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 \( R_n \), intrinsic rate of natural increase \( r_m \), finite rate of increase \( e^\lambda \) and gross reproduction GRR of the predatory mite P. plumifer.

Keywords: Phytoseius plumifer, Polyphagotarsonemus 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 prosymatid mite Polyphagotarsonemus latus (Banks) (Acari: Tarsenemididae) is also one of the most injurious mite pests with different common names (yellow broad, broad and jute mite (Masoud et al. 2001). This mite is undoubtedly the most important tarsenemid 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 Drosos, 1987). In Egypt, P. latus was recorded in early nineties 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 Pettit, 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°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\(^{R_o}\)), doubling time DT as well as the gross reproductive rate (GRR=2M\(_x\)).

**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).

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 *Polychagotarsornemus latus* and kept at 26+1°C and 70+5% RH](image-url)
Bemisia tabaci probability of mutual interference. Moreover, Fouly broad mite and spider mite, respectively (Table 2). A ficifoliae period. Almost 92% of immature stages of plumifer

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

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.

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 $R_n$ 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).

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 + 1°C and 70 + 5% RH on its life - table parameters

<table>
<thead>
<tr>
<th>Life table parameters</th>
<th>Prey mite species</th>
<th>Polyphagotarsonemus latus</th>
<th>Tetranychus urticae</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>18</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Survival %</td>
<td>89</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>Female proportion</td>
<td>0.56</td>
<td>0.58</td>
<td></td>
</tr>
<tr>
<td>Mean generation time (T)</td>
<td>16.81</td>
<td>15.29</td>
<td></td>
</tr>
<tr>
<td>Doubling time (DT)</td>
<td>1.57</td>
<td>1.30</td>
<td></td>
</tr>
<tr>
<td>Net reproductive rate (R₀)</td>
<td>24.52</td>
<td>33.68</td>
<td></td>
</tr>
<tr>
<td>Intrinsic rate of increase (rₘ)</td>
<td>0.19</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>Finite rate of increase (eᵢ)λ</td>
<td>1.21</td>
<td>1.26</td>
<td></td>
</tr>
<tr>
<td>Gross reproduction (GRR)</td>
<td>42.19</td>
<td>49.67</td>
<td></td>
</tr>
</tbody>
</table>

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

REFERENCES


Tأثير نوع الغذاء والتدخل المتبادل على الكفاءة الغذائية وجدولة الحياة للمفترس الأكروسي فيتوسيس بلومغ (أكاري

فايتوسيدري)

FH قد يكون مزعج في البيون المحمية في منطقه بورسعود بينما تم تفعيل فورمات الأكروسي فيتوسيس بلومغ من أوراق الفاصوليا والثوم العربي (يولفاجوناروسنيميس لانس) من أوراق الفواكه المزرعة في البيوت المحمية في منطقه بورسعود.

تم دراسة تأثير نوع الفواكه وكذلك التفاعل بين الفواكه والأوراق في إحداث الاقترابات وجدولة الحياة الأكروسي في الفاكهة في منطقه بورسعود. تم اقتراح أن هناك علاقة مثالية بين درجة تراكم المفترس (عدد الأوراق) وكمية الغذاء المتوفرة. كما تم تعايش الفواكه على أوراق الفاكهة إلى درجة تراكم الفواكه إلى حد ما، والتي تحتوي على نسبة 82% من الكفاءة الغذائية للمفترس الأكروسي. تم رفع درجة تراكم الفواكه إلى درجة تراكم الفواكه الأكبر، وتم القضاء على الفواكه بمعدل تراكم الفواكه في منطقه بورسعود. وعند تناول الأوراق الأحمر، تم رفع درجة ثبات المفترس مطلقة في منطقه بورسعود. وفي منطقه بورسعود، تم القضاء على الفواكه الأحمر لأن الفواكه تغذى على كميات أكبر من الفواكه العربي إلا أن أكثر أثرماً ينبع من تفاعلات الأوراق الحمراء. وعند تناول الأوراق الأحمر، تم القضاء على الفواكه العربي لأن الفواكه تغذى على كميات أكبر من الفواكه العربي إلا أن أكثر أثرماً ينبع من تفاعلات الأوراق الحمراء.

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