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RESEARCH ARTICLE

Food Preference, Predation Efficiency and Life Table Parameters of *Euseius scutalis* (Acari: Phytoseiidae) Reared on *Tenuipalpus punicae* (Acari: Tenuipalpidae) and *Siphoninus phillyreae* (Hemiptera: Aleyrodidae) Under Constant Conditions

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Abstract

The biology, life table parameters and predation efficiency of the predatory mite, *Euseius scutalis* (Acari: Phytoseiidae) feed *Tenuipalpus punicae* mobile stages and *Siphoninus phillyreae* eggs were tested at constant conditions (30 ± 1ºC & 65 ± 5 % R.H.). The predator completed its developmental times on both prey pests in 6.20 and 6.45 days. The mite was slightly influenced by the prey type, as when fed *T. punicae* mobile stages, its developmental time were shorter than preyed on *S. phillyreae* eggs. Whenever, the female predator fed the mite mobile stages, the finite rate of increase (λ) was higher than that on the insect eggs. The mean generation time (*T*) was also affected, whereas it was longer when the female preyed on *S. phillyreae* eggs compared with that on *T. punicae* mobile stages. The *E. scutalis* female consumed high number of insect eggs during its oviposition period and the longevity was longer in comparison with feed *T. punicae* mobile stages.

Keywords: Predator; Biology; Pomegranate whitefly; Egypt.

Introduction

Mites of family Phytosiidae Berlese (Mesostigmata) play as a plant inhabiting predator of agricultural arthropod pests, and are recognised as effective natural enemies and potential as biological control candidates (Gerson et al., 2003; McMurtry et al., 2013, 2015; Hoy, 2016; Yang et al., 2019). This family currently is comprising of more than 2798 described species (Demite et al., 2014, 2020). However, several phytoseiid species have been commercially produced in different continent (Van Lenteren, 2012). But many other practical useful phytoseiids remain to be discovered yet to be conducted around the glob to be used for the biological control of pest species. Species of the genus *Euseius* De Leon are important pollen feeding generalist predators (McMurtry et al., 2013) as they feed several major mite, scale insect and whitefly pests (Nomikou et al., 2001; Raza et al., 2005). *Euseius scutalis* (Athias-Henriot) was common phytoseiids in Middle East and North Africa (Porath and Swirski, 1965; Bounfour and McMurtry, 1987; Denmark, 1992; Momen and El-Sawi,

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2008). It is the most dominant predator on economic crops in Egypt (El-Laithy and Fouly, 1992; Abou-Awad et al., 2010; Mohamed and Nabil, 2014; Abdelgayed et al., 2017; Marei et al., 2020). The pomegranate false red mite, *Tenuipalpus punica*e Pritchard and Baker and the pomegranate whitefly, *Siphoninus phillyreae* (Haliday) are reported to be important pests on pomegranate orchards that cause heavy defoliation; fruits dropping and even death of trees, especially when trees are stressed (Jeppson et al., 1975; Emmanouel and Papadoulis, 1987). Up to date control studies have used phytoseiids, because of their control efficiency to keep numbers of certain pests at low populations (McMurtry and Croft, 1997). Thus, the present work aimed to test the food preference, reproductive performance, predation efficiency and life table parameters of *E. scutalis* feed *T. punicae* and *S. phillyreae* to determine the development and behaviour of such predator at constant conditions (30 ± 1˚C & 65 ± 5 % R.H.).

Materials and Methods

Rearing the predatory mite, *Euseius scutalis* (Athias-Henriot):

The predatory mite, *E. scutalis* was collected from pomegranate trees (*Punica granatum* L., Lythraceae). In the pomology farm, Faculty of Agriculture, Assiut University, 27° 02' 28.20" N, 31° 00' 25.80" E. Infested bean leaves with *T. punicae* were provided daily to the stock colony of the predator as a fresh food. The stock colony was maintained under controlled conditions (30 ± 1˚C & 65 ± 5 % R.H). Inside an incubator. Few drops of water were added when needed.

The pomegranate false red mite, *Tenuipalpus punicae* Pritchard and Baker:

Individuals of *T. punicae* were collected from fruits and leaves of pomegranate orchards daily and used as a fresh food for the predator in all experiments. The total number of consumed mobile stages by the predator was recorded daily.

