ACARINES, 17:45-55. 2023

Biological aspects and life-tables of the predatory mites, *Amblyseius swirskii* Athias-Henriot and *Neoseiulus californicus* (McGregor), reared on four types of food

Mohamed E. Sweelam & Mona A. Nasreldin*

Economic Entomology and Agricultural Zoology Dept., Fac. of Agric., Menoufia Univ., Shebin El-Kom, Egypt. E-mail: mesweelam20002000@yahoo.com, ORCID: https://orcid.org/0000-0001-6628-6978; E-mail: monanasr048@gmail.com, ORCID: https://orcid.org//0009-0009-1852-6274
**Corresponding author: monanasr048@gmail.com.*

ABSTRACT

Biological aspects and life-table parameters of the predatory mites (Phytoseiidae) : *Amblyseius swirskii* Athias-Henriot and *Neoseiulus californicus* (McGregor), feeding on four types of food i.e**.** *Carpoglyphus lactis* (Carpoglyphidae), *Tetranychus urticae* (Tetranychidae), *Rhizoglyphus robini* (Acaridae), and pollens of Castor bean plants, (*Ricinus communis* L., Euphorbiaceae) at 26±2°C and 75±5% RH. The purpose of this study was to assess the effect of the four diets on biological aspects and life-table of the two predatory mites, under investigation. *Amblyseius swirskii* and *N. californicus* successfully completed their development on the four types of food. The shortest life cycle of *A. swirskii* when fed on *C. lactis* and *R. robini* was 7.80 and 7.92 days, respectively, while the shortest period for *N. californicus* was 6.60 and 7.30 days when fed on *T. urticae* and *R. robini*, respectively. The highest fecundity of *A. swirskii* was recorded when fed on *C. lactis* as 62.64 eggs/female, while the highest fecundity of *N. californicus* was 30.50 eggs/female when fed on *T. urticae*. The highest net reproductive rate (R_0), intrinsic rate of natural increase (r_m), and finite rate of increase (λ) were reported for *A. swirskii* fed on *C. lactis*, whereas the highest of these values for *N. californicus* were recorded when fed on *T. urticae*. The highest gross reproduction rate (*GRR*) was 48.62 offspring/individual when *A. swirskii* fed on *C. lactis* and it was 22.83 offspring/ individual when *N. californicus* fed on *T. urticae*. In conclusion, *T. urticae* and *R. robini* has a great potential as a suitable food for *N. californicus*, while *C. lactis* and *R. robini* is a suitable food for mass rearing of *A. swirskii* mite.

Keywords: Phytoseiidae, biology, *Carpoglyphus lactis*, *Tetranychus urticae, Rhizoglyphus robini*, pollen.

INTRODUCTION

Predatory mites of family Phytoseiidae are crucial biological control agents for phytophagous mites, and insects. Despite 2700 known species of predatory mites from 94 genera, few studies have explored their potential as biological control agents (McMurtry et al. 2013; Knapp et al. 2018; Demite et al. 2023). *Phytoseiulus persimilis* Athias-Henriot, *Neoseiulus californicus* (McGregor), *Amblyseius swirskii* Athias-Henriot, and *Neoseiulus cucumeris* (Oudemans) are commercially available predators for the biological control of thrips, whiteflies, and spider mites (Knapp et al., 2018).

Amblyseius swirskii and *Neoseiulus californicus* are indigenous species and could be well adapted to native habitat than many other exotic phytoseiid species. The two predatory mites are generalist predator feeding eriophyid, tenuipalpid, acarid , tarsonemid mites, pollen, and small arthropods (Momen and Abdel-Khalek 2008; McMurtry et al. 2013; Fahim and ElSaiedy 2021; Elhalawany et al. 2017, 2023, and Lamlom et al. 2024).

The dried fruit mite, *Carpoglyphus lactis* (L.) (Carpoglyphidae) infests stored produces, honey, jam, rotten fruits, flour, as well as dry fruits have been documented as the most favorable media for *C. lactis* infestation (Marín et al. 2009). The two spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) is one of the most harmful pests in most agricultural systems worldwide, and has about 1161 species of host plants, including fruit trees , vegetable crops , ornamental plants, & field crops (Migeon and Dorkeld, 2023). The bulb mite, *Rhizoglyphus robini* (Acaridae) is a serious pest of ornamentals as tulips, onion and garlic crops. Females lay their eggs into the underground part of many crops cause damage to plant, and many pathogens transmitted by mites to other healthy plants (Diaz et al. 2000).

Diet is an important component of mass-production system of bio-control agents. Pollen and acarid mites has a great potential as a suitable and cost-effective diet for developing the mass-production system of *A. swirskii* and *N. californicus* on non-prey diets, where the performance of these predators remained to some extent constant across generations (Elhalawany et al. 2023 and Lamlom et al. 2024). Plant pollens contain high contents of proteins and essential amino acids and serve as high nutritional quality food for phytoseiid mites (Riahi et al. 2017), and even pollen when prey is unavailable (Rhodes and Liburd 2006; Ragusa et al. 2006).

Many researchers have examined the effects of prey species on development and reproduction of *A. swirskii* and *N. californicus* (Momen and Abdel-Khalek 2008, Mesbah et al. 2017, Riahi et al. 2017, Fahim and ElSaiedy 2021, Elhalawany et al. 2017, 2023, Lamlom et al. 2024).

