Genus *Brevipalpus* is considered one of the most important genera that belong to family Tenuipalpidae Berlese. In Egypt, *Brevipalpus* includes seven species solely, five of them are attacking citrus trees. *B. phoenicis, B. californicus* and *B. noranae* are the most dominant on Egyptian citrus. A pure culture of the three species were propagated on leaves of Common Navel orange variety. The mentioned species were studied at two different temperatures (25 and 30°C ± 2°C and 70 ± 5% R.H.). The obtained results enable us to conclude that between the three species of genus *Brevipalpus*, the citrus fruit most appropriate for the development of *B. noranae*, since the mite presents a reduced embryonic and post-embryonic period. The citrus fruit also provides the highest values of specific fertility, survival and of the intrinsic increase rate (rm), which indicates it as being a better suitable host for the mite which provide *B. noranae* to establish and rapid spread.

**Keywords:** *Brevipalpus phoenicis, Brevipalpus californicus, Brevipalpus noranae, Navel orange variety, life table*

**INTRODUCTION**

Genus *Brevipalpus* is considered one of the most important genera that belong to family Tenuipalpidae Berlese. Members of the genus *Brevipalpus* are phytophagous and some are serious pests of crop and ornamental plants in the world (Jeppson et al., 1975, Evan et al., 1993). Ten species of *Brevipalpus* have been identified on citrus worldwide and include: *B. amicus* Chaudhri, *B. californicus* (Banks), *B. Chilensis* Baker, *B. karachiensis* Chaudhri, Akbar and Rasool, *B. lewisi* (McGregor), *B. mcgregori* Baker, *B. obovatus* Donnadieu, *B. phoincis* (Geijskes), *B. rugulosus* Chaudhri, Akbar and Rasool and *B. tinsukiaensis* Sadena and Gupta. (Childers et al., 2001).

The sight of infestation caused by these species are similar which are chlorosis, blistering, bronzing, or necrotic areas on leaves and fruits (Ochoa et al., 1994; Kitajima et al., 1996; Chagas et al., 2001; Childers et al., 2001; Hele et al., 2005; Chigira & Miura, 2005). Fortunately, only five species from genus *Brevipalpus* which are *B. californicus, B. lewisi, B. obovatus, B. phoincis* and *B. noranae* have been recorded on Egyptian citrus. (Halawa and Fawzy 2014). Developmental rates are strongly influenced by mite species, temperature, relative humidity, and host plant.

Unfertilized eggs produce only females because of these species are parthenogenetic. The temperature and humidity affected on the duration of different life stages, while the humidity below 30% is critical point for the flat mite that causes incomplete its development of life cycle. (Haramoto, 1969).

Therefore, the objective of this work is to evaluate the reproductive performance of *B. phoenicis, B. californicus* and *B. noranae* as the dominant species on Egyptian citrus in two successive parameters at temperature 25°C and 30°C from the parameters calculated from the fertility life table and biology.

**MATERIALS AND METHODS**

A pure culture of *B. phoenicis, B. californicus* and *B. noranae* were propagated on leaves of common Navel orange variety. Leaf discs of about one-inch in diameter were made and washed with running water to remove any possible residuals or mites which may be found on these leaves. The leaf discs were surrounded by tangle foot, which acts as a barrier to prevent mite individuals from escaping and placed on pieces of moisten cotton wool in Petri dishes of 10cm diameter, and then a couple (male and female of mite) was placed on each disc, on the lower surface of the leaf. The Petri dishes were kept at two different temperatures (25 and 30°C ± 2°C and 70 ± 5% R.H.), for 24 hours to allow mating process between male and female. Thereafter, males were removed, while females served as a source for known-age eggs, which in turn produced known-age larvae. The moisture was kept constant by adding few drops of water to the cotton wool. Hatching larvae were transferred and kept singly to leaf discs and left to continue their life span.

Life history parameters - Parameters were obtained by survival data (lx) in relation to age (x) and specific fertility (mx) of 29 individualized females in citric fruits and 23 individualized females in coffee leaves (repetitions). Only females were used because *B. phoenicis* reproduces...
mainly by deuterotokous parthenogenesis, where non-fertilized eggs can produce either females or males. The experiments were evaluated daily at 5 h p.m. by counting the number of dead mites and oviposition until the death of all females. The sex ratio, that indicates the proportion of females, was calculated by the quotient between the number of females and the number of females added with the number of males.

Fertility life table - The fertility life table was made starting from the survival rate and specific fertility obtained from parameters of the life history and sex ratio (Birch, 1948; Dinh et al., 1988). Using the data from the life table, calculations were made for the net reproduction rate ($R_0$) or the number of times that the population increased in each generation ($R_0 = \sum m_i l_i$) and the intrinsic rate of increase ($r_m$) which expresses the number of females added to the population per female per day by the Lotka equation (Carey, 1993):

**RESULTS AND DISCUSSION**

The duration of males and females of citrus flat mites, *B. phoenicis*, *B. californicus* and *B. noranae* reared on leaves of Navel orange at temperature degrees 25 and 70 % R.H were recorded in tables (1). The obtained data in table (1) showed that the biological aspects of *B. noranae*, *B. phoenicis* and *B. californicus* were varied.