The pomegranate whitefly, *Siphoninus phillyreae* (Haliday):

Infested pomegranate leaves with the pomegranate whitefly were collected. The infested leaves were put in paper bags, then transferred to the laboratory for direct examination under a stereo-microscope. This experiment was conducted under controlled conditions (30 ± 1ºC & 65 ± 5% R.H.). Inside an incubator. The experimental unit consisted of moistened cotton pads placed upon sponges in petri dish (15 x 20 cm in diameter). The castor bean, *Ricinus communis* L. (Euphorbiaceae) leaf discs (3 cm in diameter) were placed upon the cotton pads. A few drops of water were added when needed to keep moisture prevent mite escaping.

The effect of the two prey species and the consumption rates on the development of *E. scutalis*:

Four groups of 35 newly deposited eggs of *E. scutalis* were singly put on arena (3 cm leaf disc). *Siphoninus phillyreae* eggs and *T. punicae* mobile stages were used as source of prey. The developmental stages and the number of consumed prey (eggs or mobile stages) were recorded twice daily until the predator reached adulthood. The female predator was mated with the male for one day. Each replicate was examined daily to record number of eggs laid and number of consumed prey until the death of the female predator. The leaf discs in each arena were checked each two days. Prey eggs or mobile stages were replaced daily with freshly ones.

Life tables:

Newly *E. scutalis* mated female was placed singly in an arena. Predator eggs were collected daily and reared until reaching the adulthood. The sex ratio of the predator was recorded visually. The life table of the predator was recorded using data obtained from the developmental time of immature and adult stages. These experiments were carried out under controlled conditions (temperature and photoperiod).

Statistical analysis:

Data of the developmental time, longevity and fecundity were subjected to One-way ANOVA (F-test), followed by Duncan's Multiple Range Test ($P \leq 0.05$). (Duncan, 1955) in the programme to determine the difference between means.

Life table parameters were calculated according to (Birch, 1948) using Life 48: A BASIC computer program (Abou-Setta et al., 1986).

The net reproductive rate (R_0= females/female/generation); intrinsic rate of natural increase (r_m= females/female/day) and mean generation time (T_0= in (R_0/r), in days) were estimated (Laing, 1968). After (r_m) was computed for the original data (r_{a11}), the differences in (r_m) values were tested for significance by estimating the variance using the Jack knife method to calculate the standard errors.

The Jack-knife pseudo value (*rj*) was calculated for the *n* samples by using the following equation (Sokal and Rolf, 1981; Krebs, 1998): $rj = n \times r_{a11} - (n-1) \times r_i$. The mean values of ($n$–1); jack-knife pseudo-values for the mean growth rates in each treatment were subjected to analysis of variance followed by Duncan's Multiple Range Test ($P \leq 0.01$). All mentioned analyses were conducted using SAS statistical software (SAS institute, 2010).

Results and discussion

Developmental time of the predator, *Euseius scutalis*:

The *Euseius scutalis* was completed its development on both *T. punicae* mobile stages and *S. phillyreae* eggs under constant conditions (30 ± 1°C & 65 ± 5% R.H.). The life cycle time (egg to adult) of both sexes was slightly affected by prey type (Table 1). The incubation period of eggs lasted from 1.67 to 1.96 days. The female and male larva lasted respectively 2.28 & 2.21 and 2.50 & 2.26 days when fed *T. punicae* mobile stages and *S. phillyreae* eggs. The female protonymph and deutonymph lasted respectively 1.93 & 2.04 and 2.00 & 2.21 days when fed the same previous prey species. While, the male (protonymph and deutonymph) lasted respectively 1.83 & 1.89 and 1.50 & 1.59 days. The total developmental period of the predator female was slightly longer when fed *T. punicae* mobile stages than *S. phillyreae* eggs. Momen and El-Sawi (2008); Adly (2016) and Yang et al. (2019) indicated that the developmental periods of *E.*

scutalis females and males were significantly affected by the prey type, as this period was shorter when it fed *Tetranychus urticae* Koch eggs than *Bemisia tabaci* (Gennadius) eggs and instars.

