Influence of diet on life table and population growth parameters of predatory mite Neoseiulus barkeri (Hughes) (Acari: Phytoseiidae)

Maryam Rezaie¹, Reza Javan Nezhad²

ABSTRACT: The predatory mite Neoseiulus barkeri (Hughes) is the most important and wide distributed phytoseiid mite. This predatory mite fed on plant injurious mite and small insect pests. Neoseiulus barkeri has been collected from cucumber infested with two-spotted spider mite. Life tables of this predatory mite were studied on onion thrips (Thrips tabaci Lind (Thysanoptera: Thripidae)), two-spotted spider mite (Tetranychus urticae Koch (Acari: Tetraechidae)) and corn pollen, first larvae of onion thrips and egg mites were used as prey. This research was investigated in the laboratory by using the mulberry excised leaf method in petri dishes at 27± 1˚C, 16L: 8D photoperiod and 70-80% RH. Data were analyzed based on the age-stage, two-sex life table theory. Adult longevity (male) on three diets did not show any significant difference, but adult longevity (female) on corn pollen were significantly shorter than those reared on T. tabaci and T. urticae. Preimaginal developmental time showed a significant difference in the mentioned treatments. The lifetime fecundities were 23.58, 48.67 and 26.40 offspring on T. tabaci, T. urticae and corn pollen respectively. The intrinsic rate of increase ($r_m$) on T. tabaci, T. urticae and corn pollen were 0.162 d⁻¹, 0.171 d⁻¹ and 0.103 d⁻¹ respectively and show a significant difference. Net reproduction rate ($R_0$) and Finite rate of increase ($\lambda$) on three diets were not different. The mean generation time on T. tabaci, T. urticae and corn pollen showed a significant difference. With attention to observed results, N. barkeri is a general predator and can play an important role in the biological control of T. urticae and T. tabaci. Corn pollen was suitable alternative food for this predator.

INTRODUCTION

The predatory mite Neoseiulus barkeri (Hughes) (Acari: Phytoseiidae) is a generalist predator, able to develop on a wide range of natural and factitious foods (Vantornhout et al., 2004). It is considered one of the most important biocontrol agent of the two-spotted spider mite (Karag et al., 1987; Fouly & EL-Laithy, 1992; Momen, 1995) or other pest such as, Polysphagotarsonemus latus (Banks) (Fan & Pettit, 1994), Bemisia tabaci Gennadius (Nomikou et al., 2001), Thraps tabaci Lind (Hansen, 1988; Bonde, 1989; Wu et al., 2014), Frankliniella occidentalis (Pergande) (Ramakers & van Lie burg, 1982), Stenotarsonemus lacticeps (Halbert) (Messelink and Van Holstein, 2006), Aleuroglyphus ovatus Troupeau (xia et al.,2012), Oligonychus afrasiaticus (McGreor) (Negm et al., 2014).This predatory mite can be fed on plant pollen (Bond, 1989). It is widely distributed to all countries (Moraes et al., 2004).

Studies are available on different ecological aspects of this predator, including biology (Brodsgarrd & Hansen, 1992; Houten et al., 1995; Negm et al., 2014); feeding (Momen, 1995); Functional response (Fan & Pettit, 1994; Wu et al., 2014), biological control (Fan & Pettit, 1994) and effect of abiotic factors such as temperature (Bond, 1989; Jafarie et al., 2012).

Some of phytoseiid mites utilize pollen as a food source and develop and reproduce on a pollen diet as well (Tanigoshi et al., 1993; Yue & Tsai, 1996; van Rijn & Tanigoshi, 1999; Nomikou et al., 2003). They require pollen for successful development and reproduction (Addison et al., 2000). The nutritional value of pollen varies between plant species and thus the developmental periods and reproductive response of phytoseiid mites to different pollen can also be quite variable (Tanigoshi et al., 1993,Yue et al., 1994: Yue & Tsui, 1996).
The aim of this study was to evaluate and compare biological parameters of Neoseiulus barkeri on three diets (onion thrips (Thrips tabaci), two-spotted spider mite (Tetranychus urticae), and corn pollen). First larvae of onion thrips and egg mite were used as prey. In this study, the life history and expected intrinsic growth rate on three diets were tested.

METHODS

Colony
Neoseiulus barkeri has been collected from cucumber field infested with two-spotted spider mite of Khoramabad, Lorestan province of Iran and maintained on leaves of bean which were infested with the spider mite. The stock culture of N. barkeri was maintained in a growth chamber at 27±1 °C, 70±5 RH and 16 L: 8 D hours conditions. The corn pollen tested were collected by hand from Karaj. Pollen stored in the refrigerator during the experiments.

