

Development, survival, and reproduction of *Amblyseius swirskii* (Athias- Henriot) (Acari: Phytoseiidae) feeding on different pollen grains

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Original research

ABSTRACT

In the present study, the development, reproduction, survival, and population growth rate of the predatory mite *Amblyseius swirskii* Athias- Henriot (Acari: Phytoseiidae) were evaluated when fed on pollen of eight different plant species; lebbeck [*Albizia lebbeck* (L.) Benth.], date palm (*Phoenix dactylifera* L.), Khejri [*Prosopis cineraria* (L.) Druce], castor bean (*Ricinus communis* L.), maize (*Zea mays* L.), sunflower (*Helianthus annuus* L.), cogongrass [*Imperata cylindrical* (L.) P. Beauv.], and cattail (*Typha* sp.), at 25 ± 1 °C, $65 \pm 5\%$ relative humidity and a photoperiod of 16:8 h (L: D). Pollen of maize and date palm did not exert any mortality during pre-imaginal development, while the highest immature mortality was observed on cogongrass pollen. The longest immature development of both sexes was obtained when sunflower pollen was the food source, whereas it was shortest on castor bean pollen followed by date palm pollen. Females fed on maize pollen laid the highest number of eggs, while the females on cogongrass laid the lowest number. The intrinsic rate of increase (r) and the finite rate of increase (λ) were highest on date palm pollen and the lowest on cogongrass. Overall, we found that date palm and maize pollen are the most promising alternative food sources of the species tested for *A. swirskii* because populations reared on date palm and maize pollen showed no pre-adult mortality and had the longest oviposition period, and the highest fecundity and population growth rates.

Keywords alternative diet; life table; mass rearing; pollen; population growth rate

Introduction

Predatory mites, especially the members of the family Phytoseiidae, play a significant role in the control of phytophagous mites and small insect pests such as thrips and whiteflies (McMurtry *et al.* 2013; Carrillo *et al.* 2015). Their ability to feed on various kinds of diets, short life cycles, acceptance of alternative foods, as well as, high survival, and simple reproduction make them outstanding candidates for biological control schemes (Carrillo *et al.* 2015).

The predatory mite *Amblyseius swirskii* Athias-Henriot (Acari: Phytoseiidae) originated from the Mediterranean region and can be found in different areas of the world, such as Egypt, Italy, and Turkey (Athias-Henriot 1962). It is classified as a type III generalist mite which can feed on various food types, from small arthropods to plant exudate and pollen (McMurtry and Croft 1997; McMurtry *et al.* 2013). This species has been successfully used as a biological control agent against whiteflies and thrips (Buitenhuis *et al.* 2015; Calvo *et al.*

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2015); whereas its influence on spider mites is still unclear (Messelink *et al.* 2010). Despite the broad prey range of *A. swirskii*, pollen grains exploitation helps the mites remain in the crops and surrounding plants even when there is no prey; or their density is low (Goleva and Zebitz 2013).

Pollen of plant species can provide important nutritional elements such as proteins, amino acids, lipids, carbohydrates, as well as vitamins and improve phytoseiid mite survival, development, and reproduction (Goleva and Zebitz 2013). However, the nutritional value of pollen as a food source varies according to plant species (Goleva and Zebitz 2013). Where there is little or no natural prey, pollen as an alternative diet may help the predator survive in the field and greenhouse. It can also be used as a food supplement to improve the predator's diet. In addition, pollen provision can be helpful for the early establishment of the predatory mite before prey emergence (van Rijn and Tanigoshi 1999; Broufas and Koveos 2000; van Rijn *et al.* 2002; Nomikou *et al.* 2003; Hoy 2011). Furthermore, mass rearing of predators in the laboratory can be done using pollen alone or in combination with natural prey, depending on the predator species and plant pollen species (Denno and Fagan 2003; Gerson *et al.* 2003; Hoy 2011). Depending on the natural feeding patterns of predatory mites, alternative or supplemental food in greenhouses should be consistent with the feeding spectrum of the respective predatory mite species (Goleva and Zebitz 2013). Although the demand for alternative foods of phytoseiids has been extensively known, it needs to be screened to find the best ones.

The suitability of various pollen grains from different plants and trees such as pear, apricot, opium poppy, narcissus, scots pine, hollyhock, *Typha latifolia*, date palm, almond, and maize has been tested and compared for *A. swirskii* previously (Park *et al.* 2011; Goleva and Zebitz 2013; Kumar *et al.* 2014; Riahi *et al.* 2017a; Nemati *et al.* 2019; Ansari-Shiri *et al.* 2022). Different nutritional value of various plant pollen grains illustrates the necessity to know which pollen has desirable and positive influences on the development and reproduction of *A. swirskii*, especially those producing numerous grains. Therefore, we studied the effects of feeding on pollen grains of different plants, which are frequently found in Iran (Khuzestan province, southwestern Iran) and have abundant pollen resources as an alternative food source for *A. swirskii* in the current study.