The life cycle averaged respectively 8.17 & 8.42 and 7.5 & 7.63 days for female and male when fed both prey species. Fouly et al. (2013) recorded that life cycle of *E. scutalis* lasted an average of 5.20 & 6.19, 6.40 & 7.23 and 7.30 & 7.85 days for both male and female when fed pollen grains, *T. urticae* and *B. tabaci*, respectively. Therefore, *B. tabaci* gave the longest life cycle followed by the two-spotted spider mites, while palm pollen gave the shortest one. El-Laithy and Fouly (1992) recorded that, life cycle of *E. scutalis* lasted 7.81 and 6.8 days for female and male when fed *T. urticae*. Similar results were observed with shorter times (4.2 days), when *E. scutalis* fed *Panonychus citri* (McGregor) mobile stages (Kasap and Şekeroğlu, 2004).

The mean number of eggs laid by *E. scutalis* single female mated for one day was respectively 19.38 and 16.85 eggs, when fed *S. phillyreae* eggs and *T. punicae* mobile stages, with an average of 2.05 and 1.97 eggs/day on both pests.

Life table parameters of *E. scutalis* feed *S. phillyreae* and *T. punicae*:

Data in (Table 2 & Figure 1) showed life table parameter and sex ratio of *E. scutalis* fed *S. phillyreae* eggs and *T. punicae* mobile stages. The population doubling time (*DT*) was longer when the predator fed *S. phillyreae* eggs (3.85 days) than *T. punicae* mobile stages (3.76 days). The finite rate of increase (λ) were respectively 1.20 and 1.19 when the predator female fed *T. punicae* mobile stages and *S. phillyreae* eggs. The mean generation time (*T*) of *E. scutalis* was insignificantly affected by prey type, as *S. phillyreae* eggs gave slightly longer (*T*) time (12.62 days) compared with (12.19 days) on *T. punicae* mobile stages. The gross reproductive rate (*GRR*) was respectively 19.79 and 16.52 egg/female/generation, when the predator fed both *S. phillyreae* eggs and *T. punicae* mobile stages.

Those results are in agreement with Kasap and Şekeroğlu (2004); Fouly et al. (2013) who suggested that the mean generation time (*T*) of *E. scutalis* at 26 ºC and 70% R.H. was affected by diet, whereas palm pollen gave the shortest generation time (12.39 days) in comparison with *B. tabaci* (14.91 days); the intrinsic rate of natural increase (r_m) and the finite rate of increase (r_m) averaged 0.232-1.26, 0.191-1.21 and 0.175-1.91 when *E. scutalis* fed palm pollen, *T. urticae* and *B. tabaci*, respectively. For instance, Nomikou et al. (2001) showed that (r_m) of *E. scutalis* fed on *Panonychus citri* averaged 0.23-0.29 according to the temperature. Also, Kasap (2004) recorded that (r_m) value of *E. scutalis* fed on *P. citri* was between 0.16 and 0.29 by increasing temperature, While Momen and El-Sawi (2008) stated that (r_m) value did not exceed 0.14 when the same predatory fed on eggs of cotton leaf worm. However, Al-Shammery (2010) and Osman et al. (2013) reported that (r_m) value of *E. scutalis* was 0.220 and 0.229 when reared on *T. urticae*.

Predation efficiency of *Euseius scutalis* adult and mobile stages:

The average numbers of consumed *T.*

punicae mobile stages by *E. scutalis* larval, protonymphal and deutonymphal stages at (30 ± 1°C & 65 ± 5% R.H.) were respectively 3.93, 5.30 & 7.04 and 3.50, 4.83 & 8.67 individuals for female and male. While those on *S. phillyreae* eggs were respectively 3.28, 5.76 & 13.40 and 4.00, 6.00 & 9.71 for both sexes. *E. scutalis* adult female consumed higher number of prey during its oviposition time (64.32 *S. phillyreae* eggs), with total number of 136.60 consumed eggs during its life span. While those on *T. punicae* mobile stages were respectively 52.37 and 102.63 individuals. The total prey consumption for male during its life span was respectively 87.43 eggs and 60.83 individuals (Table 3).

Table (1): Mean durations (days ± SD) of *E. scutalis* reared on two prey species at (30 ± 1ºC, 65 ± 5% R.H.)