Experiments
Gravid females of the predatory mite were transferred from the main culture to strawberry leaves and left for 24 hours to oviposit. Only one egg remained on each leaflet and the mite and additional eggs were removed. The leaflet of each mulberg leaflet (2×2 cm²) was placed upside down on water saturated cotton in a 6 cm diameter Pteri dish surrounded by strips of wet cotton wool to prevent the mites from escaping. Leaves of mulberg were provided with sufficient amount of each plant pollen and T. urticae eggs and T. tabaci larvae separately and replaced with them daily. When an individual developed to the adult stage, it was paired with an individual of the opposite sex from the cohort. Three diets were evaluated for their effect on development, survival, fecundity and life-table parameters.

Statistical analysis
Developmental time of all individuals, including male and female and those dying before adult stage and female daily fecundity were subjected to analysis of variance based on collected data, the life tables of the predator were constructed based on the theory of the age-stage, i.e. two-sex life table (Chi, 2005). In the Chi & Liu’s model (1985), the population parameters were calculated based on data of the entire cohort, i.e. both sexes and the variable developmental rate among individual. The age-stage specific survival rate (S_xj, where x = age and j = stage), the age-specific survival rate (l_x), the age specific fecundity (m_x) and the population parameters (r_m (intrinsic rate of increase), λ (finite rate of increase; λ = e^λ), R_0 (net reproduction rate, and T (the mean generation time)) were calculated by using TWO SEX-MSChart program (Chi, 2005). Data of all stage developmental time, adult life span and fecundity were analyzed using ANOVA (SPSS Inc, 2012). The mean generation time is defined as the time length that a population needs to increase to R_0-fold of its size as the stable age distribution and the stable increase rate are reached. Intrinsic rate of increase was estimated by using the iterative bisection method from the Euler-Lotka formula with age indexed from 0 (Goodman, 1982). Statistical differences in demographic parameters were tested using a jackknife procedure to estimate the variance for demographic parameters (Meyer et al., 1989).

RESULTS
Neoseiulus barkeri completed its developmental times on three diets. As food sources for the predatory mite, first larvae of onion thrips and egg T. urticae and corn pollen were selected. All diets were accepted as food by the predatory mite. The larvae of N. barkeri moult to protonymphal stage without feeding. The developmental times and reproduction rate are presented in Table 1.

The immature longevity of N. barkeri were different among treatments. Immature longevity of N. barkeri on corn pollen was longer than the other treatments. Total mortality of immature of N. barkeri on three diets were 8%, 7% and 16% on T. urticae, T. tabaci and corn pollen respectively. Immature longevity of predatory mite on corn pollen was longer. Adult longevity (female) on different diets were different and female longevity of N. barkeri when fed on T. urticae was longer than the other treatments. Life time fecundity of predatory mite fed on T. urticae was more than the fecundity rate of N. barkeri fed on T. tabaci and corn pollen (Table 1).

Estimated parameters of life table for N. barkeri on three diets are presented in Table 2. The age-stage survival rate (S_xi) of N. barkeri is shown in Fig. 1. Which shows the probability that a newly hatched mites will survive to age x and stage j. The survival curve of cohort usually shows significant stage overlapping because of the variable developmental rate among individuals. The life expectancy of newly hatched egg of N. barkeri on three diets were 8.2, 8 and 8.1 days on T. urticae, T. tabaci and corn pollen respectively (Fig. 2). The age-specific survival rate (l_x) and the age-specific fecundity (m_x) are shown in Fig. 3.
Table 1. Life history statistics (Mans ±SE) of Neoseiulus barkeri on different diets

<table>
<thead>
<tr>
<th></th>
<th>Tetanychus urticae</th>
<th>Thrips tabaci</th>
<th>Corn pollen</th>
<th>df</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immature longevity</td>
<td>3.87±0.93 b</td>
<td>3.81±1.1 b</td>
<td>4.78±1.39 a</td>
<td>151</td>
<td>5.21</td>
<td>0.0001</td>
</tr>
<tr>
<td>Adult longevity (Female)</td>
<td>19±0 c</td>
<td>13.25±1.07 b</td>
<td>9.6±0.6 a</td>
<td>111</td>
<td>18.79</td>
<td>0.0001</td>
</tr>
<tr>
<td>Adult longevity (Male)</td>
<td>11.75±5.8 a</td>
<td>6.3±2.04 a</td>
<td>6.8±0.36 a</td>
<td>111</td>
<td>4.05</td>
<td>0.06</td>
</tr>
<tr>
<td>Lifetime fecundity</td>
<td>48.67±16.53 a</td>
<td>23.75±1.8 b</td>
<td>26.4±1.6 b</td>
<td>211</td>
<td>50.04</td>
<td>0.001</td>
</tr>
</tbody>
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Means within a row followed by the same letter are not significantly different at the 5% confidence level