The citrus flat mite, *B. phoenicis* recorded longest incubation period to reach 8.00 day while *B. noranae* and *B. californicus* were shortest incubation period which were 6.06 and 7.05 days, respectively. Simultaneously, the life cycle of *B. phoenicis* showed longest period to reach 24.33, while *B. noranae* and *B. californicus* were shortest in life cycle which were 17.72 and 21.57 days, respectively. On contrary, the oviposition recorded longest period for *B. noranae* to reach 11.61 days, while *B. phoenicis* and *B. californicus* were decreased in numbers of mites which were 11.67 and 16.71 days, respectively. The life span of *B. phoenicis* recorded longest to reach 40.48 day while *B. noranae* and *B. californicus* were shortest life span which were 33.85 and 38.60 days, respectively.

The duration of males and females of citrus flat mites, *B. phoenicis*, *B. californicus* and *B. noranae* reared on leaves of Navel orange at temperature degrees 30 and 70 % R.H were recorded in tables (2). The obtained data in table (2) showed that the biological aspects of *B. noranae*, *B. phoenicis* and *B. californicus* were affected by rising temperature degrees which cause the duration periods becoming shortest unlike the obtained data at temperature 25° and 70% R.H.

The duration of males and females of citrus flat mites, *B. phoenicis*, *B. californicus* and *B. noranae* reared on leaves of Navel orange at temperature degrees 30 and 70 % R.H were recorded in tables (2). The obtained data in table (2) showed that the biological aspects of *B. noranae*, *B. phoenicis* and *B. californicus* were varied. The citrus flat mite, *B. californicus* recorded longest incubation period to reach 7.05 day while *B. noranae* and *B. phoenicis* were shortest incubation period which were 4.03 and 6.10 days, respectively.

**Table 1.** Average duration of life cycle, longevity and live span of *B. phoenicis*, *B. phoenicis* and *B. californicus* on Navel orange variety at two temperatures degrees (25°C and 70 ± 5% R.H.)
Reproductive interpretation of some *Brevipalpus* species on two temperatures degrees, using life table parameters

The life table parameters of citrus flat mites, *B. phoenicis*, *B. phoenicis* and *B. californicus* reared on leaves of Navel orange at temperature degrees 25 and 70 ± 5% R.H. were recorded in tables (3). The intrinsic rate of the population increase (rm) were estimated at 0.128, 0.128 and 0.129 females/female/day for *B. phoenicis*, *B. californicus* and *B. noranae*, respectively. In addition, the average duration period of a generation (T) was shortest for *B. phoenicis* 15.75 days than for *B. californicus* and *B. noranae* which were 18.19 and 18.71 days, respectively.

**Table 3:** Life table parameters of *B. phoenicis*, *B. phoenicis* and *B. californicus* reared on Navel orange at 25 ± 2ºC and 70 ± 5% R.H.

<table>
<thead>
<tr>
<th>Prey</th>
<th>Mean generation time</th>
<th>Net reproductive rate</th>
<th>Intrinsic rate of natural</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(T, days)</td>
<td>(Ro)</td>
<td>increase (rm/day)</td>
</tr>
<tr>
<td><em>B. phoenicis</em></td>
<td>15.75</td>
<td>7.51</td>
<td>0.128</td>
</tr>
<tr>
<td><em>B. californicus</em></td>
<td>18.19</td>
<td>10.26</td>
<td>0.128</td>
</tr>
<tr>
<td><em>B. noranae</em></td>
<td>17.62</td>
<td>9.70</td>
<td>0.129</td>
</tr>
</tbody>
</table>

**Table 4:** Life table parameters of *B. phoenicis*, *B. phoenicis* and *B. californicus* reared on Navel orange at 30 ± 2ºC and 70 ± 5% R.H.

<table>
<thead>
<tr>
<th>Prey</th>
<th>Mean generation time</th>
<th>Net reproductive rate</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(T, days)</td>
<td>(Ro)</td>
<td>increase (rm/day)</td>
</tr>
<tr>
<td><em>B. phoenicis</em></td>
<td>17.24</td>
<td>8.93</td>
<td>0.127</td>
</tr>
<tr>
<td><em>B. californicus</em></td>
<td>19.60</td>
<td>12.05</td>
<td>0.127</td>
</tr>
<tr>
<td><em>B. noranae</em></td>
<td>17.37</td>
<td>9.40</td>
<td>0.129</td>
</tr>
</tbody>
</table>

