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Different Biological Aspects of the Predaceous Mite *Euseius scutalis* (Acari: Gamasida: Phytoseiidae) and the Effects due to Feeding on Three Tetranychid Mite Species in Hail, Saudi Arabia

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Abstract: The phytoseiid predatory mite *Euseius scutalis* (Athias-Henriot) was observed feeding on different phytophagous mites, scale insects and whiteflies in Hail region, Saudi Arabia. It was reared for the whole life span on immature stages (larvae and nymphs) of the tetranychid mites *Tetranychus urticae* Koch; *Oligonychus afrasiaticus* McGregor and *Eutetranychus orientalis* Klein in the laboratory. Development of *E. scutalis* was not significantly affected by prey species but immature stages of *T. urticae* shortened the development of the predatory mite. Adult longevity was shorter when female mite fed on *O. afrasiaticus* while *T. urticae* significantly prolonged longevity time and caused the highest rate of egg production. Feeding on *T. urticae* immature stages, predatory mite has better life table parameters in comparison with the other prey mites. Mean generation time (T) averaged 14.88, 14.70 and 16.14 days; net reproductive rate (Ro) averaged 26.737, 13.248 and 13.606; intrinsic rate of natural increase (r_m) was 0.22, 0.175 and 0.161; finite rate of increase $e^{r_m}(\lambda)$ averaged 1.247, 1.192 and 1.175 when mite fed immature stages of *T. urticae*, *E. orientalis* and *O. afrasiaticus*, respectively. *Euseius scutalis* is considered a promising biological control agent against phytophagous mites, scale insects and whiteflies in Hail, Saudi Arabia.

Key words: Biology, Phytoseiid mite, *Euseius scutalis*, phytophagous mites, *Tetranychus urticae*, *Eutetranychus orientalis*, *Oligonychus afrasiaticus*

INTRODUCTION

In Saudi Arabia, phytophagous mites are serious pests on crops, vegetables and fruits and frequently cause considerable losses in plant yields. Three tetranychid mite species, *Tetranychus urticae* Koch; *Oligonychus afrasiaticus* McGregor and *Eutetranychus orientalis* Klein are considered the most abundant tetranychid mites inhabiting leaves, buds, stems, shoots and fruits of different plant species (Al-Shammery, 2008; Fouly and Al-Rahiyani, 2009). Unfortunately, high reproduction capability of tetranychid mite species attacking different plant species as well as rapid development give spider mites, especially the aforementioned species, the potential for outbreaks that may cause considerable economic damage (Al-Shammery, 2008). Traditionally, spider mites have been controlled with chemical acaricides, resulting in problems of pesticides resistance and residues on the harvested and consumed products.

The necessity of using alternative control tactics such as biological control of mite pests became a compulsive trend during the last decades to avoid problems raised from intensive

application of chemical pesticides in terms of organic farming. Predatory mites in family Phytoseiidae are cosmopolitan predators which were used as effective agents against a wide range of harmful insect and mite pests in biological control programs and IPM tactics (Sabelis, 1981; Geoghiou, 1990; Fouly *et al.*, 1995; Nomikou *et al.*, 2001; Inbar and Gerling, 2008). Fouly and Al-Rehiyani (2009) surveyed the predaceous mite species for the time in Qassim region, Saudi Arabia. They found that many of phytoseiid mites attacking phytophagous mite species that inhabiting leaves, buds and debris of crops, vegetables and fruit trees. Field observations showed that Predatory mites of genus *Euseius* (Acari: Phytoseiidae) are important predators especially *E. scutalis* (Athia-Henriot) which is generally found in association with phytophagous tetranychid mites, scale insects and whiteflies (Yousif *et al.*, 1982; Fouly and Hassan, 1991; Fouly and El-Laithy, 1992; Yue *et al.*, 1994; Nomikou *et al.*, 2001; Raza *et al.*, 2005; Al-Shammery, 2008; Emmert *et al.*, 2008; Inbar and Gerling, 2008; Fouly and Al-Rehiyani, 2009).