Thus, the present study aimed to explore the biological aspects and life-tables of *A. swirskii* and *N. californicus* reared on four prey diets.

MATERIALS AND METHODS

The experiments were conducted in the Biological Control Laboratory, Economic Entomology and Agricultural Zoology Department, Faculty of Agriculture, Shebin El-Kom, Menoufia University.

Stock culture of predatory mites:

The predatory mite, *Neoseiulus californicus* was collected from Castor bean plant leaves and *Amblyseius swirskii* collected from grape fruit trees in Shebin El-Kom, Menoufia governorate, Egypt. Individuals transferred to the biological laboratory of the Economic Entomology & Agricultural Zoology Department, the predatory mites were reared using modified methods of Elhalawany et al. (2023) where large plastic boxes measuring 26 x 15 x 10 cm were used. Mulberry leaves was used as a substrate ground of culture. Cotton pads were put in the middle of each box, leaving a space provided with water as a barrier to prevent predatory mites from escaping. In addition, a tangle foot strip ran along the edges of the cotton pads. Excised bean leaves highly infested with *Tetranychus urticae* (TSSM) were provided every other day as a food source. The plastic boxes were left at room temperature at 26±2ºC and 75±5% RH.

Prey mite culture:

The rearing of *T. urticae* was carried out in the laboratory on potted beans, *Phaseolus vulgaris* (L.). Adults of spider mite were collected from strawberry leaves and reared under laboratory conditions (26±2ºC and RH 75±5% and a photoperiod of 16:8 L: D). Plant leaves were placed upside down on water-saturated cotton in 15-cm plastic Petri dishes.

The acarid mite, *Carpoglyphus lactis* was extracted from infested dried fruit fig and the bulb mite, *Rhizoglyphus robini* collected from infested stored onion bulbs, using Berlese-Tullgren-funnels, then alive individuals were received in a glass beaker for rearing on cells. Cells were provided with a mixture of plaster (1 plaster of Paris: 9 charcoal) filled on the bottom of cells to a depth of 0.5 cm. The rearing plastic (rearing cell 3 cm diam.) for each mite species contained a mixture of wheat germ 10 g, wheat bran 25 g , yeast powder 1 g (Mesbah et al. 2019), and drops of water as a source of food and humidity were added to the mixture. The cells were covered to prevent mites from escaping. Pollen of castor bean plants (*Ricinus communis* L.) was collected from the plants grown at Shebin El-Kom, Menoufia governorate, where castor bean flowers were placed on filter paper until pollen grains released. Pollen grains were left under laboratory conditions for one week to reduce their water content and prevent the mold growth. They were poured into vials and stored in a refrigerator at 4 °C until their requirement.

Experimental design:

Acalypha leaf discs (3 cm in diameter) were placed on the upper surface down on cotton pad soaked in distilled water in Petri-dishes. The margin of each disc was covered with a strip of wet cotton wool to prevent mites from escaping. Water is added daily to the cotton pad to soak it. Eggs of each predator were transferred singly to each leaf disc (30 replicates for each experiment).

After egg hatch, the larvae were provided with the type of tested food.

The observation was carried out twice daily as different biological aspects, the number of laid eggs until the female died. Once female individuals of tested species reached the adult stage, a young male was introduced onto each disc containing a female, both staying together for observation until first copulation. The female pre-oviposition, oviposition and post-oviposition, as well as longevity, total and daily oviposition rate of each predator species as well as the progeny sex ratio were estimated. Life table parameters were defined by Birch (1948) and calculated using Life 48: A basic computer program according to Abou-Setta et al. (1986).

Statistical analysis:

The obtained data were calculated as the mean ± SD. Significance differences among the biological parameters between the four groups were analyzed using one-way ANOVA and Student's t-test with a 95 % level of significance using SAS statistical software (SAS Institute, 2003).

RESULTS AND DISCUSSION

Development and fecundity of predatory mites:

As shown in Tables (1and 2) the predatory mites: *Amblyseius swirskii* and *Neoseiulus californicus* were successfully completed their development on four diets under laboratory conditions.

For all tested prey diets, the developmental period from egg to adult of *N. californicus* females was significantly shorter than that of *A. swirskii.* The periods from egg to adult of A. swirskii were 8.85, 7.92, 7.80, and 8.60 days when fed on *Tetranychus urticae*, *Rhizoglyphus robini*, *Carpoglyphus lactis*, and pollens of castor bean plants, respectively (Table 1). While these values were 6.60, 7.30, 7.75, and 8.45 days for *N. californicus* on the same prey diets, respectively (Table 2). Moreover, the shortest generation time was recorded with that of *N. californicus* fed on *T. urticae* 7.95 days, while the shortest generation time was recorded with that of *A. swirskii* fed on *C. lactis* 9.60 days. Statistical analysis indicated that significant differences between the four prey diets (F = 6.72, P = 0.0031) and (F = 2.83, P = 0.0522) for *N. californicus* and *A. swirskii* life cycle, respectively.