Table 2. Mean ± SE of intrinsic rate of increase \( r \) (day\(^{-1} \)), finite rate of increase \( \lambda \) (day\(^{-1} \)), net reproductive rate \( R_0 \) (offspring/individual) and mean generation time \( T \) (day) of Neoseiulus barkeri on different diets

<table>
<thead>
<tr>
<th></th>
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<th>df</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>( R_0 )</td>
<td>18.59±4.671</td>
<td>15.94±2.671</td>
<td>16.95±0.751</td>
<td>65</td>
<td>0.91</td>
<td>0.40</td>
</tr>
<tr>
<td>( T )</td>
<td>13.34±0.912 b</td>
<td>11.44±0.451 b</td>
<td>9.58±0.28 a</td>
<td>65</td>
<td>3.90</td>
<td>0.001</td>
</tr>
<tr>
<td>( \gamma )</td>
<td>0.17±0.051 b</td>
<td>0.16±0.041 b</td>
<td>0.103±0.053 a</td>
<td>65</td>
<td>2.40</td>
<td>0.001</td>
</tr>
<tr>
<td>( \gamma )</td>
<td>1.19±0.061</td>
<td>1.18±0.052</td>
<td>1.23±0.064</td>
<td>65</td>
<td>0.81</td>
<td>0.56</td>
</tr>
</tbody>
</table>

Means within a row followed by the same letter are not significantly different at the 5% confidence level

Figure 1. Relative number alive in each age-stage group \( (S_{ij}) \) of N. barkeri on three diets (a: adult female of Tetanychus urticae; b: first larvae of Thrips tabaci; c: corn pollen).

Figure 2. Life expectancy in each age-stage group \( (e_{ij}) \) of N. barkeri on three diets (a: adult female of Tetanychus urticae; b: first larvae of Thrips tabaci; c: corn pollen).
Neoseiulus barkeri was able to develop and reproduce when fed on three diets. This study was to evaluate the biological and predatory efficiency of this predatory mite against *T. urticae* and *T. tabaci* as prey. The quality of food may determine the developmental time and reproductive characteristics of the predatory mite (Moraes & McMurtry, 1985). Some researchers studied about the effect of different types of food on biological parameters of *N. barkeri* (such as, Bond, 1989; Xia et al. 2012; Negm et al. 2014; Jafarie et al. 2014).

The highest mortality at the immature stage was on corn pollen and the lowest immature stage mortality was on *T. tabaci* and *T. urticae*. Jafarie et al. (2013) showed that the survival rate for the movable immature stages of *N. barkeri* fed on 1st larvae of *T. tabaci* was 100%. In addition to, Ragusa et al. (2009) were reported that 100% of *N. barkeri* individual attained adulthood when fed on *T. urticae*. In this study, the immature mortality varied between 7-16%. It could be difference in predatory strain or laboratory condition.

Development of *N. barkeri* immature period of *N. barkeri* varied between (3.67–4.78 days) on three diets. On the other hand, this developmental period were relatively smaller in our study than reported when fed on *O. atrasiaticus* (9.6 days at 25°C) (Negm et al, 2014) or when fed on *A. ovatus* (7.8 days at 24°C) (Xia et al., 2012) and Jafarie et al (2012) showed that developmental time of immature stages was 5.68 days when fed on *T. tabaci* and Developmental time *N. barkeri* immature recorded by Bond (1989) (6.2 days) and Beglyarov & Suchalkin (1983) (5.98 days) fed on *T. tabaci*. This parameter for this population of *N. barkeri* fed on *T. urticae* in the present study was 3.67 days and recorded by Jafarie et al., (2011) (4.59 days). This differences could be due to differences in laboratory condition or prey species. The obtained developmental time of *N. barkeri* in the present study was 3.81 days.