Developmental stage	*S. phillyreae*		*T. punicae*		F-value	P-value	L.S.D
	♀	♂	♀	♂			
Egg	1.96±0.75a	1.89±0.85a	1.96±0.73a	1.67±0.76a	0.79	0.503	0.43
Larva	2.21±0.51a	2.26±0.71a	2.28±0.58a	2.50±0.78a	0.95	0.421	0.36
Protonymph	2.04±0.36a	1.89±0.85a	1.93±0.27a	1.83±0.7a	0.53	0.664	0.33
Deutonymph	2.21±0.59a	1.59±0.50b	2.00±0.68a	1.50±0.51b	8.40	0.0001	0.32
Immature stages	6.46±1.06a	5.74±1.06b	6.20±1.03ab	5.83±1.37ab	2.16	0.047	0.63
Life cycle	8.42±1.02a	7.63±1.62ab	8.17±1.10ab	7.50±1.53b	2.59	0.057	0.74
Generation	10.46±1.35a	.	10.24±1.30a	.	0.34	0.560	0.74
Pre-oviposition	2.04±0.81a	.	2.07±0.73a	.	0.02	0.081	0.43
Oviposition	9.96±2.66a	.	8.74±1.68a	.	3.91	0.053	1.23
Post-oviposition	2.83±0.82a	.	3.19±0.74a	.	2.62	0.112	0.43
Longevity	14.83±2.63a	11.93±1.84b	14.00±1.57a	11.83±1.99b	13.76	0.0001	1.12
Fecundity	19.38±5.69a	.	16.85±5.89a	.	2.40	0.127	3.27
Daily rate	2.05±0.76a	.	1.97±0.70a	.	0.16	0.686	0.41
Life span	23.25±2.91a	19.56±3.34b	22.17±1.74a	19.33±3.47b	10.90	0.0001	1.63

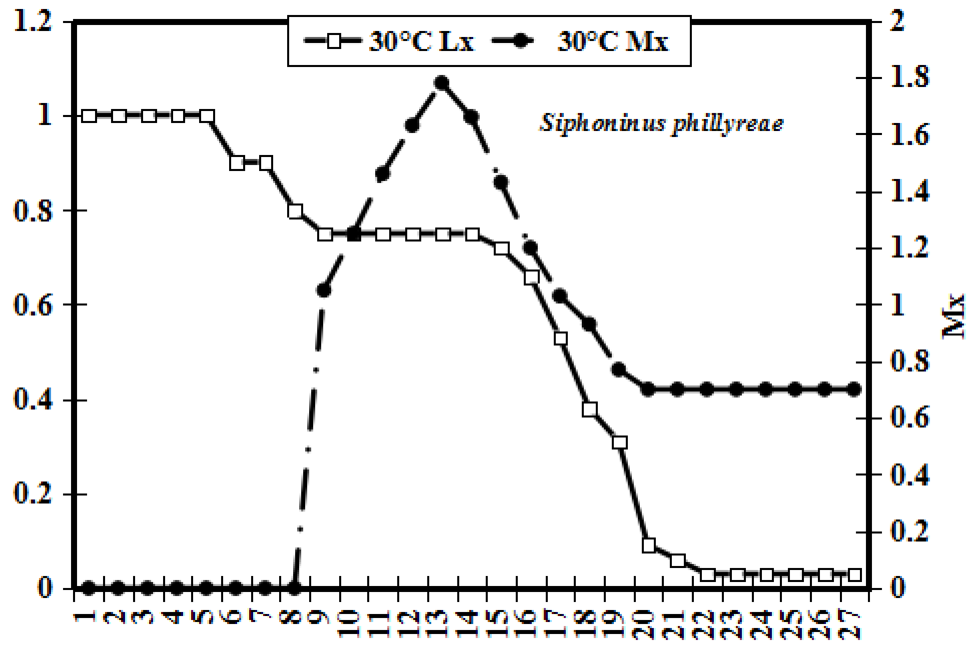
The means are followed by different letters in the same rows are significantly divergent ($P < 0.05$, Duncan).

Table (2): Life table parameters of *E. scutalis* reared on *S. phillyreae* and *T. punicae* at (30 ± 1ºC, 65 ± 5% R.H.**)**

Parameter	*S. phillyreae*	*T. punicae*
Mean generation time (T_c) [a]	12.62	12.19
Doubling time (*DT*) [a]	3.85	3.76
Net reproductive rate (R_0) [b]	9.82	9.47
Intrinsic rate of increase (r_m) [c]	0.180	0.184
Finite rate of increase (λ)[c]	1.19	1.20
Gross reproduction rate (*GRR*)[b]	19.79	16.52
50% mortality [a]	17	16
Survival rate %	0.75	0.70
Sex ratio (♀/total)	0.70	0.80

[a]Days, [b]per generation, [c] Individuals/female/day

$R_0 = \Sigma(l_x \times m_x)$; $T = \Sigma(x \times l_x \times mx) / \Sigma(l_x \times m_x)$; $r_m = ln(R_0)/T$; $DT = ln(2)/r_m$ and $\lambda = \exp(r_m)$.



