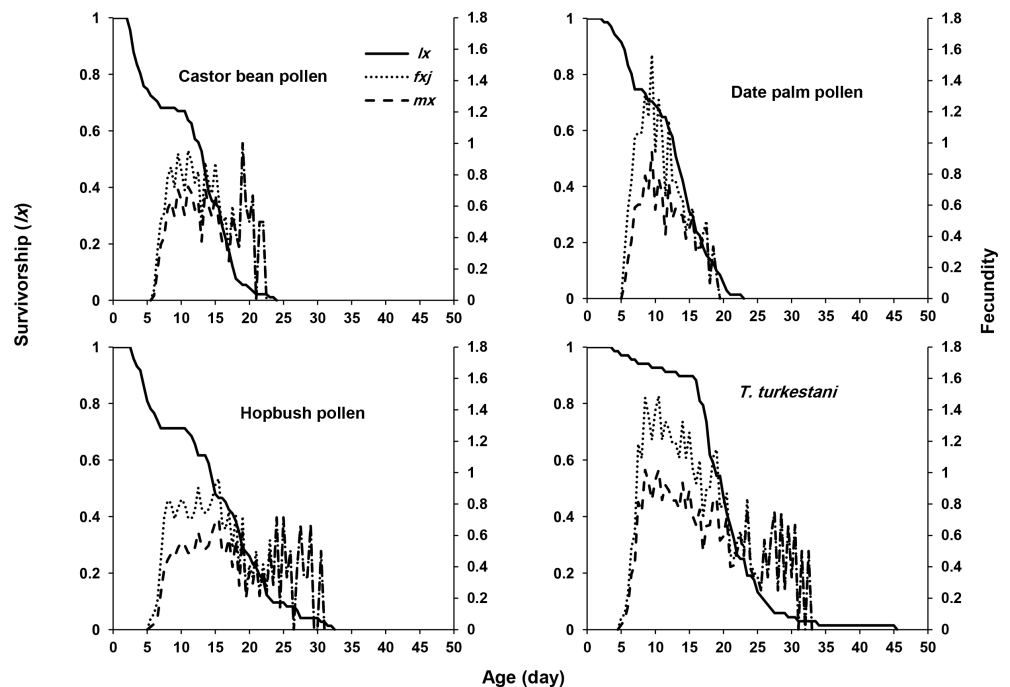
Means (± SE) within rows followed by different letters are significantly different ( $P < 0.05$ ). Differences between parameters were examined using paired bootstrap test.

APOP: Adult pre-oviposition period, TPOP: Total pre-oviposition period

and  $m_x$  were 0.96 and 0.71 eggs, respectively on hopbush pollen which happened on the 15th and 24th day, respectively (Figure 3).

Life-table parameters of *E. scutalis* on different diets are presented in Table 3. The obtained gross ( $GRR$ ) and net ( $R_0$ ) reproductive rates of *E. scutalis* on *T. turkestani* were greater than the values attained from other diets (Table 3). The intrinsic rate of increase ( $r$ ) changed from 0.1675 (on hopbush pollen) to 0.2537  $d^{-1}$  (on spider mites), while the finite rate of increase ( $\lambda$ ) varied from 1.1824 to 1.2888  $d^{-1}$  on the above-mentioned diets (Table 3). As it is apparent,  $R_0$ ,  $GRR$ ,  $r$ , and  $\lambda$  were almost the same with all pollen diets tested. The mean generation time ( $T$ ) was 12.59 and 11.84 days on hopbush and *T. turkestani*, and declined to 11.09 days on castor bean pollen, and finally decreased to 10.15 days on date palm pollen (Table 3).