Because of no previous data with regard to the effectiveness of predatory mites attacking different kind of pests under Saudi conditions, the present protocol is considered a preliminary effort in due course. This study aims to evaluate the effect of prey mite species on different biological aspects and life table parameters of the native species *E. scutalis* as a biological control agent against three of phytophagous tetranychid mites, two-spotted spider mite *T. urticae*, brown citrus mite *E. orientalis* and red date palm spider mite *O. afrasiaticus* under laboratory conditions in Hail region, Saudi Arabia.

MATERIALS AND METHODS

Individuals of *E. scutalis* were collected from eggplant leaves grown at a special farm in Hail region during Summer, 2009. A pure culture of the predatory mite was maintained on the two-spotted spider mite *T. urticae* as a prey and reared on eggplant leaves under laboratory conditions. Adult males and females of *E. scutalis* were left together where the deposited eggs were daily extracted for a week and singly transferred into small discs of eggplant leaves (2 cm in diameter) and limited with tangle foot of a mixture of Canada balsam, citronella oil and castor oil to prevent mites from escaping. Five of these discs were placed together on a layer of cotton wool soaked in water in a Petri-dish (10 cm in diameter). Suitable moisture was daily maintained to the cotton layer. Eggs were left to hatch and the incubation period was counted. Approximately of 90 newly hatched larvae of nearly the same age were divided into three groups (treatments) thirty larvae each, where the first group was singly fed on a surplus amount of immature stages of *T. urticae*, while the second and third groups were subjected to *E. orientalis* and *O. afrasiaticus* during their whole life span. Consumed prey individuals were daily replaced by new ones. In all cases, data was statistically analyzed by ANOVA test to compare means (LSD test, where $p > 0.05$). To study the effect of different prey species on life table parameters of *E. scutalis*, we followed the formula of Andrewartha and Birch (1954), Laing (1968) and the basic computer program of Abou-Setta *et al.* (1986) where:

- L = No. of female alive
- x = Actual female age (in days)
- Mx = Age specific fecundity rate (Mean number of daughters born in an interval to a mother of age x)
- Lx = Rate of survival at day x (the fraction of females surviving from age 0 until at least age x)
- Ro = The net reproductive rate ($\sum Lx Mx$) (the total females born in two successive generations or the rate of multiplication in one generation)

- T = The mean generation time ($\sum Lx Mx \cdot x / \sum Lx Mx$)
 r_m = The intrinsic rate of natural increase (females/female/day)
 $e^{rm}(\lambda)$ = The finite rate of increase (number of times the population multiplies in a unit of time (Birch, 1948)

RESULTS

As in other phytoseiid mite species, both sexes passed through an egg, larva, protonymph and deutonymph before reaching adulthood. Under experiment conditions as shown in Table 1, the incubation period ranged from 1.6 to 2.0 days for both sexes. Concerning duration time of immature of *E. scutalis*, larval stage lasted 1.2; 1.0 and 1.54 days when it was provided with immature of *T. urticae*, *E. orientalis* and *O. afrasiaticus*, respectively. The same trend was observed for predator protonymph, where it lasted an average of 2.34, 2.61 and 2.78 days, while the deutonymph lasted 2.68, 2.56 and 2.74 days when they were fed on the same aforementioned preys, respectively. Therefore, the earlier results showed that the developmental time of *E. scutalis* wasn't significantly affected by food source and lasted 8.02, 8.19 and 9.06 days when predator immature stages of females were subjected to immature of *T. urticae*, *E. orientalis* and *O. afrasiaticus*, respectively (Table 1). Whatever the prey mite species, data showed that males of the predatory mite *E. scutalis* emerged earlier than females. In all cases, it was noticed that immature stages of *T. urticae* accelerated the development more than *E. orientalis*, while immature *O. afrasiaticus* were not as preferable food source as the other two species. Adulthood of *E. scutalis* showed that males lived for shorter time than females. Males fed on immature *T. urticae*, *E. orientalis* and *O. afrasiaticus* lived for 23.64, 18.80 and 16.46 days while females lived for 26.4, 22.6 and 19.4 days, respectively (Table 1). From the earlier results, it can be noticed that *T. urticae* prolonged the longevity of predator followed by *E. orientalis* and *O. afrasiaticus*. During oviposition period, female mite lived for 18.60 days and laid an average of 30.66 eggs with a daily rate of 1.64 eggs, while it lived for 16.40 and 14.6 days and laid 19.25 and 14.60 eggs with an average of 1.17 and 1.11 eggs day⁻¹ when female predator preyed on immature stages of *T. urticae*, *E. orientalis* and *O. afrasiaticus*, respectively (Table 2). Therefore, feeding on *T. urticae* significantly prolonged predator longevity and caused a higher rate of fertility (egg production).

