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Effect of Nourishment and Mutual Interference on Feeding Capacity and Life-Table Parameters of *Phytoseius plumifer* (C. & F.) (Acari: Phytoseiidae)

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ABSTRACT

Effect of crowding and mutual interference of the phytoseiid predatory mite *Phytoseius plumifer* (C. & F.) fed on spider mite *Tetranychus urticae* Koch and broad mite *Polyphagotarsonemus latus* (Banks) on its feeding capacity was studied in the laboratory. Increasing number of predatory mite per each arena decreased food consumption. A negative correlation was found between numbers of *P. plumifer* and its feeding capacity. Influence of prey species on different life-table parameters of *P. plumifer* revealed that feeding on broad mite prolonged generation time (*T*) and doubling time (*DT*) of the predatory mite, while feeding on *T. urticae* increased the net reproductive rate R_o, intrinsic rate of natural increase r_m, finite rate of increase e^{rm} *(λ)* and gross reproduction *GRR* of the predatory mite *P. plumifer*.

Keywords: *Phytoseius plumifer, Polphagotarsonrmus latus, Tetranychus urticae,* mutual interference, life-table parameters

INTRODUCTION

The two-spotted spider mite (TSSM), *Tetranychus urticae* Koch (Acari: Tetranychidae) is considered to be one of the major mite pests attacking different agricultural crops including vegetables. Among 1200 species of spider mites known in the world (Zhang, 2003), *T. urticae* has been reported from 150 host plants of economic value (Zaher 1986 and Wilkerson *et al*., 2005). TSSM feeds by puncturing cells and draining the contents, producing characteristics yellow specking of the leaf surface. It also produces silk webbing, which is clearly visible at high infestation level (Alzoubi and Cobanoglu, 2006) and this reduces plant's ability to build carbohydrates, which, therefore, results in reduction of the total yield.

On the other hand, the prostigmatid mite *Polyphagotarsonemus latus* (Banks) (Acari: Tarsonemidae) is also one of the most injurious mite pests with different common name (yellow broad, broad and jute mite (Masoud *et al.* 2001). This mite is undoubtedly the most important tarsonemid mite pest of many economic crops throughout the tropics and ornamentals in greenhouses worldwide such as pepper, tomato and cucumber, African violet, begonia, chrysanthemum, cyclamen, dahlia, Gloxinia, Fuchsia, Gerbera, Hibiscus, Impatiens and ivy. It causes equivalent hazards as of the two-spotted spider mite (Gerson, 1992; Zhang, 2003 and de Moraes and Flechtmann, 2008). It was also reported that *P. latus* acts as a vector of leaf curl virus (Chakraborti, 2000). Damaged leaves may split or crack open and have a rugged appearance. Injured flowers have distorted and discolored rays (de Moraes and Flechtmann, 2008).

Damage of cucumber, aubergines and squash includes crinkling, cracking, discoloration, malformations, swelling and necrosis similar to those caused by a hormonal weed killer (Meyer, 1981 and Roditakis and Drossos, 1987). In Egypt, *P. latus* was recorded in early ninety of the last century on cucumber plants in Giza and Qualyobia Governorates and it then spread infesting other vegetables not only in plastic houses but also in open fields (Mostafa, 2007).

Chemical control is generally the main method of combating mite pests (Oliveira *et al.* 2007). So far, acaricides are the only tool for mite pest management that is reliable for emergency action when mite pest populations approach or exceed the action threshold (Metcalf, 1982). Nevertheless, some beneficial arthropods can play an important and promising role in mite control especially in an Integrated Mite Management (IMM). For this purpose, predatory mites especially those in family Phytoseiidae have been used successfully in IMM programs (Sabelis 1981 and 1985, Gerson, 1992; Fan and Petitt, 1994, Fouly *et al.,* 1995; McMurtry and Croft 1997; Fouly 1997 and Fouly *et al.,* 2014).

Phytoseius plumifer (Cantestrini and Fanzago) is one of the most frequent phytoseiids in Port Said farms and almost collected from plant samples all the year around (Zaher *et al.,* 1969, Rasmy and El-Benhawy, 1974 and Zaher, 1986).

Accordingly, the present protocol aims to evaluate the effect of crowding and mutual interference of predatory mite *P. plumifer* fed on each of spider mite and broad mite on its feeding capacity. Moreover, the influence of *T. urticae* and *P. latus* as food sources on life-table parameters of the predatory mite, *P. plumifer* was determined under laboratory conditions.