While the reproduction value ( $v_{xj}$ ) considers the entire population (except adult males), higher values are usually associated with females (Figure 4). The reproductive values of *E. scutalis* at age zero ( $v_{0,1}$ ) was 1.135, 1.105, 1.088, and 1.087 after feeding on *T. turkestani*, date palm, castor bean, and hopbush pollen, respectively. The maximum value of this curve displayed an increasing trend as a function of age and stage of development. The highest peaks



**Figure 3** The age-specific survivorship ( $l_x$ ), age-stage specific fecundity of female ( $f_{xj}$ ) (eggs) and age-specific fecundity ( $m_x$ ) of *Euseius scutalis* reared with different diets.



**Table 3** Population parameters of *Euseius scutalis* fed on different diets.

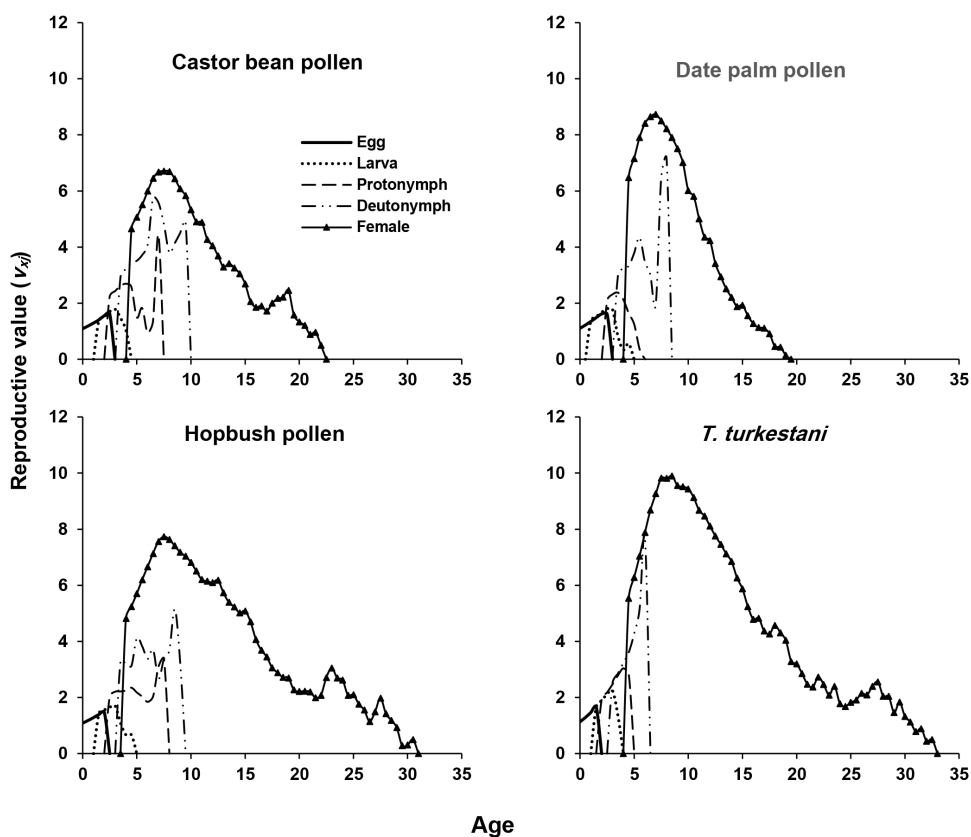
Parameter	Hopbush pollen	Castor bean pollen	Date palm pollen	<i>T. turkestani</i>
<i>GRR</i> (offspring)	21.09 ±3.29 b	16.71 ±1.94 b	13.67 ±1.88 b	33.09 ±3.53 a
<i>R</i> <sub>0</sub> (offspring)	8.25 ±1.60 b	6.53 ±0.86 b	7.59 ±1.29 b	20.15 ±2.19 a
<i>r</i> (day <sup>-1</sup> )	0.1675 ±0.0175 b	0.1692 ±0.0125 b	0.1996±0.0184 b	0.2537 ±0.0101 a
$\lambda$ (day <sup>-1</sup> )	1.1824 ±0.0205 b	1.1843 ±0.0148 b	1.2209 ±0.0224 b	1.2888 ±0.0130 a
<i>T</i> (day)	12.59 ±0.38 a	11.09 ±0.24 b	10.15 ±0.21 c	11.84 ±0.19 a