cycle of *B. californicus* showed longest period to reach 21.57, while *B. noranae* and *B. phoenicis* were shortest in life cycle which were 12.71 and 18.90 days, respectively. On contrary, the oviposition recorded longest period for *B. noranae* to reach 11.61 days, while *B. phoenicis* and *B. californicus* were shortest in oviposition period which were 7.65 and 11.45 days, respectively. Simultaneously, the fecundity of *B. noranae* increased in numbers of mites to reach 23.95 while *B. phoenicis* and *B. californicus* were decreased in numbers of mites which were 16.71 and 16.71 days, respectively. The life span of *B. californicus* recorded longest to reach 38.6 day while *B. noranae* and *B. phoenicis* were shortest life span which were 27.38 and 32.57 days, respectively.
were 18.19 and 17.62 days, respectively. Simultaneously, the net reproductive rate \((R_o)\) was shortest for \(B.\) phoenicis reached 7.51 days than for \(B.\) californicus and \(B.\) noranae which were 10.26 and 9.70 days, respectively.

The life table parameters of citrus flat mites, \(B.\) phoenicis, \(B.\) noranae and \(B.\) californicus reared on leaves of Navel orange at temperature degrees 30°C and 70 % R.H were recorded in tables 4. The intrinsic rate of the population increase \((r_m)\) were estimated at 0.127, 0.127 and 0.129 females/female/day for \(B.\) phoenicis, \(B.\) californicus and \(B.\) noranae, respectively. In addition, the average duration period of a generation \((T)\) was shortest for \(B.\) phoenicis 17.24 days than for \(B.\) californicus and \(B.\) noranae which were 19.60 and 17.37 days, respectively. Simultaneously, the net reproductive rate \((R_o)\) was shortest for \(B.\) phoenicis reached 8.93 days than for \(B.\) californicus and \(B.\) noranae which were 12.05 and 9.40 days, respectively.

This study evaluates the effect of different temperatures on reproductive parameters of three main citrus flat mites \(B.\) phoenicis, \(B.\) noranae and \(B.\) californicus. As shown in our research, Although the incubation period of \(B.\) californicus was not affected by increasing temperature, \(B.\) noranae and \(B.\) phoenicis were affected by increasing temperature from 25 to 30°C to become shorter from 6.06 and 8.00 days to reach 4.03 and 6.10 days, respectively. Simultaneously, the life cycle of \(B.\) californicus was not affected by increasing temperature from 25 to 30°C to reach 21.57 days, \(B.\) noranae and \(B.\) phoenicis were affected by increasing temperature to become shorter from 17.72 and 24.33 days to reach 12.71 and 18.9 days, respectively. On contrary, Although the increasing temperature did not provide any effect on oviposition period of \(B.\) noranae and \(B.\) californicus, \(B.\) phoenicis was affected by increasing temperature to become shorter from 9.36 and 7.65 days. Our data shows that \(B.\) phoenicis and \(B.\) noranae were significantly affected with increasing temperature over incubation period, life cycle and oviposition period unlike \(B.\) californicus which was negatively affected by increasing temperature, this may be resulted by presence a cryptic types within \(B.\) californicus which are type 1, 2 and 3, which did not specify in this study based on Childers & Rodrigues study in 2011.

In fact, this data doesn’t provide a realistic fact of the stability and spread of \(B.\) noranae, \(B.\) phoenicis and \(B.\) californicus on citrus trees. Therefore, the evaluation based on the life table parameter as far as it is a key in developing an integrated pest management strategy (Naseri et al., 2011). In addition, for what can provide a comprehensive description of the survival, fecundity and fertility of the pest populations. This study clearly shows that temperature had a great effect on the reproductive parameters of citrus flat mites (Vargas et al., 2000).

From Life table parameters (table 3 and 4), Our results revealed that the optimum temperature for net and gross fecundity and fertility rates of citrus flat mite is around 25°C.

The Intrinsic rate of natural increase \((r_m/day)\) was higher at temperature 25°C which reached 0.128, 0.128, 0.129 unlike 0.127, 0.127, 0.129 at temperature 30°C for \(B.\) phoenicis, \(B.\) californicus and \(B.\) noranae, respectively. Simultaneously, The Intrinsic rate of natural increase \((r_m/day)\) was higher by \(B.\) noranae which reached 0.129 unlike \(B.\) phoenicis; \(B.\) californicus which reached 0.128 and 0.128 at temperature 30°C and 0.127 and 0.127 at temperature 25°C, respectively. This maybe provide a conclusion that citrus trees are more suitable for \(B.\) noranae to establish and rapid spread. In addition, this can be providing an explanation of the reasons for first record of \(B.\) noranae in India Jalilirad et al., (2013), lately from the date of first description by Halawa and Fawzy 2014.

**CONCLUSION**

The obtained results enable us to conclude that between the three species of genus \(Brevipalpus\), the citrus fruit most appropriate for the development of \(B.\) noranae, since the mite presents a reduced embryonic and post-embryonic period. Citric fruit also provides the highest values of specific fertility, survival and of the intrinsic increase rate \((r_m)\), which indicates it as being a better suitable host for the mite which provide \(B.\) noranae to establish and rapid spread.

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