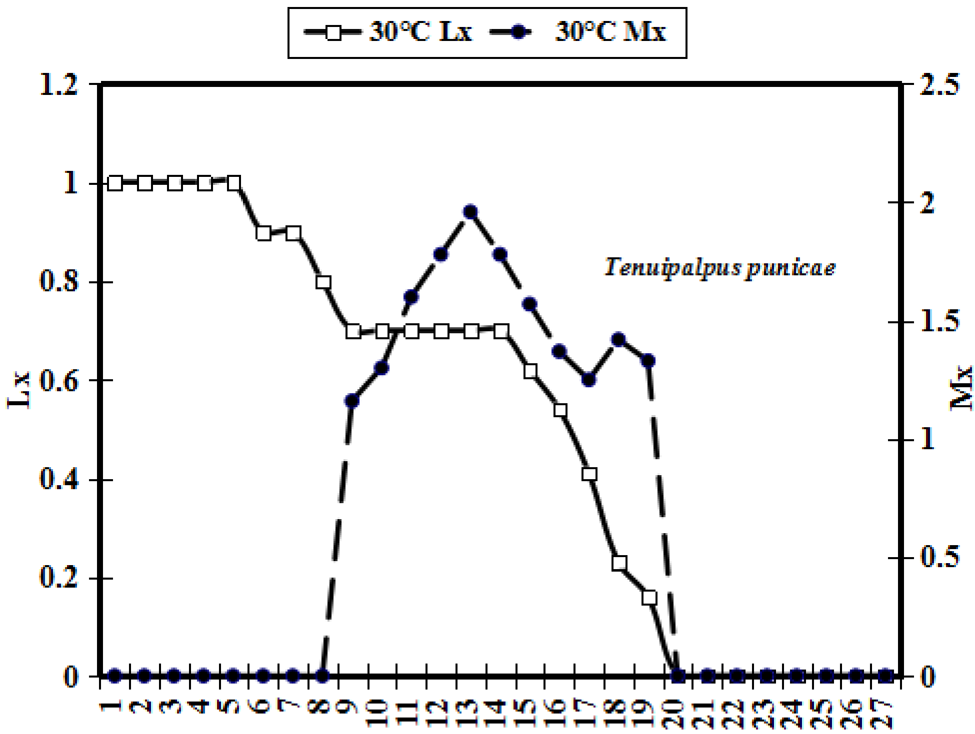


FIGURE (1). Age specific survivorship (Lx) and age specific fecundity (Mx) for *E. scutalis* feed *S. phillyreae* and *T. punicae* at 30 ± 1ºC & 65 ± 5% R.H.

Table (3): Number of consumed preys (Mean ± S.D.) by *E. scutalis* reared on *S. phillyreae* and *T. punicae* at (30 ± 1ºC, 65 ± 5% R.H.)

Developmental Stages	*S. phillyreae*	*T. punicae*	L.S.D 5%	T-value
		Female ♀		
Larva	3.28±1.46 a	3.93±1.17 a	0.74	3.12
Protonymph	5.76±2.42 a	5.30±2.64 a	1.41	0.48
Deutonymph	13.40±5.52 a	7.04±4.67 b	2.84	20.23
Pre-oviposition	25.36±5.74 a	15.30±4.56 b	2.87	49.3
Oviposition	64.32±17.92 a	52.37±16.46	9.57	6.28
Post-oviposition	24.48±5.56 a	18.70±4.37 b	2.77	17.49
Life span	136.60±22.16 a	102.63±15.63 b	10.62	41.30
		Male ♂		
Larva	4.00±1.0 a	3.50±1.87 a	1.79	0.38
Protonymph	6.00±1.63 a	4.83±3.31 a	3.10	0.68
Deutonymph	9.71±5.71 a	8.67±5.16 a	6.69	0.12
Life span	87.43±10.53 a	60.83±15.66 b	16.06	13.28

Means within rows followed by the same letter were not significantly different at the 5% level.

Conclusion

From the obtained results, it can be suggested that the phytoseiid, *Euseius scutalis* plays an important role as one of the natural control agents for its ability to control different arthropod pests.

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