The adult longevity (female) of *N. barkeri* was different among diets and varied between (9.60–19 days), however, the male longevity of predatory mite was not different and varied between (6.8-11.73 days) on three diets. Female longevity of *N. barkeri* on *O. afrasiaticus* was 27.4 days (Negm et al., 2014). The adult longevity in the present study on *T. urticae* was 19 days and on *T. tabaci* was 13.25 days, however, this parameter is shorter than that reported by Jafarie (2011, 2013) as 20.17 days fed on *T. tabaci* and 25.45 days fed on *T. urticae*. Female longevity of *N. barkeri* on *O. afrasiaticus* was 27.4 days (Negm et al., 2014). Jafarie et al. (2013, 2011) were reported that the adult longevity on *T. tabaci* was 2017 days and on *T. urtica* was 25.45 days.

The sex ratio of *N. barkeri* on *T. tabaci* was female biased (61.66%). Similarly Momen (1995) reported the female ratio of *N. barkeri* on *T. urticae* was as 60%. In other study, Xia et al. (2012) reported the sex ratio for this...
 predator was 60.87%. Jafari et al. (2010) reported this parameter for N. barkeri fed on T. urticae was 60%. The sex ratio in the present study was female biased (on T. urticae (68%), on T. tabaci (65%) and on corn pollen (48%). The sex ratio of the predatory mite on corn pollen is male dominant. In another study, Jafari et al. (2013) reported the sex ratio for this predator to be 61.66% when fed on T. tabaci.

Rugusa et al. (1995) was reported that female usually lay eggs only on food considered adequate for postembryonic development of the progeny. Jafari et al. (2013) reported daily and total fecundity of N. barkeri as 2.48 eggs/female /day and 36.40 eggs/female respectively. In another study, Bond reported daily and total fecundity of this predator as 2.3 eggs/female/day and 47.1 eggs/female on T. tabaci at 25°C. The mentioned parameter in the present study were 2.12 eggs/female/day and 23.75 eggs/female, however, Jafarie et al (2010) was reported 2.57 eggs/female/days and 38.62 eggs/female respectively fed on T. urticae. The mentioned parameters in the present study were 2.52 eggs/female/day and 48.67 eggs/female. The oviposition rate was 34.8 eggs/female (Negm et al., 2014).

The \( r_m \) value is most important intrinsic parameters that indicate the potential of predator for growth, reproduction and survival (Southwood, 1978). This parameter is the most important population growth parameter (southwood & Manderson, 2000). Jafari et al (2012) showed that N. barkeri successfully developed on 1st instar larvae of T. tabaci. The intrinsic rate of increase (\( r_m \)) was 0.252 day\(^{-1}\). In case of N. barkeri against Thrips tabaci at 25°C, the life table parameter \( R_0, T, r_m \) value were 27.78, 19.10, 0.22 respectively (Bond) on A. ovatus, at 24°C the parameter were 20.14, 20.07, 0.14 (Xia et al., 2012) and on T. urticae 22.02, 13.95, 0.22 (Jafari et al, 2012), while in the present study on different diet were different (on T. urticae (8.59, 13.34, 0.17)) on Thrips tabaci (5.94, 11.44, 0.16) on corn pollen (6.95, 9.58, 0.10).The \( r_m \) value of N. barkeri on O. afrasticus was 0.16 day\(^{-1}\) (Negm et al., 2014), on Alegorlyphus ovatus was 0.17 day\(^{-1}\) (Xia et al., 2012). The \( r_m \) value of this predator on T. tabaci was 0.252 day\(^{-1}\) (Jafari et al., 2013). \( r_m \) – value of N.barkeri fed on A.ovatus was 0.165 day\(^{-1}\) (Xia et al., 2012).

With attention to observed results, N. barkeri is a general predator and can play an important role in the biological control of T. urticae. Neoseiulus barkeri could be considered as a biological agent for the control of T. tabaci (Jafari et al., 2012). Jafari et al (2013) showed that the 1st larvae of T. tabaci is suitable prey for N. barkeri and this predator can be used as a biological control agent. This predatory mite with exclusive feeding on corn pollen can complete the developmental stages and can oviposit. Corn pollen was suitable alternative food for the mass rearing of this predator.

Effect of different plant pollen on life table of phytoseid mite was investigated by some researchers, such as, ice plant on Euseius mesembrinus (Dean) (Abou-setta, childers, 1977) data palm pollen on Proprioioseioips asetus (Chant) (fouly,1997), corn pollen on Amblyseius gossipli Elbadry (Elbadry & elbenhaury, 2011), cattail (Typha latifolia) pollen on Amblyseius (Typhlodromips) swirskii Athias - Henriot (park et al, 2011).

Neoseiulus barkeri is an indigenous biological control agent in Iran that preys on spider mites and T.tabaci and can prevent the outbreak of them.

REFERENCES