The obtained results in Tables (1 and 2) indicated that the pre-oviposition, oviposition, and longevity of *N. californicus* and *A. swirskii* were significantly affected by prey diets. The shortest oviposition periods were 19.70 and 19.80 days when *A. swirskii* fed on *T. urticae*, and *R. robini*, whereas the longest periods were 23.20 and 22.30 days when *A. swirskii* fed on *C. lactis*, and Castor pollen, respectively. While, the longest oviposition period was 22.30 days when *N. californicus* fed on *C. lactis.*

In addition, the highest total numbers of laid eggs per *A. swirskii* female were (62.64) when fed on *C. lactis*, while the highest numbers were 30.50 eggs when *N. californicus* was fed on *T. urticae* which was significantly different from other prey diets ($P \geq 0.05$)**.**

The male duration of the tested predatory mites were calculated in Tables (3 and 4) where the shortest life cycle was recorded on *C. lactis* (5.70 days) for *A. swirskii* and 6.0 days on *T. urticae* for *N. californicus,* and there was no significant difference on the other three diets for both predatory mites. The longest male longevity recorded for *A. swirskii* was 23.0 days when castor bean pollens were offered. Whereas, for *N. californicus,* no significant difference between the four prey diets was recorded for longevity.

The obtained results on the oviposition period (Tables 1 and 2) presented the same duration as found by Gotoh et al. (2004), and Elhalawany et al. (2023) for *N. californicus,* and agree with the finding by Mesbah et al. (2019) for *A. swirskii*. The longest life cycle of *N. californicus* when fed on *Rhizoglyphus echinopus* was 8.43 and 8.15 days, while *T. urticae* has a shorter life cycle of 5.97 and 5.85 days , as well as has the highest egg lay per female (Elhalawany et al. 2023). Furthermore the obtained results are in harmony with those of Mesbah et al. (2019) who reported that the pre-oviposition, oviposition, and post-oviposition periods were obviously affected by different prey types, whereas the immature stages of the bulb mite, *R. robini* was the most favorable prey for *A. swirskii* female fecundity, as it gave the highest reproduction rate of 66.20 eggs/ female.

Table 1. Durations in days (Mean ± SD) of immature and adult stages of *Amblyseius swirskii* females feeding on four types of food at 26±2°C and 75±5% RH.

Parameters	***T. urticae***	***R. robini***	***C. lactis***	**Castor pollen**	**LSD 5%**
Egg	1.90±0.32^{a}	1.90±0.57^{a}	2.30±0.48^{a}	2.10±0.74^{a}	0.49
larva	1.50±0.47^{ab}	1.20±0.35^{b}	1.30±0.42^{b}	1.80±0.35^{a}	0.36
Protonymph	2.65±0.35^{a}	2.52±0.4a	2.45±0.44^{a}	2.80±0.35^{a}	0.35
Deutonymph	2.80±0.35^{a}	2.30±0.48^{b}	1.75±0.72^{c}	1.90±0.57^{bc}	0.49
Immature stages	6.95±0.51^{a}	6.02±0.61^{bc}	5.50±1.18^{c}	6.50±0.85^{ab}	0.75
Life cycle	8.85±0.75^{a}	7.92±0.69^{b}	7.80±1.23^{b}	8.60±1.07^{ab}	0.87
Generation	10.35±0.66^{b}	9.92±0.69^{b}	9.60±1.29^{b}	11.30±1.11^{a}	0.88
Pre-oviposition	1.50±0.41^{c}	2.00±0.0^{b}	1.80±0.35^{bc}	2.70±0.48^{a}	0.32
Oviposition	19.70±3.71^{b}	19.80±1.62^{b}	23.20±1.40^{a}	22.30±1.49^{a}	2.05
Post oviposition	2.00±0.62^{a}	2.30±0.42^{a}	1.90±0.32^{a}	2.00±0.67^{a}	0.27
Longevity	23.20±3.93^{b}	24.10±1.51^{b}	26.90±1.74^{a}	27.00±2.0^{a}	2.25
Fecundity	21.70±2.91^{b}	24.00±2.21^{b}	62.64±7.21^{a}	21.60±2.27^{b}	2.25
Daily rate	1.12±0.16^{bc}	1.21±0.10^{b}	2.71±0.42^{a}	0.97±0.13^{c}	0.21
Life span	32.05±4.0^{b}	32.02±1.7^{b}	34.70±1.99^{a}	35.60±1.58^{a}	2.31

Means within each row followed with different letters are significantly different at $P < 0.05$.

Table 2. Durations (Mean ± SD) in days of immature and adult stages of *Neoseiulus californicus* females feeding on four types of food at 26±2°C and 75±5% RH.