Table 1: Developmental time of immature stages, adult longevity and sex ratio of *Euseius scutalis* fed on *Tetranychus urticae*, *Eutetranychus orientalis* and *Oligonychus afrasiaticus* at 26°C and 70% RH

Prey mite species	Sex	Egg	Larva	Protonymph	Deutonymph	Total	Adult longevity
<i>Tetranychus urticae</i>	Male	1.6±0.06	0.78±0.10	1.54±0.34	2.48±0.64	6.40±0.38	23.64±2.12
	Female	1.8±0.05	1.20±0.40	2.34±0.89	2.68±0.39	8.02±0.58	26.40±2.89
<i>Eutetranychus orientalis</i>	Male	1.90±0.6	1.00±0.02	2.21±0.62	2.12±0.33	7.23±0.48	18.80±1.96
	Female	2.0±0.04	1.00±0.30	2.61±0.46	2.58±0.58	8.19±0.78	22.60±1.43
<i>Oligonychus afrasiaticus</i>	Male	1.80±0.4	1.46±0.42	2.11±0.45	2.24±0.35	7.61±0.64	16.46±1.23
	Female	2.0±0.2	1.54±0.33	2.78±0.38	2.74±0.44	9.06±0.84	19.40±1.95
LSD (p>0.05)	--	--	--	--	--	--	2.82

Values are represent as Mean±SE

Table 2: Effect of different prey mite species on the duration of oviposition period, total and daily rate of egg production of *Euseius scutalis*

Prey mite species	Duration of oviposition period	Average No. of deposited eggs	
		T	D
<i>Tetranychus urticae</i>	18.60±1.02	30.66±3.62	1.64±0.06
<i>Eutetranychus orientalis</i>	16.40±0.89	19.25±1.87	1.17±0.04
<i>Oligonychus afrasiaticus</i>	14.62±0.64	16.24±1.08	1.11±0.02
LSD (p>0.05)	1.44	3.88	0.42