Material and methods

Mite culture

The predatory mite *A. swirskii* was obtained from a previously-established colony in Shahid Chamran University, Ahvaz, Iran. One laboratory colony was established by rearing them on strawberry spider mite, *Tetranychus turkestanii* Ugarov and Nikolski for multiple generations at 25 ± 1 °C, $65 \pm 5\%$ RH, and a 16 L: 8 D h photoperiod. The predatory mites were kept on a piece of green plastic sheet (9 × 7 cm) placed on a same-sized sponge in a water-containing circle petri dish (14 cm diameter). Wet tissue paper immersed in the water in the petri dish was used to cover all edges of the sheets to prevent the predatory mites from escaping. Bean leaves infested with *T. turkestanii* were added to the sheets every 2 days as a food source.

Pollen source

Pollen of eight plants, including lebbeck [*Albizia lebbeck* (L.) Benth.], date palm (*Phoenix dactylifera* L.), khejri [*Prosopis cineraria* (L.) Druce], castor bean (*Ricinus communis* L.), maize (*Zea mays* L.), sunflower (*Helianthus annuus* L.), cogongrass [*Imperata cylindrical* (L.) P. Beauv.], and cattail (*Typha* sp.), was selected for experiments. Date palm pollen was obtained from southwestern Iran Abadan city, Khuzestan province. The pollen of cattail was collected from Hamidabad Thicket, Dezful city, Khuzestan province, Iran. The pollen of other plants was collected on the campus of the Agricultural Research Center of Safi Abad, Dezful, Iran. The pollen collection was done in sunny, dry weather, from pesticide-free plants, using a

brush or flower shaking. After collection, the pollen was maintained at room temperature for two days for drying, and then they were sieved and shaken to obtain pure pollen. All pollen grains were stored at -20 °C in a freezer.

Experimental units and protocols

The experimental units were prepared according to the rearing units used for the mite culturing, but a smaller plastic sheet (3 × 3 cm), sponge (3 × 3 cm), and petri dish (9 cm in diameter) were used for rearing predators separately. Wet sheets of tissue paper were used to cover all edges of the plastic sheet as a barrier to prevent mites from escaping. In addition, a few cotton threads were added to the center of the units as a place for shelter and oviposition sites.

For starting the experiments, a few cotton threads were placed in the rearing units for less than 24 h. Then, the predatory mite eggs were separated from the threads using a fine brush under a stereo microscope and transferred individually to the experimental units, one egg per unit. The units were randomly assigned to eight groups. Each group was fed on one of the eight pollen, including lebbeck, date palm, Khejri, castor bean, maize, sunflower, cogongrass, and cattail, immediately after egg hatching. Forty-five replicates were prepared for each group, except for maize (42 replicates). A daily check was performed to record the immature development of the predatory mite in each unit until adulthood. The duration of development of egg, larva, protonymph, and deutonymph stages were recorded individually on each diet at 25 °C, 65 ± 5% RH, and a 16L:8D h photoperiod. After adult emergence, each female was paired with a newly-appeared male fed on the same diet at the above-mentioned conditions. The units were monitored daily to determine the pre-oviposition and oviposition periods, as well as the number of eggs laid. Data recording was continued until the death of all individuals.

Data analysis

Two sex life tables were constructed for each treatment using the computer program TWOSEX_MS Chart (Chi 2022). All biological parameters, including the age-stage-specific survival rate (s_{xj}), the age-stage specific fecundity (f_{xj}) of adult females; the age-specific survival rate (l_x); the age-specific fecundity (m_x), the duration of different stages, adult pre-oviposition period (APOP), total pre-oviposition period (TPOP), adult longevity, and fecundity, along with life table parameters such the gross reproductive rate (GRR), net reproductive rate (R_0), intrinsic rate of increase (r), finite rate of increase (λ), and mean generation time (T), were calculated according to Chi and Liu (1985) and Chi (1988). The bootstrap method in the TWOSEX_MS Chart software was used to estimate the standard errors of various parameters (Efron and Tibshirani 1993; Akca *et al.* 2015; Chi 2022). The difference among treatments was explored using paired bootstrap tests with 100,000 samplings (Akca *et al.* 2015).