Parameters	***T. urticae***	***R. robini***	***C. lactis***	**Castor pollen**	**LSD 5%**
Egg	1.30±.48^{a}	1.30±0.48^{a}	1.50±0.53^{a}	1.60±0.52^{a}	0.45
larva	1.40±0.46^{b}	1.80±0.35^{a}	1.90±0.57^{a}	2.10±0.32^{a}	0.45
Protonymph	1.90±0.32^{b}	2.00±0.47^{b}	2.20±0.59^{ab}	2.55±0.50^{a}	0.51
Deutonymph	2.00±0.67^{a}	2.20±0.42^{a}	2.15±0.58^{a}	2.20±0.42^{a}	0.36
Immature stages	5.30±0.92^{c}	6.00±0.53^{bc}	6.25±1.03^{ab}	6.85±0.88^{a}	0.37
Life cycle	6.60±1.20^{c}	7.30±0.71^{bc}	7.75±0.92^{ab}	8.45±0.90^{a}	0.83
Generation	7.95±1.28^{c}	9.00±0.78^{b}	9.85±1.0^{ab}	10.05±1.12^{a}	0.96
Pre-oviposition	1.35±0.41^{b}	1.70±0.48^{ab}	2.10±0.57^{a}	1.60±0.70^{ab}	0.49
Oviposition	20.40±2.12^{b}	21.20±1.14^{ab}	22.30±1.49^{a}	20.70±0.95^{b}	1.35
Post oviposition	1.80±0.63^{a}	1.80±0.63^{a}	2.00±0.47^{a}	1.70±0.48^{a}	0.5
Longevity	23.55±2.37^{ab}	24.70±1.64^{a}	22.40±3.34^{b}	24.00±1.49^{ab}	1.38
Fecundity	30.50±4.25^{a}	22.00±1.41^{b}	19.10±1.66^{c}	21.60±2.27^{b}	2.39
Daily rate	1.51±0.23^{a}	1.04±0.08^{b}	0.86±0.10^{c}	1.04±0.10^{b}	0.12
Life span	30.15±2.86^{a}	32.00±1.15^{a}	30.15±3.21^{a}	32.45±1.57^{a}	1.98

Means within each row followed with different letters are significantly different at $P < 0.05$.

Table 3. Durations (Mean ± SD) in days of immature and adult stages of *Amblyseius swirskii* males feeding on feeding on four types of food at 26±2°C and 75±5% RH.

Parameters	*T. urticae*	*R. robini*	*C. lactis*	Castor pollen	LSD 5%
Egg	1.55±0.50[a]	1.65±0.47[a]	1.90±0.52[a]	1.80±0.63[a]	0.48
larva	1.20±0.26[a]	1.25±0.3[a]	0.85±0.24[b]	1.40±0.52[a]	0.32
Protonymph	2.05±0.37[a]	1.75±0.63[a]	1.85±0.58[a]	2.00±0.47[a]	0.47
Deutonymph	1.90±0.21[a]	1.95±0.16[a]	1.10±0.32[b]	1.70±0.48[a]	0.28
Immature stages	5.15±0.63[a]	4.95±0.83[a]	3.80±0.79[b]	5.10±0.57[a]	0.64
Life cycle	6.70±0.79[a]	6.6±0.91[a]	5.70±0.95[b]	6.90±0.74[a]	0.77
Longevity	18.4±1.71[c]	18.4±1.71[c]	21.50±1.58[b]	23.00±1.25[a]	1.42
Life span	25.1±2.12[c]	25.0±2.45[c]	27.20±1.65[b]	29.90±0.99[a]	1.71

Means within each row followed with different letters are significantly different at $P < 0.05$.

Table 4. Durations (Mean ± SD) in days of immature and adult stages of *Neoseiulus californicus* males feeding on feeding on four types of food at 26±2°C and 75±5% RH.

Parameters	*T. urticae*	*R. robini*	*C. lactis*	Castor pollen	LSD 5%
Egg	1.20±0.35[a]	1.25±0.42[a]	1.3±0.48[a]	1.4±0.7[a]	0.45
larva	1.30±0.35[b]	1.60±0.5[ab]	1.7±0.5[ab]	2.0±0.6[a]	0.39
Proto nymph	1.60±0.52[b]	1.90±0.6[ab]	1.9±0.5[ab]	2.2±0.6[a]	0.43
Deuto nymph	1.90±0.32[a]	2.10±0.32[a]	2.0±0.4[a]	2.0±0.4 [a]	0.48
Immature stages	4.80±0.86[b]	5.60±0.8[a]	5.6±0.7[a]	6.2±0.8[a]	0.78
Life cycle	6.00±0.91[b]	6.85±1.1[a]	6.9±0.7[a]	7.6±0.8[a]	0.85
Longevity	18.40±1.71[a]	19.00±1.3[a]	18.1±1.1[a]	19.0±1.8[a]	2.11
Life span	24.40±1.73[b]	25.85±2.2[ab]	25.0±1.4[ab]	26.6±1.9[a]	1.04

Means within each row followed with different letters are significantly different at $P < 0.05$.

Effect of prey diet on life-table parameters of *A. swirskii*:

Regarding to the life-table parameters of the predatory mite, *A. swirskii* Table (5) no significant differences between the four-prey diets for the mean generation time (*T*). Finite rate of increase (λ), survival rate and sex ratio. The shortest time for population density doubling was detected when *A. swirskii* fed on *C. lactis* (2.90 days) were the longest time recorded when individuals fed on *T. urticae* (TSSM) and castor pollen(L.S.D = 0.23).

The highest net reproductive rate (R_0) was 41.10♀/♀/ generation, and the intrinsic rate of natural increase (r_m) was 0.239 individuals/♀/ generation when fed on *C. lactis*, while the lowest value was found when fed on *T. urticae*. The highest gross reproduction rate (*GRR*) was recorded (48.62 offspring/individual) when fed on *C. lactis and* the lowest value (18.87 offspring/individual) when fed on *R. robini*. These result agree with observed by Asgari et al. (2020) reported that the predatory mite, *Amblyseius swirskii* favored dried fruit mite, *Carpoglyphus lactis* stages for female fecundity, and it gives the highest reproduction rate (82.0 eggs) and the highest intrinsic rate of natural increase.