Values are represent as Mean±SE

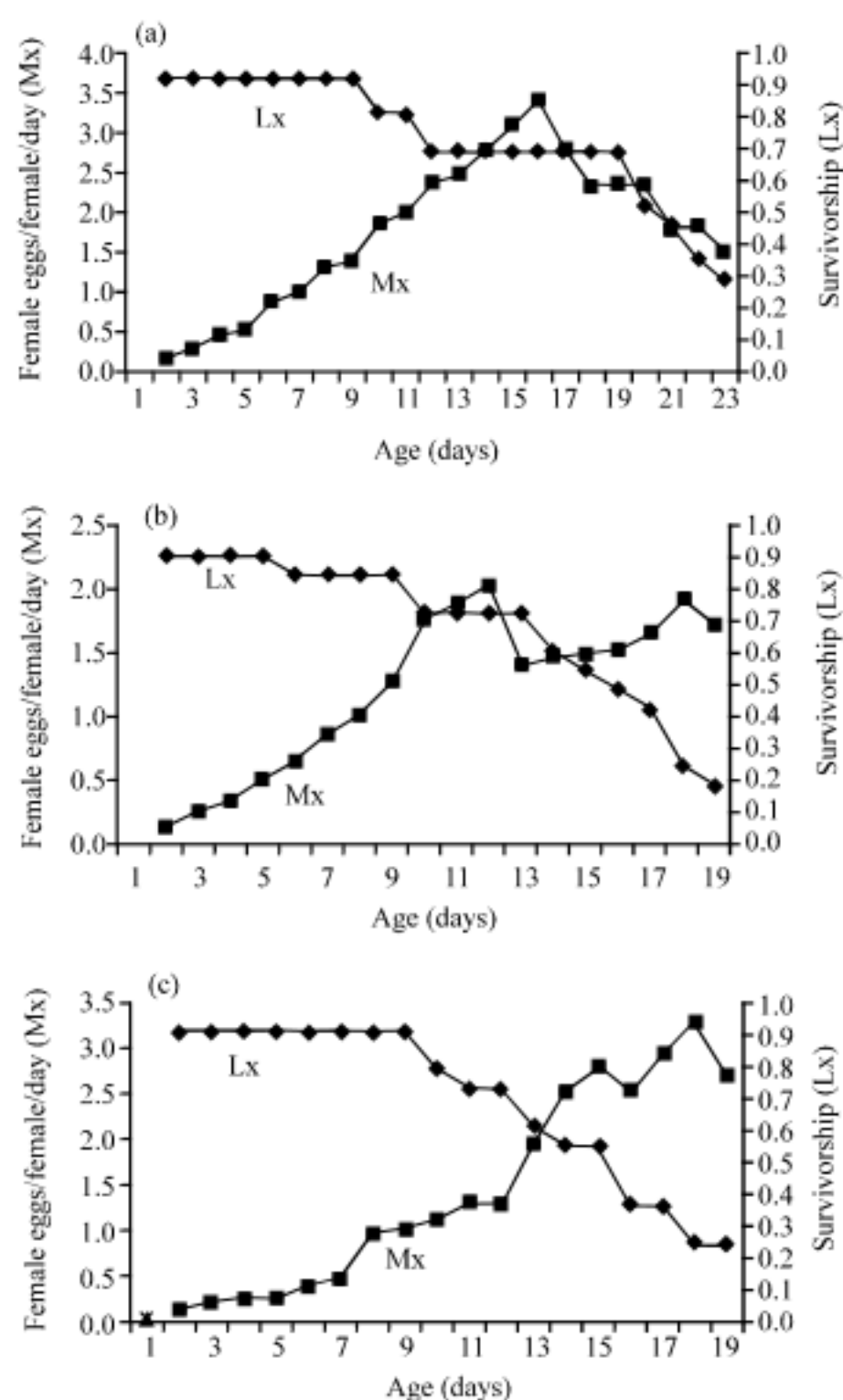


Fig. 1: Age-specific fecundity (Mx) and survival (Lx) of *Euseius scutalis* fed on *Tetranychus urticae*, *Eutetranychus orientalis* and *Oligonychus afrasiaticus*. (a) *Euseius scutalis* fed on *Tetranychus urticae* immature, (b) *Euseius scutalis* fed on *Eutetranychus orientalis* immature and (c) *Euseius scutalis* fed on *Oligonychus afrasiaticus*

Concerning the effect of different prey mites on the table parameters of *E. scutalis* under laboratory conditions, data in Table 1 and 3 clearly showed that sex ratio was not affected by food source, where females percentages (females/females+males) averaged 58, 56 and 55% when mites were fed on immature stages of *T. urticae*, *E. orientalis* and *O. afrasiaticus*, respectively. These values were subsequently used in calculation the specific rate of fecundity (Mx). It was also noticed that feeding on *T. urticae* or *E. orientalis* caused a mean generation time (T) of 14.70 and 14.88 days, while T value was longer when the predatory mite was subjected to date palm red spider mite *O. afrasiaticus* (16.14 days), respectively. As shown in Table 2 and Fig. 1a-c, it was clear that *T. urticae* immature caused the highest value of net reproductive rate ($Ro = \sum_{i=0}^{i=Lx} Mx_i$) of 26.73 expected female daughters per female. Feeding on immature of both *E. orientalis* and *O. afrasiaticus* resulted in lower sub-equal Ro values of 13.248 and 13.606 expected female/female, respectively. That means *E. orientalis* and *O. afrasiaticus* resulted in Ro about 50% of that obtained by feeding on *T. urticae*.

