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LIFE HISTORY PARAMETERS OF *PHYTOSEIUS PLUMIFER* (ACARI: PHYTOSEIIDAE) FED ON CORN POLLEN

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ABSTRACT — The life table parameters of the predatory mite, *Phytoseius plumifer* (Canestrini and Fanzago) (Acari: Phytoseiidae) fed on corn pollen (*Zea mays* L. var. 704) were determined at 27 ± 1 °C, 50 ± 5 % RH and a photoperiod of 16:8 h (L:D). The gross reproductive rate (GRR), net reproductive rate (R_0), intrinsic rate of increase (rm), finite rate of increase (λ), mean generation time (T) and doubling time (DT) of *P. plumifer* were 6.23 female offspring, 4.40 female offspring, 0.112 day^{-1} , 1.118 day^{-1} , 12.99 days and 6.18 days, respectively. Compared to spider mite prey, corn pollen, as the only food source, increased the juvenile developmental time and decreased the longevity and fecundity of adult females of *P. plumifer* considerably, although the predators could develop and reproduce successfully.

KEYWORDS — intrinsic rate of increase; predatory mite; corn pollen

INTRODUCTION

Although phytoseiid mites have been mainly described as predators of mites and small insects, several species can feed and reproduce on pollen as well (McMurtry and Croft, 1997; Van Rijn and Tanigoshi, 1999). The potential of phytoseiids to regulate phytophagous mites and keep them at low equilibrium densities has been more attended recently and studies have examined some of the characteristics that contribute to the persistence of phytoseiid populations and the ability to feed on alternative food, such as pollen (McMurtry and Croft, 1997). Pollen is also known as an easy food source for rearing of phytoseiid mites (McMurtry and Scriven, 1964; McMurtry and Croft, 1997) and

has been recognized as an important factor in the successful biological control of spider mites (Van Rijn and Tanigoshi, 1999; Bouras and Papadoulis, 2005).

The ability to utilize pollen as food source has also been used to characterize the life styles of phytoseiid mites. McMurtry and Croft (1997) categorized the life styles of phytoseiid mites based on their feeding habits and related biological and morphological traits. The life styles are: type I (specialized predators of *Tetranychus urticae*); type II (selective predators of tetranychids); type III (generalist predators) that may feed on pollen but perform better on prey; type IV (specialized pollen feeders-generalist predators). *Phytoseius* species are commonly categorized as type III predators.

The predatory mite *Phytoseius plumifer* (Canestrini and Fanzago) is an important generalist indigenous predator of tetranychid and eriophyid mites on various crops in Iran (Kamali *et al.*, 2001; Hajizadeh *et al.*, 2002; Nadimi *et al.*, 2009) as well as in other countries (Rasmy and Elbanhawy, 1974; Castagnoli and Liguori, 1985). Knowledge of the nutritional value of different plant pollens for *P. plumifer* is not only important for mass rearing of the mite, but also for a better understanding of its population dynamics in the field. Some phytoseiid species reach their highest reproductive potential on pollen (Bouras and Papadoulis, 2005), and in other species spider mites alone are not suitable for development unless supplementary foods are added (Zhao and McMurtry, 1990; Broufas and Koveos, 2000). The effect of pollen as food source on the life history of predatory mites such as *Neoseiulus californicus* (McGregor), *Typhlodromus pyri* Scheuten, *Iphiseius degenerans* (Berlese), *Neoseiulus cucumeris* (Oudemans), *Euseius stipulatus* (Athias-Henriot) and *Euseius finlandicus* (Oudemans) has been investigated (Overmeer, 1981; Croft *et al.*, 1998; Van Rijn and Tanigoshi, 1999; Broufas and Koveos, 2000; Bouras and Papadoulis, 2005; Bermudez *et al.*, 2009). Liguori and Guidi (1990) studied the effect of conditioning *Typhlodromus eximius* Ragusa with different food types including pollen on its subsequent prey consumption. Yue *et al.* (1994) compared the suitability of several plant pollens for rearing *Euseius mesembrius* (Dean) under laboratory conditions. The present study deals with the effect of corn pollen, as only food source, on the life table parameters of *P. plumifer* under laboratory conditions. The provided information could be important for their use as biological control agents.

MATERIALS AND METHODS

Predator rearing

Adult females of *P. plumifer* were originally collected from a fig orchard located in the Faculty of Agriculture of Tarbiat Modares University (35°44'N, 51°10'E, Tehran, Iran) in June 2008. In the laboratory, the collected mites were transferred onto rearing arenas and kept at 27 ± 1 °C, 50 ± 5 % RH

and photoperiod of 16:8h (L:D). The rearing arenas were made from two plastic Petri dishes (8 cm diameter $\times$ 1.5 cm height and 9 cm diameter $\times$ 1.5 cm height). The smaller dish had a central hole in its base and was placed inside the larger one, which was filled with water to supply the leaf arena. The leaf arena consisted of a fig leaf placed upside down on a moistened layer of cotton (2 mm thick) in the smaller Petri dish. Fig leaves were surrounded with water-saturated cotton tissue to prevent escaping of the mites. Mixed life stages of *T. urticae* and corn pollen (*Zea mays* L. var. 704) were provided as food sources. The leaf discs were replaced by new ones weekly.