Effect of prey diet on life-table parameters of *N. californicus*:

The life-table parameters of *N. californicus* fed on four-prey diets are shown in Table (6). The survival rate of predatory mite females of *N. californicus* had no significant differences between tested diets. The shortest mean generation time (*T*) and time for population density doubling were detected when predator mites fed on *T. urticae* (13.67 and 3.01 days), while the longest (15.96 and 4.44 days) were recorded when fed on castor bean pollens. The highest net reproductive rate (R_0), intrinsic rate of natural increase (r_m), and finite rate of increase (λ) were found when fed on *T. urticae*, while the lowest value was found when fed on castor bean pollens. The highest gross reproduction rate (*GRR*) (22.83 offspring/individual) was recorded when fed on *T. urticae* and the lowest value (15.39 offspring/individual) was recorded when fed on *C. lactis*.

These results are in agreement with finding of Elhalawany et al. (2017) who reported that the (r_m) reached 0.272 individuals/♀/day with motile stages of *T. urticae* and 0.14 individuals/♀/day with motile stages of the eriophyid mite, *Tegolophus guavae* (Boczek, 1960) as prey. The shortest time for population doubling (*DT*) fed on *T. urticae* motile stages 3.54 days. The intrinsic rate of natural increase (r_m) ranged from 0.162 to 0.285, and was maximal at 25°C, and the net reproductive rate (R_0) was 22.9 ♀/♀/ generation on *T. urticae* (Canlas et al. 2006).

The intrinsic rate of increase (r_m) was 0.2 and the mean generation time (*T*) was 17.2 days. The population doubled every 4.1 days when the predatory mite *N. californicus* fed on *T. urticae* and castor bean pollen (Marafeli et al. 2014).

Age specific survival rate of *A. swirskii* and *N. californicus*:

Age-specific survival rate (*lx*) and age-specific fecundity (m_x) curves for *A. swirskii* are present in Figure (1). The daily age-specific survival rate was highest for *C. lactis*, and decreased for *R. robini* and castor bean pollen. The maximum number of eggs produced (day 17: 3.0 egg/♀/day) when fed on *C. lactis* was the lowest (day 12: 1.12 egg/♀/day) when fed on *T. urticae* and castor bean pollen. The illustrated data in Figure (2) showed that the daily age-specific survival rate was highest for *C. lactis* and decreased on the other prey diets for *N. californicus*. The maximum number of eggs produced by *N. californicus* (day 13: 1.54 egg/♀/day) when fed on *T. urticae was* the lowest (day 11: 0.95 and 0.98 egg/♀/day) when fed on *C. lactis* and *R. robini*, respectively.

Furthermore, the obtained results are in harmony with those of McGregor et al. (2020) who reported that several mite species from the Phytoseiidae (Acari) have been successfully developed as products for augmentative biological control, studied feeding behaviour and predation for *Neoseiulus fallacis* on *T. urticae* and three Astigmatid (Acari) mites*: Lepidoglyphus destructor* (Schrank) (Acari: Glycyphagidae), *Aleuroglyphus ovatus* (Tropeau) (Acari: Acaridae) and *Thyreophagus entomophagus* (Laboulbe `ne) (Acari: Acaridae) and added that Although *N. fallacis* grabbed prey mites of all four species, successful feeding attempts were more frequent for the native host, *T. urticae*, than for the three Astigmatid species. *N. fallacis* rejected *A. ovatus* and *T. entomophagus* as hosts more often than *T. urticae*. In addition , Asgari et al. (2020) who evaluated the suitability of *Carpoglyphus lactis* L, *Tyrophagus putrescentiae* (Schrank), and their mixture for rearing *A. swirskii* using the two-sex life table, and found that rearing *A. swirskii* on *C. lactis*, the durations of egg, deutonymph, total pre-adult, total pre-oviposition period, and adult male longevity were (1.95, 1.17, 6.13, 6.30, and 10.09 days, respectively).

Table 5. Life-table parameters of *Amblyseius swirskii* feeding on four types of food at 26±2°C and 75±5% RH.

Parameters	*T. urticae*	*R. robini*	*C. lactis*	Castor pollen	LSD 5%
Survival rate	0.85	0.80	0.90	0.85	ns
Sex ratio (female/total)	0.70	0.72	0.75	0.70	ns
Net reproductive rate (R_0)[b]	12.55[b]	13.82[b]	41.10[a]	12.91[b]	5.90
Intrinsic rate of increase (r_m)[c]	0.158[b]	0.173[b]	0.239[a]	0.162[b]	0.326
Mean generation time (T)[a]	15.97	15.12	15.49	15.78	ns
Finite rate of increase (λ)[c]	1.17	1.18	1.27	1.17	ns
Doubling generation (DT)[a]	4.38 [a]	4.0[b]	2.90[c]	4.27[a]	0.23
Gross reproduction rate (GRR)[d]	18.94[b]	18.87[b]	48.62[a]	19.52[b]	5.49

[a] Day, [b] females/female/generation, [c] individuals/female/day, [d] offspring/individual
Means within each row followed with different letters are significantly different at $P < 0.05$.

Table 6. Life-table parameters of *Neoseiulus californicus* feeding on four types of food at 26±2°C and 75±5% RH.