Table 3: Life table parameters of *Euseius scutalis* fed on *Tetranychus urticae*, *Eutetranychus orientalis* and *Oligonychus afrasiaticus* in lab at 26°C and 70% RH

Prey mite species	Female (%)	Mean generation time (days) (T)	Net reproductive rate (female egg/female) (Ro)	Intrinsic rate of natural increase (r_m)	Finite rate of increase (e^{rm})
<i>Tetranychus urticae</i>	58	14.88	26.737	0.220	1.247
<i>Eutetranychus orientalis</i>	56	14.70	13.248	0.175	1.192
<i>Oligonychus afrasiaticus</i>	55	16.14	13.606	0.161	1.175

Concerning the intrinsic rate of increase (r_m) (female/female/day), Prey mites tested here obviously affected the intrinsic rate of increase of *E. scutalis* where it was 0.22 female progeny/female/day when predatory mite fed *T. urticae* and sharply declined to 0.17 and 0.16 with *E. orientalis* and *O. afrasiaticus*, respectively (Table 3). Concerning the finite rate of increase e^{rm} (λ) (population multiplications in a unit of time) data showed that it was at its highest level (1.247) when *E. scutalis* individuals fed immature stages of *T. urticae* and declined to 1.192 and 1.175 after feeding *E. orientalis* and *O. afrasiaticus*, respectively.

DISCUSSION

Field observations showed that individuals of the predatory mite *E. scutalis* were found to feed on all stages of the two-spotted spider mite *T. urticae* inhabiting eggplant leaves and on citrus brown mite *E. orientalis* inhabiting citrus leaves as well as different scale insects and whiteflies. The previous results showed that the developmental time of *E. scutalis* wasn't significantly affected by food source. Similar results were obtained by Yue *et al.* (1994), who noticed that *Euseius mesembrinus* (Dean) developed in 8.5-12.5 days after feeding on different kinds of pollen grains, while Abou-Setta *et al.* (1997) found that *Proprioseiopsis rotendus* (Muma) lasted only 6.58 days when immature stages fed on *T. urticae*. Data also showed that males of the predatory mite *E. scutalis* emerged earlier than females. Similar results were obtained by Abou-Setta *et al.* (1997) and Mohamed *et al.* (2008) who reared *P. rotendus* and *Neoseiulus cucumeris* (Oudemans) on mobile stages of *T. urticae* and European red spider mite *Panonychus ulmi* (Koch), respectively. Moreover, the present results agree with those of El-Laithy and Fouly (1992), who noticed that male and female life cycle of *E. scutalis* averaged 6.8 and 7.8 days, respectively. Immature stages of *T. urticae* generally accelerated the development of predatory mite more than *E. orientalis*, while immature stages of *O. afrasiaticus* were not as preferable food source as the other two species. Similarly, Abou-Setta *et al.* (1997) found that immature stages of two-spotted spider mite *T. urticae* also accelerated the development of the phytoseiid mite *P. rotendus* fed different kind of food sources. However, most phytoseiid species completed their development from egg to adult female at a constant temperature of 25-26°C with a range of 5-7 days (Sherif, 1982; Abou-Setta and Childers, 1989; Caceres and Childers, 1991; Fouly and El-Laithy, 1992; Kasap and Lu, 2004; Raza *et al.*, 2005).