Results

The duration of different stages of *A. swirskii* was significantly affected by the diets (Table 1). The total developmental time of individuals was significantly shorter on date palm, castor bean, and lebbeck pollen than on other pollen. The longest total duration of the immature stage (total population) was obtained on sunflower, followed by Khejri pollen. Diet had a significant influence on the developmental time of each sex (Table 1). Immature development of males and females was the longest when sunflower pollen was the food source. However, it was shortest on castor bean pollen, followed by date palm pollen. Adult longevity of females was shortest on cogongrass pollen, taking only 11.07 days, and longest on the date palm and maize pollen grains, lasting 41.00 and 36.44 days, respectively. The greatest male longevity was 34.53 days on sunflower pollen and the shortest was 10.40 days on castor bean pollen (Table 1).

A summary of the mortality per stage recorded for *A. swirskii* fed with the different diets verifies that pollen grains influenced this parameter (Figure 1). The pollen of maize and date

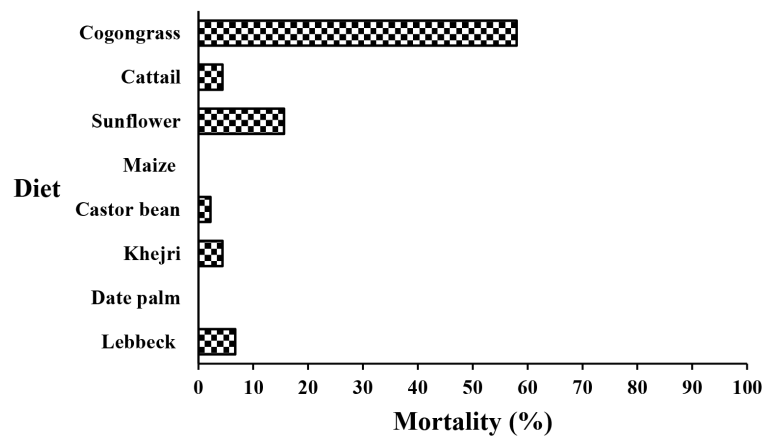


Figure 1 Total immature mortality of *Amblyseius swirskii* fed on eight different pollen grains.

palm did not exert any mortality during pre-imaginal development. When fed with pollen of lebbeck, cattail, castor bean, and khejri, negligible pre-imaginal mortality ranging from 2.2 to 6.7% was detected (Figure 1). Sunflower pollen exerted only low mortality (15.6%), while considerably higher mortality was represented by cogongrass pollen (58.0%) (Figure 1).

Feeding on sunflower pollen resulted in significantly longest pre-oviposition durations (APOP and TPOP) (Table 2). *Amblyseius swirskii* fed on khejri pollen had the shortest adult pre-oviposition time. However, there was no significant difference of this parameter with the mites reared on lebbeck, date palm, cattail, and cogongrass (Table 2). Fecundity on cogongrass and sunflower pollen was extremely low (lower than ten eggs). Females fed on maize pollen laid the highest number of eggs, while the females on cogongrass laid the lowest number. The oviposition period was the longest and shortest when the mites were provided with pollen of maize and cogongrass, respectively (Table 2).

The highest mean fecundity per day was seen on maize and the lowest was found on cogongrass (Figure 2). Fecundity curves in maize and date palm had higher peaks than others. The age-stage specific fecundity (f_{xj}) was highest at the age of 15 (1.96 eggs/ female/day), 9 (1.69 eggs/female/day), 12 (0.64 eggs/female/day), 10 (1.62 eggs/female/day), 14 (0.67

Table 1 Comparison of different stage durations, and developmental time, as well as adult longevity (mean ± SE) of females and males of *Amblyseius swirskii* fed on eight pollen grains.