Parameters	*T. urticae*	*R. robini*	*C. lactis*	Castor pollen	LSD 5%
Survival rate	0.80	0.80	0.85	0.80	ns
Sex ratio (female/total)	0.70	0.70	0.73	0.70	ns
Net reproductive rate (R_0)[b]	17.08[a]	12.32[b]	11.16[b]	12.09[b]	3.39
Intrinsic rate of increase (r_m)[c]	0.207[a]	0.175[b]	0.165[b]	0.156[b]	0.024
Mean generation time (T)[a]	13.67	14.31	14.59	15.96	ns
Finite rate of increase (λ)[c]	1.23	1.19	1.17	1.16	ns
Doubling generation (DT)[a]	3.01	3.96	4.20	4.44	ns
Gross reproduction rate (GRR)[d]	22.83[a]	16.5[b]	15.39[b]	16.03[b]	3.55

[a] Day, [b] females/female/generation, [c] individuals/female/day, [d] offspring/individual
Means within each row followed with different letters are significantly different at $P < 0.05$.

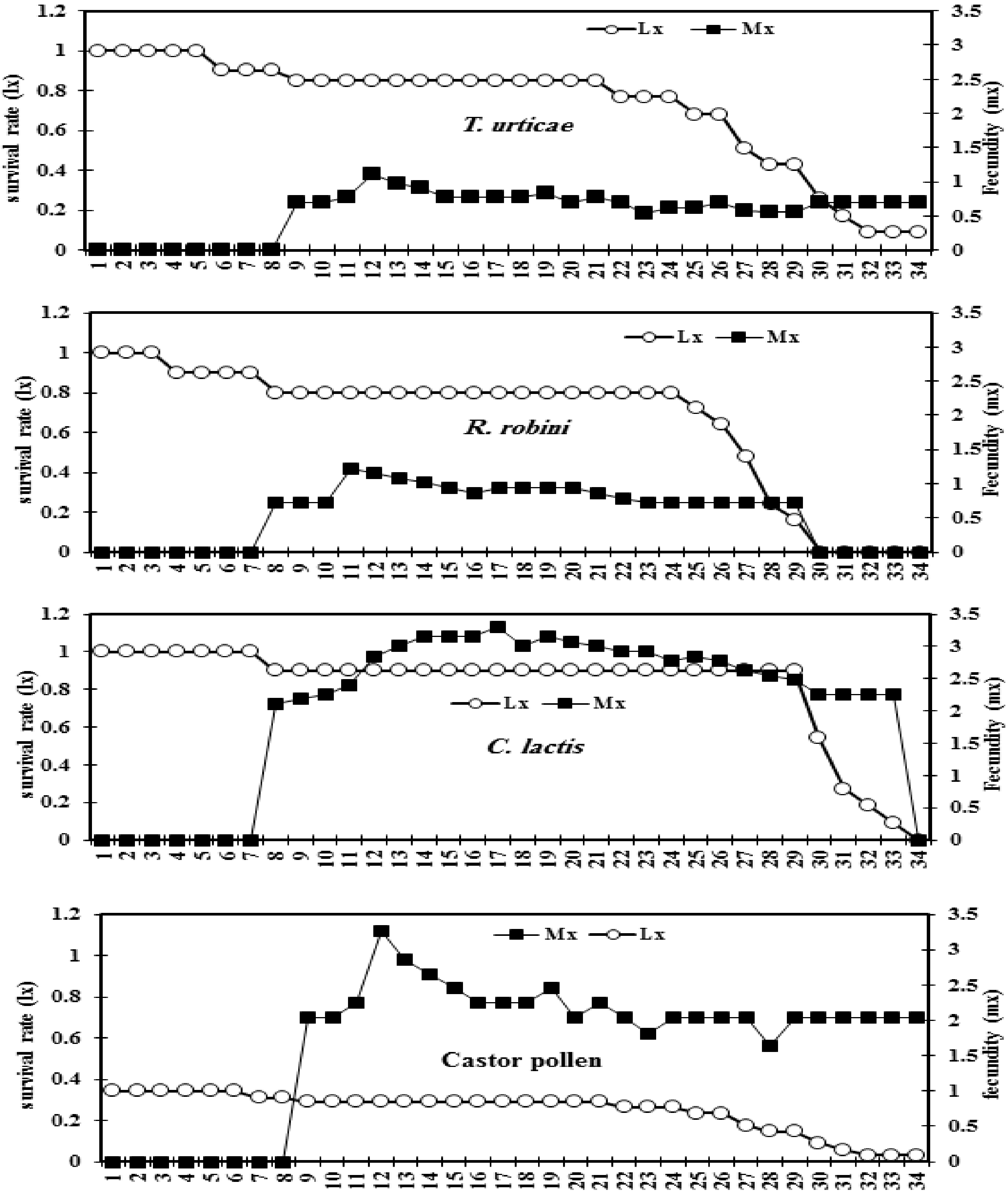

Figure 1. Age-stage-specific survival rate (*lx*) and age-specific fecundity (m_x) curves of *Amblyseius swirskii* feeding on four types of food at 25±1°C and 75±5% RH.