MATERIALS AND METHODS

Tetranychus urticae and *Polyphagotarsonemus latus* cultures

Cultures of spider mites were collected from bean plants *Phaseolus vulgaris,* while broad mite were found on cucumber leaves growing in a private farm at Port Said province in summer 2017. Adult females of both spider mites and broad mites have been collected and transferred onto bean seedlings growing in plastic pots (20 cm in diameter). Plant seedlings received normal agricultural maintains and left for 30-40 days to give mites the opportunity to build up their populations and used as food sources of predatory mite *P. plumifer* in further experiments.

Phytoseius plumifer culture

For rearing predatory mites, fig leaves *Ficus carica* of similar dimensions as mentioned above were used as rearing substrates and placed upside down on cotton in Petri dishes (15 cm in diameter) where drops of water were added daily to keep leaf discs fresh, and to prevent mite individuals from escaping. Predatory mite individuals were provided with a surplus amount of spider mite and used in subsequent experiments. Devoured preys were replaced by alive ones every other day. A pure culture of the predatory mite was maintained in an incubator at 26±1°C and 70±5% RH and 14:10 (D:L) photoperiod.

Effect of crowding on feeding capacity of *Phytoseius plumifer*

Newly deposited eggs of *P. plumifer* were collected daily for ten days and then divided into five groups of 10 eggs each/arena. As soon as nymphs reached maturity, the first group was represented by a newly emerged single female was coupled with a male from the culture and provided with a surplus amount of motile stages of spider mites. The second to the fifth groups were represented by 2, 3, 4 and 5 adult females in each arena and fed on spider mites for ten days. Each group was replicated for five times. Other five groups of 1, 2, 3, 4 and 5 adult females of predatory mite *P. plumifer* were provided with broad mites *P. latus* as a prey. In all experiments, number of consumed preys was counted daily and all treatments were kept in an incubator at 26±1°C and 70±5% RH and 14:10 (D:L) photoperiod.

Life-table parameters of *Phytoseius plumifer*

Life table parameters of *P. plumifer* were investigated when it was provided with each of *T. urticae* and *P. latus* as preys under laboratory conditions of 26±1^{o}C and 70±5% RH. Duration of developmental stages, mortality in each stage, female proportion and number of deposited eggs (fecundity) of *P. plumifer* females were determined daily and used for calculating the life-tables (Birch, 1948), Laing (1968) and then all data was subjected to the Basic Computer Program of Abou-Setta *et al.* (1986). Life-table parameters of *P. plumifer* are: the intrinsic rate of natural increase (r_m), L_x the age-specific survival rate and M_x the oviposition rate at age x, the net reproductive rate (R_o), the mean generation time in days (T), sex ratio or the proportion of females (number of females /Σ females + males), the finite rate of increase ($e^{rm}=\lambda$) , doubling time DT as well as the gross reproductive rate ($GRR=\Sigma Mx$).

RESULTS AND DISCUSSION

Data in table (1) showed that during 10 days a single female of *P. plumifer* consumed an average of 9.7 mite individuals of *P. latus* / day and that significantly decreased when two females were confined together in each arena where each female consumed 7.25 mites / day.

There were no significant differences between feeding capacity of 3-5 *P. plumifer* females provided with broad mite as a prey. That means *P. plumifer* showed its highest food consumption rates when it was kept without any kind of crowding (F 86.60; df 4, 45; P=0.000).

Concerning *P. plumifer* fed on spider mite *T. urticae*, data showed that there were significant differences between the feeding capacity of a single female of *P. plumifer* or more in each arena as shown in Table (1). Each predatory mite fed on average of 5.23, 5.41, 4.33, 4.09 and 3.74 prey individuals/day when 1, 2, 3, 4 and 5 females of predatory mites were confined together in each plant arena, respectively (F 264.99; df 4, 45; P=0.000).

Table 1. Effect of crowding of predatory mite, *Phytoseius plumifer* fed on broad mite *Polyphagotarsonemus latus* and spider mites *Tetranychus urticae* on its feeding capacity and kept at 26±1^{o}C and 70±5% RH

Prey species	No. predatory mite females *Phytoseius plumifer/ arena*						Coefficient of determination R^2
	1	2	3	4	5	L.S.D	
Polyphagotarsonemus latus	9.7±^{Aa}1.4	7.25^{Ba}±1.0	5.93^{Ca}±0.6	5.20^{Ca}±0.5	5.02^{Ca}±0.4	0.55	0.871
Teranychus urticae	5.23^{Bb}±0.6	5.41^{Ab}±0.7	4.33^{Cb}±0.4	4.09^{Db}±0.3	3.74^{Eb}±0.3	0.13	0.873
L.S.D	1.24	1.08	1.02	1.06	1.18	--	--