Parameter	Lebbeck (days±S.E.)	Date palm (days±S.E.)	Khejri (days±S.E.)	Castor bean (days±S.E.)	Maize (days±S.E.)	Sunflower (days±S.E.)	Cogongrass (days±S.E.)	Cattail (days±S.E.)
Egg	1.96 ±0.03 a	1.87±0.05 b	2.00±0.0 a	2.00 ±0.00 a	2.00 ±0.00 a	2.00 ±0.00 a	2.00 ±0.00 a	2.00±0.0 a
Larva	1.02±0.02 de	1.02±0.02 de	1.07 ±0.04 d	1.11 ±0.05 c	1.00 ±0.00 e	1.96 ±0.03 a	1.55 ±0.08 ab	1.24 ±0.06 c
Protonymph	1.27 ±0.07 d	1.42±0.07 cd	1.82 ±0.06 b	1.09 ±0.04 e	1.62 ±0.08 c	1.98 ±0.02 a	1.56 ±0.08 c	1.44 ±0.07 cd
Deutonymph	1.98 ±0.02 ab	1.64 ±0.07 d	2.00 ±0.00 a	1.82 ±0.06 cd	1.88 ±0.05 bc	2.00 ±0.00 a	1.63 ±0.11 d	1.81 ±0.06 cd
Pre-adult	6.21 ±0.09 e	5.96 ±0.13 e	6.88 ±0.07 b	5.98±0.08 e	6.50±0.09 cd	8.00±0.00 a	6.32±0.19 de	6.51 ±0.12 cd
Female pre-adult	6.21 ±0.11 c	5.79 ±0.17 d	6.97 ±0.08 b	5.96 ±0.07 d	6.48 ±0.12 c	8.00 ±0.00 a	6.29 ±0.24 c	6.35 ±0.14 c
Male pre-adult	6.21 ±0.15 c	6.24 ±0.20 c	6.71 ±0.13 c	6.00 ±0.16 d	6.53 ±0.12 c	8.00 ±0.00 a	6.40 ±0.24 c	6.76 ±0.20 b
Female adult longevity	24.32 ±1.86 b	41.00 ±1.66 a	25.86 ±1.79 b	26.46 ±1.93 b	36.44 ±1.97 a	26.29 ±1.52 b	11.07 ±1.35 c	27.65 ±2.01 b
Male adult longevity	22.14 ± 2.26 c	34.53 ± 2.57 a	22.36 ±2.45 c	23.67 ±2.80 c	30.59 ± 1.80 b	19.93 ± 2.38 c	10.40 ± 1.78 d	20.65 ± 2.45 c
Female total life span	30.54 ±1.84 d	46.79 ±1.72 a	32.83 ±1.78 c	34.42 ±1.93 c	42.92 ±2.03 b	34.29 ±1.52 c	17.36 ±1.37 e	34.00 ±2.04 c
Male total life span	28.36 ±2.31 b	40.76 ±2.56 a	29.07 ±2.44 b	29.67 ±2.81 b	37.12 ±1.79 a	27.93 ±2.38 b	16.80 ±1.77 c	27.41 ±2.49 b

The difference between treatments were evaluated using paired bootstrap test. Means in a row followed by different letters are significantly different (P<0.05, paired-bootstrap).

Table 2 Comparison of fecundity, adult pre-oviposition period (APOP), total pre-oviposition period (TPOP), oviposition days, and sex ratio (mean $\pm$ SE) of *Amblyseius swirskii* fed on eight pollen grains.

Parameter	Lebbeck	Date palm	Khejri	Castor bean	Maize	Sunflower	Cogongrass	Cattail
APOP (day)	2.25 $\pm$ 0.08 cd	2.30 $\pm$ 0.09 cd	2.21 $\pm$ 0.08 d	2.46 $\pm$ 0.1 b	2.72 $\pm$ 0.09 b	4.46 $\pm$ 0.12 a	2.42 $\pm$ 0.19 cd	2.42 $\pm$ 0.10 cd
TPOP (day)	8.46 $\pm$ 0.14 cd	8.14 $\pm$ 0.21 d	9.17 $\pm$ 0.10 b	8.42 $\pm$ 0.14 cd	9.20 $\pm$ 0.16 b	12.46 $\pm$ 0.12 a	8.75 $\pm$ 0.41 bcd	8. $\pm$ 0.18 bc
Oviposition days (day)	10.00 $\pm$ 0.89 d	19.04 $\pm$ 0.82 b	11.55 $\pm$ 1.08 cd	14.42 $\pm$ 1.48 c	19.72 $\pm$ 1.12 a	7.75 $\pm$ 0.69 e	4.08 $\pm$ 0.61 f	14.15 $\pm$ 1.33 c
Fecundity (Eggs/Female)	14.29 $\pm$ 1.55 d	32.86 $\pm$ 1.38 b	16.55 $\pm$ 1.71 cd	22.08 $\pm$ 2.32 c	36.68 $\pm$ 2.25 a	7.75 $\pm$ 0.69 e	4.08 $\pm$ 0.61 f	20.81 $\pm$ 1.95 c
Sex Ratio (Nf/N, %)	0.62 $\pm$ 0.07 a	0.62 $\pm$ 0.07 a	0.64 $\pm$ 0.07 a	0.58 $\pm$ 0.07 a	0.59 $\pm$ 0.08 a	0.53 $\pm$ 0.07 a	0.31 $\pm$ 0.07 b	0.58 $\pm$ 0.07 a

The difference between treatments were evaluated using paired bootstrap test. Means in a row followed by different letters are significantly different ($P < 0.05$, paired-bootstrap).

eggs/female/day), 14 (2.08 eggs/female/day), 9 (1.46 eggs/female/day), and 10 day (1.62 eggs/female/day), on date palm, castor bean, cogongrass, cattail, sunflower, maize, lebbeck, and Khejri pollen, respectively, where the immature survivorship was 1, 0.98, 0.33, 0.96, 0.84, 1, 0.93, and 0.96, respectively (Figure 2).