Adulthood of *E. scutalis* showed that males lived for shorter time than females. The present results showed that *T. urticae* prolonged the longevity of predator followed by *E. orientalis* and *O. afrasiaticus*. Similarly, El-Laithy and Fouly (1992) found that female longevity of *A. (Euseius) scutalis* fed on the same prey species lasted 27.8 days, while *N. cucumeris* fed on *P. ulmi* lasted 20.15 days (Mohamed *et al.*, 2008). Feeding on *T. urticae* significantly prolonged predator longevity and caused a higher rate of fertility (egg production). Similar results were obtained by Fouly and El-Laithy (1992) who found that female of *A. (Neoseiulus) barkeri* (Hughes) laid an average of 1.02 egg day⁻¹ during an oviposition period of 13 days. Moreover, Abou-Setta *et al.* (1997) found that *T. urticae* prolonged the oviposition period of the phytoseiid predatory mite *P. rotendus* over any kind

of food sources. Therefore, it can be concluded that prolongation in oviposition period of a predatory mite may give a higher rate of egg production. Sabelis (1981) stated that the prey consumption formed a ratio of about 70% of the biomass of deposited eggs by the predatory mite. In other word, the total eggs deposited during the ovipositional period represented about 70% from total protein of consumed preys.

Survival curves (L_x) of *E. scutalis* fed on the previously mentioned mite preys followed a type I in which most eggs developed to maturity (92, 90 and 91%, respectively) and most female death occurred gradually after extended ovipositional period. These results agree with those obtained by El-Laithy and Fouly (1992), Abou-Setta *et al.* (1997), Fouly (1996) and Escudero and Ferragut (2005), who reared *A. (Euseius) scutalis*, *A. (Typhlodromips) swirskii*, *Proprioseiopsis rotendus*, *P. aetus* and *Neoseiulus californicus* (McGregor), respectively. Feeding on *E. orientalis* and *O. afrasiaticus* resulted in R_o about 50% of that obtained by feeding on *T. urticae*. El-Laithy and Fouly (1992) found that R_o of *A. (Euseius) scutalis* and *A. (Typhlodromips) swirskii* were 17.22 and 22.97. Contradictory, Escudero and Ferragut (2005) found a higher R_o value with *N. californicus* and *P. persimilis* where it reached 49.25 and 45.61 expected female progeny/female after feeding on the two-spotted spider mite *T. urticae*. Momen and El-Sawi (2008) found that lower R_o value was obtained when *E. scutalis* was provided with eggs of two Lepidopterous insects where it averaged 10.94 and 5.40 expected females/female after feeding on eggs of *Spodoptera littoralis* Boisduval and *S. ipsillon* (Hufnagel). Emmert *et al.* (2008) contradictory found that *T. urticae* was not the favorable prey mite where it caused R_o value of *P. aetus* 50% lower than feeding on thrips *Frankliniella occidentalis* (Pergande) or cattail pollen *Typha latifolia* L.

Concerning the intrinsic rate of increase (r_m), Birch (1948) stated that r_m is the rate of increase of an insect species under specific physical conditions, in unlimited environment where the effects of increasing density don't need to be considered. The present study cleared that tested prey mites obviously affected the intrinsic rate of increase of *E. scutalis* where it was higher when predatory mite fed *T. urticae* and sharply declined after feeding on *E. orientalis* and *O. afrasiaticus*. Nomikou *et al.* (2001) reported that r_m of *E. scutalis* fed citrus red spider mite *P. citri* averaged 0.23-0.29 according to the temperature. Kasap and Lu (2004) also found that r_m value of *E. scutalis* fed *P. citri* was between 0.16 to 0.29 female/female/day by increasing temperature. While Momen and El-Sawi (2008) found that r_m value didn't exceed 0.14 when the same predatory mite fed eggs of cotton leaf worm *S. littoralis*. Concerning the finite rate of increase e^{r_m} (λ) (population multiplications in a unit of time) data showed that it was at its highest level when *E. scutalis* individuals fed immature of *T. urticae* and declined after feeding *E. orientalis* and *O. afrasiaticus*. Similar results were obtained by El-Laithy and Fouly (1992), who found that e^{r_m} (λ) of *E. scutalis* fed *T. urticae* was 1.157, while it was only 1.106 when Momen and El-Sawi (2008) reared *E. scutalis* on eggs of the insect *S. ipsillon*. From the earlier results, it can be concluded that rearing *E. scutalis* on immature stages of *T. urticae* was considerably better than other prey mite to obtain higher values of egg production under laboratory conditions. Further experiments are highly needed to know more about different species of predatory mites as biological control agents in Saudi Arabia.

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