Similar capital letters in each raw are not significantly different, similar small letters in each column are not significantly different, L.S.D values when P=0.05

On the other hand, it was obviously noticed that *P. plumifer* consumed a higher number of broad mite than spider mite even the number of predatory mites in each arena. Data in Table (1) showed that 9.7 of broad mite and 5.23 of spider mite individuals were consumed by a single female of predatory mite, respectively (F 1685.6; df 1, 18; P=0.000). Similar trend was observed where numbers of devoured preys increased by each predator and all differences were significant. These differences between feeding capacity of *P. plumifer* which was provided with broad mite and spider mites proved that *P. latus* is preferable diet to predatory mite. That may be also due to either the small size of broad mite individuals or the higher nutritional value of spider mites (Figs 1-2). Similar results were obtained by McMurtry *et al.* (2013) who found that *Phytoseius* species with the small size and laterally compressed idiosoma aid them to move between leaf trichomes. This is the place where tetranychid or tarsonemid mites usually lay their eggs and not occupied by other types of predators. So, they can find easily their preferred food without interruption by other predaceous arthropods.

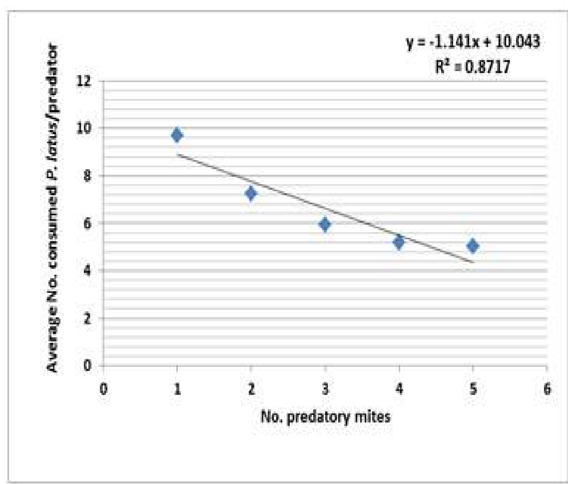

Fig. 1. Regression analyses of prey consumption of *Phytoseius plumifer* fed on broad mite *Polyphagotarsonemus altus* and kept at 26+1^{o}C and 70+5% RH

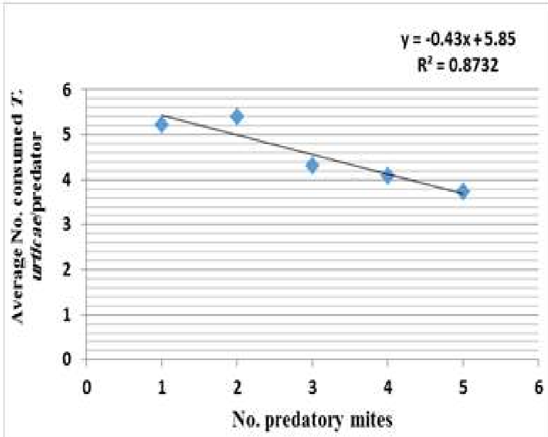

Fig. 2. Regression analyses of prey consumption of *Phytoseius plumifer* fed on spider mite *Tetranychus urticae* and kept at 26+1°C and 70+5% RH

In all cases, Figs (1-2) showed that there was a negative effect of crowding on predator feeding capacity.

Approximately 87.1% and 87.3% of the differences in prey consumption of *P. plumifer* directly resulted by its crowding factor (R^2= 0.871 and 0.873 for a diet of broad mite and spider mite, respectively). Therefore, it can be concluded that crowding is the key factor affecting food consumption of the predatory mite *P. plumifer* fed on either broad mite or spider mite. Similar results were obtained by Khodayari *et al.* (2016) who stated that as *P. plumifer* density increased, the per capita predation rate and per capita searching efficiency decreased significantly when it was provided with *T. urticae* as a food. They added that there was significant decrease of the number of prey consumed per predator with an increased predator density suggests that interference amongst predators also increase at higher predator density. This is probably due to a closed experimental arena with limited predation time and high probability of mutual interference. Moreover, Fouly *et al.,* (2011) obtained similar results when they reared *Typhlodromips swirskii* (Athias-Henriot) on whitefly *Bemisia tabaci* Genn.