Figure 3 shows the age-stage specific survival rate (s_{xy}) of *A. swirskii* on eight different pollen. The obvious overlaps among stages which are seen in the survival curves are due to the variable developmental rate among individuals. The survival rate on cogongrass was lower than on other diets. The survival rate of females and males on date palm and maize pollen was higher than on other diets (Figure 3).

The effects of exploiting different pollen diets on the life table parameters of *A. swirskii* are summarized in Table 3. Significant differences between all parameters were found. The gross reproductive rate (GRR) and the net reproductive rate (R_0) reached the maximal value on date palm and maize pollen. The value of GRR varied from 1.88 to 23.46, and the net reproductive rate from 1.09 to 21.83. When the females were fed lebbeck and cogongrass pollen, GRR and R_0 values were the lowest. The intrinsic rate of increase (r) and the finite rate of increase (λ) were highest on date palm pollen and the lowest on cogongrass. The mean generation time (T) of *A. swirskii* on lebbeck and cogongrass was significantly shorter than on other pollen grains.

Discussion

Life table characteristics are the best indices of population growth under a given set of situations. This study revealed the life history traits of the generalist predatory mite *A. swirskii* on eight pollen diets. In line with previous studies (Goleva and Zebitz 2013; Riahi *et al.* 2017a; Nemati *et al.* 2019; Kadkhodazadeh *et al.* 2021), we found that various diets reflected different influences on biological parameters and life table characteristics of this predator. It is vital to find and use a suitable alternative diet for the development and oviposition of phytoseiid mites to achieve success in biological control programs.

Our results determined that *A. swirskii* could develop into the adult stage and reproduce on all diets tested. However, immature development and survival varied significantly depending on the diet consumed. Date palm, castor bean, and maize pollen resulted in higher developmental

Table 3 Comparison of life table parameters (mean $\pm$ SE) of *Amblyseius swirskii* fed on eight pollen grains.

Parameter	Lebbeck	Date palm	Khejri	Castor bean	Maize	Sunflower	Cogongrass	Cattail
GRR (offspring)	1.88 $\pm$ 1.90 c	20.94 $\pm$ 2.53 a	12.80 $\pm$ 1.84 b	15.94 $\pm$ 2.56 ab	23.46 $\pm$ 2.22 a	5.75 $\pm$ 0.81 b	3.64 $\pm$ 0.79 c	15.73 $\pm$ 2.36 ab
R_0 (offspring)	8.89 $\pm$ 1.40 c	20.44 $\pm$ 2.52 a	10.67 $\pm$ 1.61 b	12.76 $\pm$ 2.08 b	21.83 $\pm$ 3.07 a	14.13 $\pm$ 0.68 b	1.09 $\pm$ 0.31 d	12.022 $\pm$ 1.89 b
r (day^{-1})	0.1599 $\pm$ 0.0108 b	0.1915 $\pm$ 0.0094 a	0.1563 $\pm$ 0.0097 b	0.1688 $\pm$ 0.0108 ab	0.1785 $\pm$ 0.0091 ab	0.0739 $\pm$ 0.0087 c	0.0068 $\pm$ 0.025 d	0.1642 $\pm$ 0.0105 ab
λ (day^{-1})	1.1734 $\pm$ 0.0126 b	1.2111 $\pm$ 0.0114 a	1.1691 $\pm$ 0.0113 b	1.1839 $\pm$ 0.0128 ab	1.1954 $\pm$ 0.01009 ab	1.0867 $\pm$ 0.0093 c	1.0068 $\pm$ 0.025 d	1.1785 $\pm$ 0.0123 ab
T (day)	13.664 $\pm$ 0.465 c	15.759 $\pm$ 0.352 b	15.15 $\pm$ 0.345 b	15.08 $\pm$ 0.04 b	17.28 $\pm$ 0.370 ab	19.21 $\pm$ 0.384 a	12.60 $\pm$ 3.02 c	15.14 $\pm$ 0.427 b

The difference between treatments were evaluated using paired bootstrap test. Means in a row followed by different letters are significantly different ($P < 0.05$, paired-bootstrap). GRR : gross reproductive rate; R_0 : net reproductive rate; r :