Experimental design

Thirty gravid adult females from the stock colony were transferred to a new arena and left to oviposit for 24h at 27 ± 1 °C, 50 ± 5 % RH and a photoperiod of 16:8h (L:D). Females were then removed and their eggs left to molt to larvae. The study was initiated with 30 larvae but some drowned in the surrounding tissue, resulting in 7 females reaching adulthood and being successfully mated. Newly molted larvae were individually transferred to experimental arenas consisting of punched-out leaf discs. Leaf discs were placed in Petri dishes (3.5 cm diameter $\times$ 1.5 cm height) made in the same manner as the rearing arenas. Pollen was sprinkled as food source daily on each unit. The developmental stages of each individual were recorded every 24h. After their last molting, the sex was determined and males were added to the females. Since there were not enough males to pair with females, males from the stock colony were used too. The survival of females and their fecundity were recorded daily until the death of the last female. The deposited eggs were collected and followed for determination of hatch rate and sex ratio. The following demographic parameters were calculated (Carey, 1993): the age specific survivorship (l_x), the age specific fecundity (m_x) - which denotes the expected number of female offspring produced by a surviving female aged x (Carey, 1982). L_x gives the number of days lived by the average individual within a cohort in

the interval x to $x + 1$ and T_x denotes this in total:

$$L_x = \frac{l_x + l_{x+1}}{2} \quad \text{and} \quad T_x = \sum_{y=x}^{\omega} L_y$$

- the life expectancy,

$$e_x = \frac{T_x}{l_x}$$

- the gross reproductive rate,

$$GRR = \sum m_x$$

- the net reproductive rate,

$$R_0 = \sum (l_x m_x)$$

- the intrinsic rate of increase r_m , which is calculated by iteratively solving the Euler equation

$$\sum (e^{-r_m \cdot x} l_x m_x) = 1 \quad (\text{Birch, 1948})$$

- the finite rate of increase,

$$\lambda = e^{r_m}$$

- the mean generation time,

$$T = \frac{\ln R_0}{r_m}$$

- the doubling time,

$$DT = \frac{\ln 2}{r_m}$$

- and the stable age distribution,

$$C_x = \frac{l_x \cdot e^{-r_m \cdot x}}{\sum_{x=0} (l_x \cdot e^{-r_m \cdot x})}$$

RESULTS AND DISCUSSION

Data of *P. plumifer* fed on corn pollen were used to calculate all main life table and population growth parameters (Table 1). Survivorship of immature stages was 97 % and the first adult females appeared on day 10 and started laying eggs. On day 16 a sharp decline was observed in the survival curve and all individuals died within 4 days (Figure 1). The mean number of eggs produced by a female was 0.98 ± 0.18 (SE) eggs/day, 98 % of eggs hatched and 70 % of hatched eggs were female. The average life time was 17.4 ± 0.5 (SE) days with nearly 19% of their lifespan spent in the adult stage. The calculated life expectancy (the number of days of life remaining at a given age) was 15.43 days for the first day and 0 for the 20th day.

Assessing the nutritional value of pollen is fundamentally important to conserve and augment phytoseiids as natural enemies of phytophagous mites. Until this study, there was no information on the life table parameters of *P. plumifer* fed exclusively on corn pollen. We showed that *P. plumifer* can develop and reproduce on corn pollen, which could allow the predators to survive on crops when its main prey is rare or absent. Zaher *et al.* (1969) studied the life history of *P. plumifer* with various pollen as food. They showed that the predators can develop and reproduce successfully on date-palm pollen but at slower rate than with spider mite prey. On hollyhock and cotton pollen or sweet potato leaves, the immatures failed to develop to adulthood. Rasmy and Elbanhawy (1974) studied the effect of the eriophyid mite *Aceria ficus* Cotte, the tetranychid mite *Tetranychus arabicus* Attiah and castor-oil pollen on the development and fecundity of *P. plumifer*. They found that *A. ficus* was a more favourable prey for the predators than *T. arabicus*,

TABLE 1: Life table parameters of *P. plumifer* fed on corn pollen at 27 ± 1 °C, 50 ± 5 % RH and 16:8h L:D photophase containing: gross reproductive rate (GRR), net reproductive rate (R_0), intrinsic rate of increase (r_m), finite rate of increase (λ), mean generation time (T) and doubling time (DT) and the stable age distribution (C_x)

GRR	R_0	r_m	λ	T	DT	C_x
6.23	4.40	0.112	1.118	12.99	6.18	80.89 % immature 19.11 % adult

FIGURE 1: Age specific survivorship (l_x) and age-specific fecundity (m_x) (φ/φ) of *Phytoseius plumifer* fed on corn pollen at $27 \pm 1^\circ\text{C}$, $50 \pm 5\%$ RH and 16:8h L:D photoperiod

and pollen food resulted in a marked decrease of the predator's reproduction.

Kouhjeni-Gorji *et al.* (2008) studied temperature-dependent development of *P. plumifer* fed on a mixture of *T. urticae* and corn pollen. They found that the developmental time of immature stages of the predator was 6.8 days at 27°C . Hamedi *et al.* (2011) determined that *P. plumifer* fed on a mixture of *T. urticae* and corn pollen reaches an r_m of 0.200 day^{-1} and a doubling time (DT) of 3.43 days. They found that all individuals survived the first 4 days after hatching, then 50 % natural mortality was observed during the next 36 days and the longest lived individual survived 50 days. The r_m is the most important population growth parameter reflecting an overall effect of climatic and food conditions on development, survival and reproduction (Southwood and Handerson, 2000). Comparing our results with those of Hamedi *et al.* (2011) and Kouhjeni-Gorji *et al.* (2008) it can be concluded that corn pollen as only food source extended the juvenile developmental time and decreased longevity and fecundity of adult females, altogether resulting in a considerably decreased r_m of 0.112 day^{-1} . Nonetheless, *P. plumifer* could develop and reproduce successfully on corn pollen, which is similar to the findings of Zaher *et al.* (1969) on pollen of date-palm. Further laboratory and field experiments are required in or-

der to better understand the influence of various pollens on the population dynamics of *P. plumifer* and its impact on the biological control of spider mites.

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