Effect of crowding of *Phytoseius plumifer* on its life-table parameters

Fig 3 shows that survivorship curves of *P. plumifer* (Lx) followed the pattern in which most eggs hatched and most developing stages succeeded to reach maturity and death gradually occurred over an extended oviposition period. Almost 92% of immature stages of *P. plumifer,* which were fed *T. urticae,* reached adulthood, while 89% from mites fed on broad mite passed to maturity as represented by *Lx* values (Fig. 1). Sanderson and McMurtry (1984) and Louni *et al.* (2014) demonstrated that 100% of developmental stages of *P. plumifer* passed to adulthood when it was provided with *Rhyncaphytoptus ficifoliae* Keifer Prey species had no remarkable effect on female proportion in the first generation which was represented by 0.56 and 0.58 when predatory mites fed on broad mite and spider mite, respectively (Table 2). A higher female proportion was obtained by Louni *et al.* (2014) who found that the sex ratio of *P. plumifer* was 65% females when it fed on *R. ficifoliae*. In general, the variation of sex ratio in the present study may provide circumstantial signal for the hypothesis that a mite female such as *P. plumifer* may produce more males under any kind of stress like prey species. Nachman (2006) obtained similar results but with *Pytoseiulus persimilis* A.-H., where he noticed that increasing predator individuals significantly decreased its feeding capacity.

The mean generation time (*T*) was obviously affected by diets as shown in Table (2). Feeding on broad mite prolonged *T* time to 16.81 days, while it was 15.29 days for *P. plumifer* mites fed on spider mite, respectively.

Similar results were obtained by Louni *et al.* (2014) who found that *P. plumifer*, which fed on *R. ficifoliae*, the mean generation time was 18.78 days. Accordingly, broad mite prolonged *DT* time (the time required for a population to double itself). Therefore, *P. plumifer* needed approximately 1.57 days to double its population by feeding on broad mite but it needed only 1.30 days when fed on spider mites.

Concerning fecundity, a diet of *T. urticae* proved to be more preferable for predatory mite to give a higher rate of fecundity where net reproductive rate R_o was 33.68 female eggs / female / generation while it was only 24.52 when it was provided with broad mite. These results indicated that broad mite reduced the fecundity of *P. plumifer* by 27.2% as compared with fecundity when spider mite was available as a food source (Fig. 4). The same trend was also observed with intrinsic rate of natural increase (r_m), which is a useful issue to predict the population growth potential of mite species under certain environmental conditions. Feeding on broad mite and spider mite gave r_m values of 0.19 and 0.23 female offspring/female ($female^{-1} day^{-1}$), respectively (Table 2). In other words, feeding of *P. plumifer* on broad mite reduced its intrinsic rate of increase by 17.39% in comparison with feeding on spider mite as shown in Table (2).

Concerning the finite rate of increase ($e^{rm} = \lambda$), the present results showed that it decreased when *P. plumifer* was subjected to broad mite as a prey and reduced by 3.97% when fed on spider mite. Gross reproduction rate *GRR* ($\sum Mx$) was also affected by prey types, where it was 49.67 and declined to 42.19 offspring when *P. plumifer* was provided with spider mite and broad mite, respectively. Similarly, Louni *et al.* (2014) indicated that the net reproductive rate, intrinsic rate of increase and finite rate of increase of *P. plumifer* fed on *R. ficifoliae* were 17.99 female offspring, 0.154 and 1.166 day^{-1}, respectively. Similar results were obtained by Nawar *et al.* (2001) with *P. plumifer* and Fouly *et al.* (2014) with three phytoseiid mites, *Neoseiulus cucumeris* (Oudemans), *N. barkeri* (Hughes) and *T. swirskii*.

From the previous results, it can be concluded that crowding of predatory mite *P. plumifer* had a negative effect on its feeding capacity where number of consumed preys negatively correlated with number of predatory mites lived together in a certain plant arena. Moreover, feeding on spider mites accelerated the development of *P. plumifer* and gave a shorter generation time as well as doubling time. Although, predatory mite ate more broad mites but showed a lower rate of fecundity which was represented by the net reproductive rate, intrinsic rate of increase and finite rate of increase.