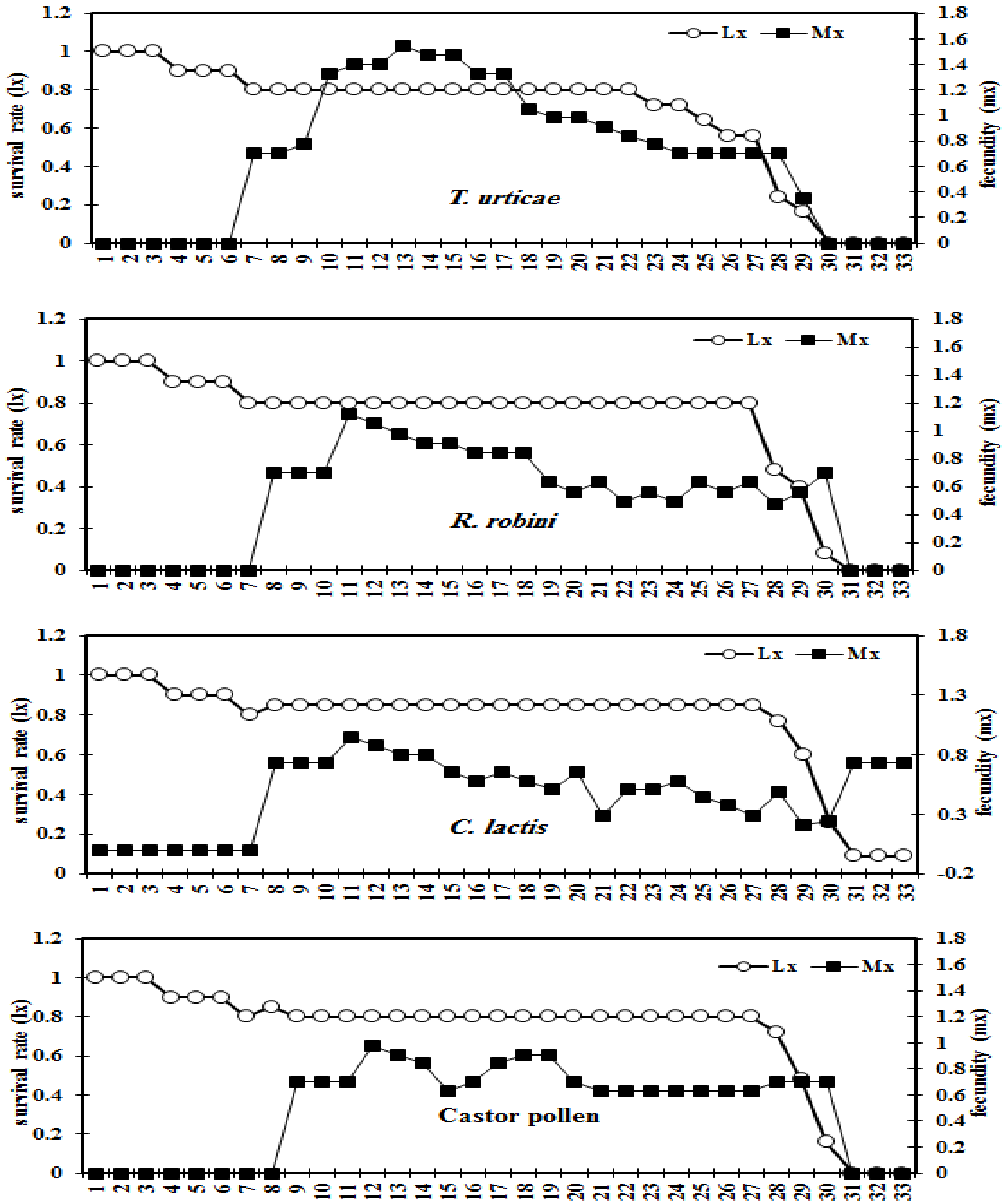

Figure 2. Age-stage-specific survival rate (*lx*) and age-specific fecundity (m_x) curves of *Neoseiulus californicus* feeding on four types of food at 25±1°C and 75±5% RH.

CONCLUSION

This study examined the biological aspects and life-table parameters of two phytoseiid predatory mites, *A. swirskii* and *N. californicus*, fed on four types of food. The tested mites successfully completed their development on these food types. The shortest life cycle for *A. swirskii* was recorded when fed on *C. lactis* and *R. robini*, while *N. californicus* had shorter periods when fed on *T. urticae* and *R. robini*. *Amblyseius swirskii* recorded the highest fecundity when fed on *C. lactis*, while *N. californicus* gave the highest when fed on *T. urticae*. The study concluded that *T. urticae* has potential as a suitable food for *N. californicus*, while *C. lactis* is suitable for mass rearing of *A. swirskii*.

REFERENCES

Abou-Setta MM, Sorrell RW, Childers CC. 1986. Life 48: A basic computer program to calculate life table parameters for an insect or mite species. *Florida Entomologist*, 69(4), 690–697.

Asgari, FM, Moayeri,H R S, Kavousi, A Enkegaard, A Chi, H. 2020. Demography and Mass Rearing of Amblyseius swirskii (Acari: Phytoseiidae) Fed on Two Species of Stored- Product Mites and Their Mixture. *Biological and Microbial Control*, 113(6), 2604–2612. doi: 10.1093/jee/toaa187

Birch LC. 1948. The intrinsic rate of natural increase of an insect population. *Journal of Animal Ecology*, 17, 15–26.