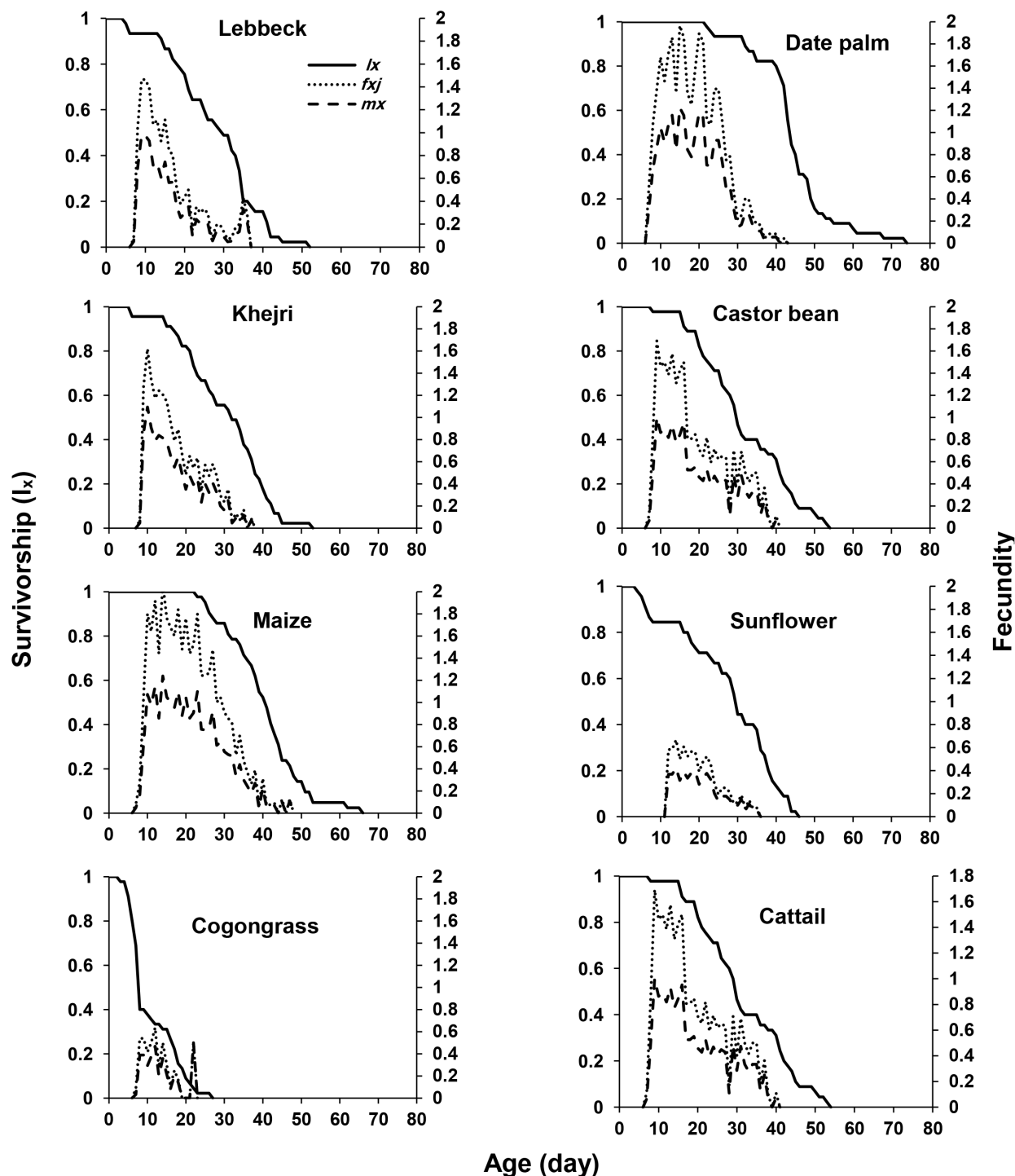


Figure 2 Age-specific survival rate (l_x), age-specific fecundity (m_x), and age-stage-specific fecundity of female (f_{xj}) of *Amblyseius swirskii* fed on eight different pollen grains.

rates and longer adult longevity when compared with other pollen. Similarly, egg-to-adult development of *A. swirskii* on the pollen of some anemophilous and entomophilous plant species (Goleva and Zebitz 2013), almond (Riahi *et al.* 2017a,b), maize (Riahi *et al.* 2017b), wild almond, pistachio, peach, pomegranate, and walnut (Kadkhodazadeh *et al.* 2021) was