Table 2. Effect of crowding of Phytoseius plumifer fed on Tetranychus urticae and Polyphagotarsonemus latus and kept at 26 + 1oC and 70 + 5% RH on its life - table parameters

Life table parameters	Prey mite species: *Polyphagotarsonemus latus*	Prey mite species: *Tetranychus urticae*
No.	18	20
Survival %	89	92
Female proportion	0.56	0.58
Mean generation time (T)	16.81	15.29
Doubling time (DT)	1.57	1.30
Net reproductive rate (R_o)	24.52	33.68
Intrinsic rate of increase (r_m)	0.19	0.23
Finite rate of increase (e^{rm}) λ	1.21	1.26
Gross reproduction (GRR)	42.19	49.67

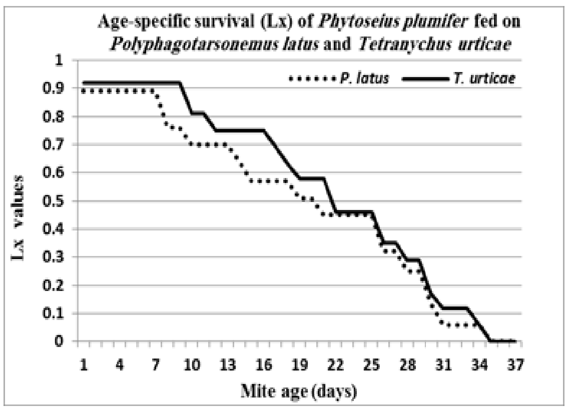

Fig. 3. Age specific survival (Lx) of *Phytoseius plumifer* fed on broad mite and spider mite and kept at 26+1°C and 70+5% RH

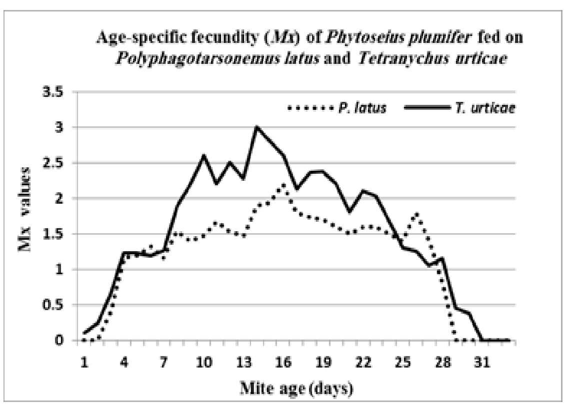

Fig. 4. Age specific fecundity (Mx) of *Phytoseius plumifer* fed on broad mite and spider mite and kept at 26+1°C and 70+5% RH

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تأثير نوع الغذاء والتدخل المتبادل على الكفاءة الغذائية وجداول الحياة للمفترس الأكاروسي فايتوسيس بلومفير (أكاري : فايتوسييدي)

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[١] قسم الحيوان الزراعي – كلية الزراعة – جامعة المنصورة - المنصورة

[٢]الهيئة العامة للرقابة على الصادرات والواردات – ميناء بورسعيد - بورسعيد

تم جمع أفراد من العنكبوت الأحمر (تترانيكس اورتيكا) من أوراق الفاصوليا والحلم العريض (بوليفاجوتارسونيمس لاتس) من أوراق الخيار المنزرع في البيوت المحمية في محافظة بورسعيد - بينما تم جمع أفراد المفترس الأكاروسي فايتوسيس بلومفير من أوراق التين في نفس المنطقة الجغرافية. تمت دراسة تأثير نوع الفريسة وكذلك التنافس النوعي والتزاحم بين أفراد المفترس على الكفاءة الافتراسية وجداول حياة المفترس الأكاروسي حيث أوضحت النتائج أن هناك علاقة سلبية بين درجة تزاحم المفترس (عدد الأفراد/وحدة المساحة) وكفاءته الغذائية متمثلة في عدد الفرائس التي يتغذى عليها خلال عشرة أيام. وكانت نسبة ٨٧% من الكفاءة الغذائية للمفترس الأكاروسي راجع إلى درجة التزاحم بين أفراده. كما أدت التغذية على أفراد الحلم العريض إلى إطالة فترة الجيل وكذلك إطالة المدة الزمنية اللازمة لعشيرة المفترس لكي تضاعف أعدادها بينما أدت التغذية على أفراد العنكبوت الأحمر إلى رفع درجة خصوبة المفترس متمثلة في عدد البيض الكلي وكذلك معدل التزايد النوعي ومعدل التضاعف خلال الجيل واليوم الواحد. وعلية بالرغم من أن المفترس تغذى على كميات أكبر من الحلم العريض إلا أنه أعطى أفضل نتائج لمعايير جداول الحياة عندما تغذى على العنكبوت الأحمر.