Canlas LJ, Mamano H, Ochiai N, Takeda M. 2006. Biology and predation of the strain Japanese of *Neoseiulus californicus* (McGregor) (Acari: Phytoseiidae). *Systematic and Applied Acarology*, 11(2), 141-157.

Demite PR, Moraes GJ de, McMurtry JA, Denmark HA, Castilho RC. 2023. Phytoseiidae Database. Available from: https://www.lea.esalq.usp.br/ phytoseiidae (accessed 14/04/2023).

Diaz A, Okabe K, Eckenrode CJ, Villoni MG, Oconnor BM. 2000. Biology, ecology, and management of the bulb mites of the genus *Rhizoglyphus* (Acari: Acaridae). *Experimental and Applied Acarology*, 24, 85–113.

Elhalawany AS**,** AbdelKhalik AR, Walash EH. 2023. Developmental and life table of *Neoseiulus californicus* (McGregor) (Acari: Phytoseiidae) fed on three astigmatid mites and *Tetranychus urticae* Koch. (Acari: Tetranychidae). *Egyptian Journal of Plant Protection Research Institute*, 6 (1): 64–73.

Elhalawany AS, Abdel-Wahed NM, Ahmad NFR. 2017. Influence of Prey Type on the Biology and Life–Table Parameters of *Neoseiulus californicus* (McGregor) (Acari: Phytoseiidae). *Journal of the Egyptian Society of Acarology (Acarines)*, 11, 15–20.

Fahim SF, El-Saiedy EM. 2021 Life table parameters of *Amblyseius swirskii* and *Neoseiulus californicus* (Acari: Phytoseiidae) reared on two strawberry cultivars. *International Journal of Acarology*, 47: 568–574. DOI: 10.1080/01647954.2021.1976835

Gotoh T, Yamaguchi K, Mori K. 2004. Effect of temperature on life history of the predatory mite *Amblyseius (Neoseiulus) californicus* (Acari: Phytoseiidae). *Experimental and Applied Acarology*, 32, 15–30. DOI:10.1023/B:APPA.0000018192.91930.49.

Knapp M, van Houten Y, van Baala E, Groot T. 2018. Use of predatory mites in commercial biocontrol: current status and future prospects. *Acarologia*, 58, 72–82.

Lamlom M, Fahim SF, Momen FM. 2024. The effects of maize pollen on development and population growth potential of *Amblyseius swirskii* and *Cydnoseius negevi* (Acari: Phytoseiidae) in subsequent generations. *Persian Journal of Acarology*. 13, 115–130. DOI: 10.22073/pja.v13i1.82742

Marafeli PP, Reis PR, Silveira ECD, Souzapimentel GC, Toledo MA. 2014. Life history of *Neoseiulus californicus* (McGregor, 1954) (Acari: Phytoseiidae) fed with castor bean (*Ricinus communis* L.)

pollen in laboratory conditions. *Brazilian Journal of* Biology, 74, 691–697.

Marín J., Ocete R., Pedroza M., Zalacain A., de Miguel C., López M.A., and Salinas M.R. 2009. Influence of the mite *Carpoglyphus lactis* (L) on the aroma of pale and dry wines aged under flour yeasts. *Journal of Food Composition and Analysis*, 22, 745–750.

McMurtry JA, de Moraes GJ, Sourassou NF. 2013. Revision of the lifestyles of phytoseiid mites (Acari: Phytoseiidae) and implications for biological control strategies. *Systematic & Applied Acarology,* 18, 297–320.

McGregor Robert, Katelyn Crisp, Camile Castiglia 2020. Feeding lifestyles of the Phytoseiidae revisited: searching for a factitious rearing host for Neoseiulus fallacis (Acari: Phytoseiidae) BioControl. DOI 10.1007/s10526-020-10024-z

Mesbah AE, Roshdy OM, Amer AI. 2019. Acaridida mites as a factor for mass production of predator mite, *Amblyseius swirskii* (Acari: Phytoseiidae). *Egypt. Journal of Plant Protection Research Institute*, 2 (1), 134–141.

Migeon A, Dorkeld F. 2023**.** Spider mites web: a comprehensive database for the Tetranychidae. Available from http://www1.montpellier.inra.fr/CBGP/spmweb (Accessed 1/12/2023).

Momen FM, Abdel-Khalek A 2008. Effect of the tomato rust mite *Aculops lycopersici* (Acari:Eriophyidae) on the development and reproduction of three predatory phytoseiid mites. *International Journal of Tropical Insect Science*, 28, 53–57.

Ragusa S. 2006. Phytoseiid mites (Parasitiformes Phytoseiidae) of some Eptanissan Islands (Greece). *Redia*, 89, 1–7.

Rhodes LM, Liburd OE. 2006. Evaluation of predatory mites and Acramite for control of twospotted spider mites in strawberries in north central Florida. *Journal of Economic Entomology*, 99(4), 1291–1298. https://doi.org/10.1093/jee/99.4.1291

Riahi E, Fathipour Y, Talebi A A, Mehrabadi M. 2017. Attempt to develop cost-effective rearing of *Amblyseius swirskii* (Acari: Phytoseiidae): assessment of different artificial diets. *Journal of Economic Entomology*, 110(4), 1525–1532.

SAS Institute 2003.SAS Statistics and graphics guide, release 9.1. *SAS Institute, Cary, North Carolina 27513, USA.*