Means (± SE) within rows followed by different letters are significantly different ( $P < 0.05$ ). Differences between parameters were examined using paired bootstrap test.

were recorded at 8 (9.90 d<sup>-1</sup>), 7 (8.73 d<sup>-1</sup>), 7 (6.71 d<sup>-1</sup>), and 7 (7.73 d<sup>-1</sup>) days on the mentioned diets, respectively (Figure 4). The highest  $v_{xy}$  was seen in the females reared with *T. turkestani* (Figure 4).

### Discussion

The data demonstrated that both natural prey, *T. turkestani*, and pollen grains provide sufficient food for the development, longevity, and reproduction of *E. scutalis*. The successful development and reproduction of this predator has been demonstrated by previous studies when fed on different plants pollen including date palm, maize, castor bean, broad bean, cattail, *Chloris gayana* Kunth, alfalfa *Medicago sativa* L., and sour orange *Citrus aurantium* L. (Nomikou et



**Figure 4** Age-stage reproductive value ( $v_{xy}$ ) of *Euseius scutalis* reared with different diets.

*al.* 2001, 2003; Al-Shammery 2011; Maoz *et al.* 2011; Abou-Ellella *et al.* 2013; Shishehbor *et al.* 2022), along with mites and insects (Abou-Ellella *et al.* 2013; Nawar 2017; Shishehbor *et al.* 2022). In contrast, it has been reported that *E. scutalis* could not survive and develop to the adult stage on all life stages of the citrus flat mite, *Breuiipalpus lewisi* McGregor (Bounfour & McMurtry 1987) and the eggs of *Eutetranychus orientalis* (Klein) (Momen & Abdel-Khalek 2008).

Based on the present results, the chosen diets had a direct influence on the duration of the different stages and therefore on the total pre-adult duration. In general, predators fed with *T. turkestanii* developed more rapidly allowing *E. scutalis* to mature one day earlier than other diets (Table 1). The *E. scutalis* reared on *Bemisia tabaci* (Genn.) and *Insulaspis pallidula* (Green) showed a longer pre-adult duration (6.5 and 6.75 d, respectively) under the same experimental conditions than what we obtained on *T. turkestanii* (Abou-Ellella *et al.* 2013; Nawar 2017). In addition, those fed with *Tetranychus urticae* Koch (4.2 d), *E. orientalis* (4.7 d), and *Phoenicococcus marlatti* Cockerell (5.25 d) showed a developmental time similar to our data on *T. turkestanii* (Abou-Ellella *et al.* 2013; Nawar 2017). *Euseius scutalis* had a much longer immature development when fed on eggs of *E. orientalis* (8.13 d) and some artificial diets (13.9 d) (Abou-Awad *et al.* 1992; Momen & Abdel-Khalek 2008). This difference could be explained by the fact that the nutrient content varies between the diets, especially protein.