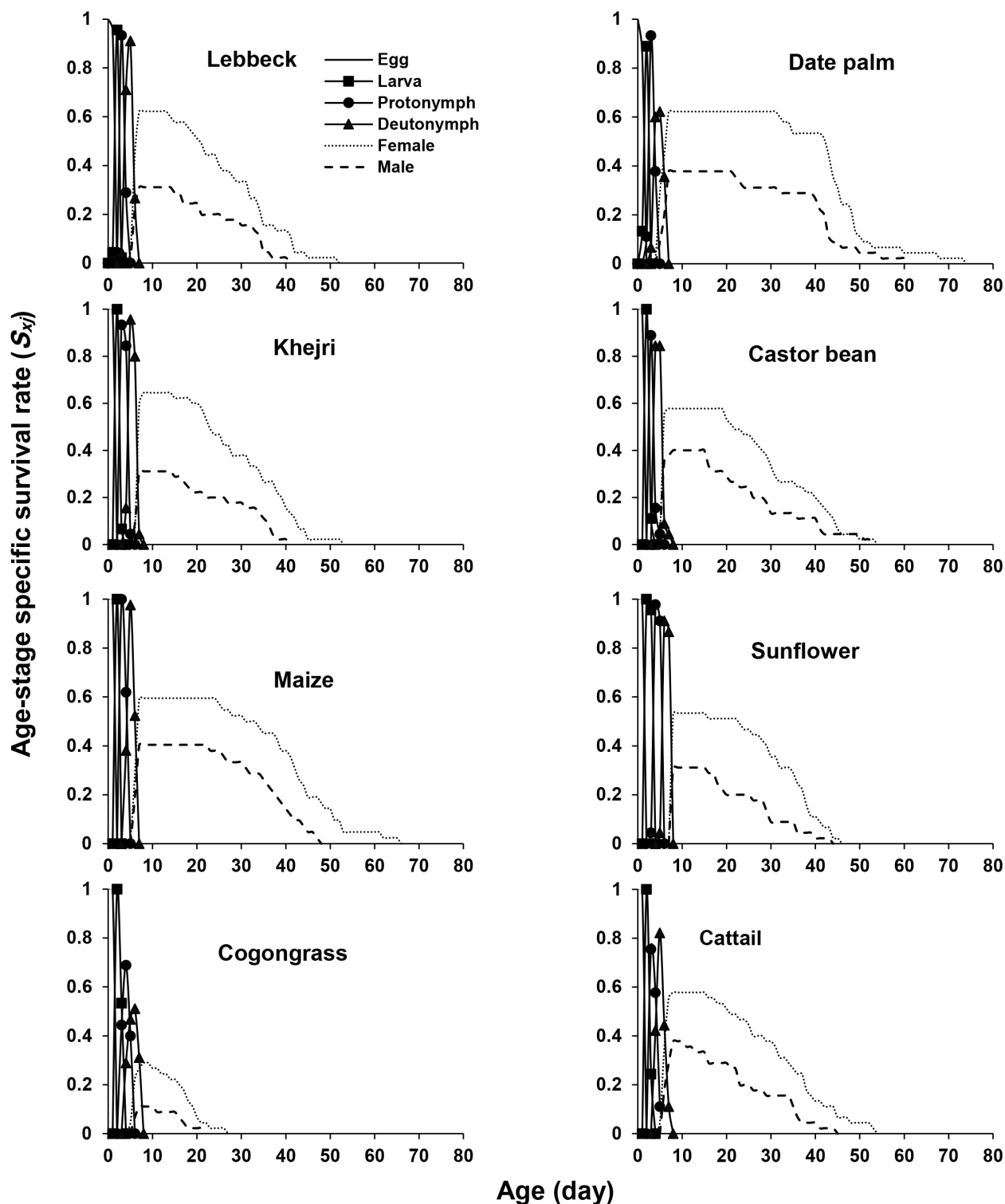


Figure 3 Age-stage specific survival rate (S_{xj}) of *Amblyseius swirskii* fed on eight different pollen grains.

reported to be completed within 6–8 days. In addition, similar findings were obtained by Asgari *et al.* (2020) who reported that *A. swirskii* needed 6.13 and 6.97 days to complete the immature development on *Carpoglyphus lactis* (L.) and *Tyrophagus putrescentiae* (Schränk).