The findings of the present study showed that a total average number of 31.14 eggs per female and a daily rate of 2.77 eggs per female per day were laid by females *E. scutalis* provided with *T. turkestanii*. However, our results on *T. turkestanii* were similar to the values obtained on this prey (23.61 eggs per female) (Shishehbor *et al.* 2022), *T. urticae* (28.63 and 29.68 eggs per female) (Osman *et al.* 2013), and *B. tabaci* (24.30 eggs per female) (Fouly *et al.* 2013) on one hand; but higher than the results of El-Laithy and Fouly (1992) (on *T. urticae*, 13.5 eggs per female), and Momen and Abdel-Khalek (2008) (on *E. orientalis* nymphs and *Icerya aegyptiacina* (Douglas), 21.81 and 20.50 eggs, respectively) on the other hand. A higher total egg production of this predator was recorded by Kasap (2004) when offered *Panonychus citri* (McGregor). Furthermore, in our study, where pollen grains were offered as food, the total fecundity ranged from 12.64 (on castor bean) to 17.39 eggs per female (on date palm pollen). It was considerably lower than other studies investigating the effects of castor bean, corn, date, cattail, alfalfa, and bee pollen on *E. scutalis* efficacy (Allawi 1991; Al-Shammery 2011; Abou-Ellella *et al.* 2013; Shishehbor *et al.* 2022). Differences in prey and pollen quality, experimental temperature levels, data analysis, and local populations are the main factors explaining the difference between the results of different studies. As Reuveny *et al.* (1996) showed, there can be variations in the life history parameters of a species collected from different geographic regions.

We found that *E. scutalis* developed faster, lived longer, and reproduced higher on *T. turkestanii* than on pollen grains. Similarly, this predator showed a preference for tetranychid mites over the pollen (Abd-Elgayed & El-Khouly 2019; Shishehbor *et al.* 2022). By contrast to our results, better reproduction on pollen than on arthropods was documented by some authors for different *Euseius* species. Better demographic parameters of *E. scutalis* were observed on pollen than on arthropod prey, *Aceria ficus* (Cotte), *Rhyncaphytoptus ficifoliae* Keifer, *E. orientalis*, and *I. aegyptica* (Momen & Abdel-Khalek 2008). Pollen grains increased the reproductive value and population growth rate and decreased the mean generation time of *E. scutalis* compared to *T. urticae* (Fouly *et al.* 2013). Other species such as *Euseius finlandicus* (Oudemans) (Abdallah *et al.* 2001), *Euseius tularensis* (Congdon), *E. hibisci* (Chant), and *E. stipulatus* (Athias-Henriot) (Zhimo & McMurtry 1990), along with *Euseius yousefi* Zaher and El-Borolossy (Momen 2004) showed the same preference.

Among three pollen grains tested in this study, it was clarified that date palm pollen improved survival, accelerated development, and caused oviposition to start earlier. In addition, adult longevity and mean generation time were shorter, the oviposition period was longer, and fecundity was higher than on other pollen grains. Therefore, date palm pollen was more favorable for *E. scutalis* than the two other pollen grains. It was also introduced as the most

suitable pollen for this predatory mite previously (Allawi 1991; Nomikou *et al.* 2001, 2003; Maoz *et al.* 2011). Furthermore, more superior life table parameters of *E. scutalis* were indicated when fed on date palm pollen than castor bean pollen (Momen & Abdel-Khalek 2008; Al-Shammery 2011). In another study, cattail and date palm pollen were introduced as the most appropriate alternative diet origins for straightforward and cost-effective rearing of *E. scutalis* (Shishehbor *et al.* 2022). This pollen has also been recommended as the best food source for other phytoseiid species, *Typhlodromips swirskii* (Athias-Henriot) (Ali & Zaher 2007; Abou-Elella *et al.* 2013), and *Amblyseius swirskii* Athias-Henriot (Rahmani Piyani *et al.* 2021).

In general, all diets tested in this study were adequate for development to maturity and oviposition in *E. scutalis*, but *T. turkestanii* was the most favorable diet; it shortened the developmental and pre-oviposition periods, increased the growth rate and egg production, and extended adult longevity. Consequently, the role of this predator in the biocontrol of this pest is of most importance. In addition, date palm pollen was an ample useful alternative food source that accelerated the survival and reproduction of *E. scutalis* and it can be used for easy rearing of this predator in the laboratory as well as conservation of predator population during prey scarcity or absence. Further research is required to better understand the effectiveness of this predator on other pollen grains (from different plant species) and against various insects and mites. In addition, since pollen's nutritional composition varies from one plant species to another, more work analyzing the pollen composition is recommended.

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