Our findings are contradicted by the studies conducted on the pollen of Poaceae mixture, pumpkin, sunflower, opium poppy, apricot, and pear, as well as bee pollen, which reported a longer developmental time for this predatory mite (Goleva and Zebitz 2013; Riahi *et al.* 2017a; Nemati *et al.* 2019). A shorter developmental time was recorded on almond pollen by Ansari-Shiri *et al.* (2022). As mentioned by Snyder *et al.* (2000) the development can be influenced by the type of diet; low-quality food delays the development, while high-quality food accelerates it. Therefore, the quality of pollen nutrients is the most effective factor that results in changing the immature development of *A. swirskii*. In contrast to Riahi *et al.* (2017a) and Rahmai Piyani *et al.* (2021), who mentioned that 7.3 and 4.20 days are needed to develop into the adult stage on date palm pollen, respectively, the present study showed that 5.96 days are required. The difference between our study and Riahi's might be related to the difference in the type of experimental substrate, artificial substrate versus leaf substrate. Rahmani Piyani *et al.* (2021) had reared *A. swirskii* on a mixture of spider mites and date palm pollen for several generations before starting the experiments, which is different from our study. Differences in geographic origin, climatic conditions, and soil type can also be the factor behind such differences.

We found no mortality when the immature individuals fed on maize and date palm pollen, while the highest immature mortality rate was obtained on cogongrass (58.0%), followed by sunflower (15.6%) pollen. These differences can be caused by the absence of one or more primary essential nutrients or their inadequacy, as well as secondary metabolites. Given the low number of immatures that reached adulthood on the latter pollen grains, it can be concluded that sunflower and cogongrass are unfavorable food for immature *A. swirskii*. Similarly, no mortality was also observed by Swirski *et al.* (1967) and Goleva and Zebitz (2013) when feeding *A. swirskii* on maize pollen at the same temperature as we did. Other phytoseiid mites, such as *Neoseiulus californicus* McGregor showed the highest survival (100%) when fed on maize and date palm pollen (Khanamani *et al.* 2016).

Similarly, female fecundity was also dependent on the quality of diets. This highest value of the number of laid eggs (36.68 eggs) in this study was substantially higher than the total fecundities reported for females of this predator reared on wild almond, peach, oak, pomegranate, walnut, common hazel, scots pine, sweet grasses, *narcissus*, and bee pollen (from 2.23 to 24.36 eggs/ female at 25 °C) (Goleva and Zebitz 2013; Kadkhodazadeh *et al.* 2021); factitious prey, including *C. lactis* (29.03 eggs/ female, at 23 °C) (Nguyen *et al.* 2013) and *T. putrescentiae* (3.69 eggs/ female, at 25 °C) (Riahi *et al.* 2017b), as well as artificial diets (Nguyen *et al.* 2013). The lifetime fecundity of *A. swirskii* has been reported to be 40.12 and 8.24 eggs per female on maize and sunflower pollen, respectively (Goleva and Zebitz 2013); these values are close to the fecundity of the mentioned pollen studied here.

The most valuable parameter which is used for comparing the potential of population growth is the intrinsic rate of increase (r) (Southwood 1966). The shorter the length of the pre-ovipositional period, the higher the growth rate is expected. The highest value of growth rates in the current study was higher than those reported for *A. swirskii* reared on different mites and insects at the same temperature, including *Tetranychus urticae* Koch (Tetranychidae) (Riahi *et al.* 2017a), *Cenopalpus irani* Dosse (Tenuipalpidae) (Bazgir *et al.* 2018); *Thrips tabaci* (Lindeman) (Thripidae), and *Frankliniella occidentalis* (Pergande) (Thripidae) (Wimmer *et al.* 2008). Surprisingly, the growth rate of females fed on date palm and maize pollen was also superior to that recorded on the dried fruit mite *C. lactis* (Nguyen *et al.* 2013). Riahi *et al.* (2017b) and Ansari-Shiri *et al.* (2022) found a lower r -value on maize pollen and almond pollen than what we obtained on date palm pollen. Contradictory, Asgari *et al.* (2020) found that the r value of *A. swirskii* fed on *C. lactis* and *T. putrescentiae* and their mixture was higher and reached 0.3792 day⁻¹. Similar results were observed by Rahmani Piyani *et al.* (2021), who reported that r of *A. swirskii* fed date palm pollen was 0.396 day⁻¹. These differences are probably because of different chemical compounds and nutritional value of diets, different experimental arenas, the diet on which the prey feeds, prey stage and species, and data analysis methods.

In conclusion, the positive effects of date palm and maize pollen on development, survival, fecundity, pre-oviposition period, and population growth rate demonstrated that these pollen grains are nutritionally more valuable and favorable than others. In addition, feeding on cogongrass and sunflower pollen had negative effects on *A. swirskii* population, such as slow development, high immature mortality, low fecundity, and growth rate, indicating the low nutritional value of these pollen grains. These findings could be useful for success in biocontrol programs using *A. swirskii*. Further study on the analysis of pollen components and the correlation between life-table parameters and food substances is recommended.

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