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Effect of three pollen grains on life table parameters of Neoseiulus californicus (Acari: Phytoseiidae)

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***Abstract*— Neoseiulus californicus (McGregor) is a predatory mite that can control spider mites. The effect of different diets such as, corn pollen, walnut pollen and date pollen along with the two-spotted spider mite (Tetranychus urticae Koch) eggs on life table parameters of the predatory mite was determined on strawberry detached leaves in Petri dishes. The experiments were carried out under laboratory conditions at 27 ± 1°C, 16L: 8D h photo-period and 70 ± 5% RH. Life table parameters were analysed based on age-stage, two-sex life table. There was no significant difference of total longevity among the different diets. The fecundity rate on date pollen (14.21±2.92 eggs) was higher than the other diets tested. The intrinsic rate of increase (r) of the predatory mites fed with date pollen (0.201±0.032 day -1) was higher than the other treatments. Among the three pollens, date pollen was recognized suitable for development and reproduction of N. californicus.**

***Index Terms*—Life table parameters, Neoseiulus californicus, pollen, spider mite eggs.**

I. INTRODUCTION

Neoseiulus californicus (McGregor) (Acari: Phytoseiidae), is an important spider mite predator [1], [2]. This predator can successfully develop and reproduce on *Tetranychus urticae* Koch up to 28 generations per year [3]. *Neoseiulus californicus* could feed on other pest mites, small insects and even plant pollen [4]. Some researchers studied about the effect of different types of food on biological parameters of *N. californicus* [5-9].

Some of phytoseiid mites utilize pollen as a food source, they develop and reproduce on a pollen diet as well [10], [11]. The nutritional value of pollen varies between plant species and thus the developmental periods and reproductive response of phytoseiid mites on different pollens can also be quite variable [12], [13]. Pollen can be used as a food source for mass rearing or to improve predator efficacy in the field. Several studies were reported the influence of pollen on life history of some phytoseiid mites *i.e.* ice plant pollen on *Euseius mesembrinus* (Dean) [14]; date pollen on *Proprioseiopsis asetus* (Chant) [15]; Oak (*Quercus virginiana*) pollen on *Amblyseius largoensis* (Muma) [16]; pollen of cumbungi, *Typha orientalis* Presl on *Amblyseius victoriensis* (Womersley) and *Typhlodromus doreenae* Schicha [17] and cattail pollen on *Typhlodromips swirskii* (Athias-Henriot) [18], tea pollen on *Amblyseius sojaensis* Ehara [19], Friut tree pollen on *Euseius stipulates* (Athias-Henriot) [20], 21- type plant pollens on *T. swirski* [21].

In this study, we compared the effects of three pollens as supplementary food sources on life history and intrinsic population growth rate of *N. californicus.* The aim of this study was to focus on the effect of three pollens (corn pollen, date pollen and walnut pollen) on the performance of the predatory mite *N. californicus* to mass rearing of this predator by demographic parameters of this predator on these pollens with *T. urticae.*

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II. MATH

Colony: The stock culture of *T. urticae* was maintained on common beans (*Phaseolus vulgaris* L.) in a growth chamber (27± 1 °C, 70±5 RH and 16: 8 hours L:D). *Neoseiulus californicus* was obtained from 'Koppert Biological Systems' and maintained on leaves of common bean, which were previously infested with *T. urticae*. The stock culture of *N. californicus* was maintained in a growth chamber (27± 1 °C, 70±5% RH and 16: 8 hours L:D). Laboratory colonies of *N. californicus* were reared in the green plastic arenas (18×13×0.1 cm) on water– saturated sponge in a Plexiglas box (25×18×10 cm) that was half-filled with water. The edges of the arenas were covered with moist tissue paper to provide moisture and prevent predator from escaping. The tested pollens were collected by hand (walnut pollen from Tabriz, corn pollen from Karaj and date pollen from Bam). Pollens were stored in the refrigerator during the experiments.

Experiments:Gravid female of the predatory mites were transferred from the main culture onto strawberry leaves (cultivar: Gaviota) 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 strawberry leaves (2×2 cm^2) 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 were provided with sufficient amount of each plant pollen and *T. urticae* eggs separately and replaced with them daily. When an individual developed to the adult stage, it was paired with an individual of the opposite sex to obtain the cohort individuals. The duration of developmental stages of the predator was recorded at 24-hour intervals. The oviposition rate of *N. californicus* was recorded daily. Each test was continued until all individuals died and for each diet 70–100 individuals were tested.

Statistical analysis: Developmental times of all individuals, including male and female and those who died before adult stage and female daily fecundity were subjected to analysis of variance. The life tables of the predator were constructed based on two- sex life table [22]. The population parameters were estimated based on Chi & Liu's model [23], using data of both sexes and the variable developmental rate among individuals. The population parameters (r (intrinsic rate of increase), λ (finite rate of increase; $\lambda = e^r$), R_0 (net reproduction rate), and T (the mean generation time) were calculated using TWO SEX-MSChart program [22]. Developmental times, adult life span and fecundity rates were analyzed using ANOVA [24]. The mean generation time was defined as the duration that a population needs to increase to R_0- fold of its size to reach stable age distribution and stable increase rate. Intrinsic rate of increase was estimated using the iterative bisection method from the Euler-Lotka formula with age indexed from 0 [25].

Bootstrap technique was used to estimate variances and standard errors of the population parameters. In our study, 10000 replications were used [26], because bootstrapping uses random re-sampling and if a small number of replications were used, it would result in variable means and standard errors which could end up in unreliable results. Multiple comparison tests among treatments were conducted in Kruskalmc program.

III. Helpful Hints

Neoseiulus californicus was able to develop and reporoduce when fed on three diets (date pollen+ egg of *T. urticae*, walnut pollen + egg of *T. urticae* and corn pollen + egg of *T. urticae*). The most eggs used in this study successfully hatched (85%, 86% and 84% when fed on corn pollen, date pollen and walnut pollen plus *T. urticae* eggs respectively. The highest mortality at the immature stages was on corn pollen (29%) and the lowest immature stages mortality was on date pollen (26%). The duration of different life stages of *N. californicus* fed on three pollens is shown in Table 1.

The egg incubation period of *N. californicus* varied between 1.84-1.89 days. Development of *N. californicus* immature period varied between 2.23 to 2.40 days. The male and female longevity of *N. californicus* was not significantly different on the tested pollens.

In addition, the duration of total life span of *N. californicus* did not indicate any significant difference among the tested pollens. Total fecundity of the predatory mite fed on date pollen (14.21±2.29 eggs/ female) was higher than that observed on the other treatments.

The sex ratio of *N. californicus* was female biased (on corn pollen 70%, date pollen 70%, walnut pollen 61%). The adult preoviposition period (APOP) and total preoviposition period (TPOP) did not show any significantly different.

The analysis of the life table parameters of *N. californicus* indicated the significant difference among the tested pollens (Table 2). The individual fed on date pollen had the highest intrinsic rate of increase. In addition, the mean generation time of predatory fed on different pollens did not show any significant difference.

Table 1. Life history statistics (Mean ± SE) of *Neoseiulus californicus* on different plant pollens and *Tetranychus urticae* eggs.

Developmental time	Corn pollen & spider mite	Date pollen & spider mite	Walnut pollen & spider mite	df	F	P
Egg	1.86±0.30	1.84±0.30	1.89±0.37	145	0.38	0.68
Larva & nymph	2.40±0.38	2.25±0.24	2.23±0.37	99	2.40	0.10
Adult longevity						
Female	13.04±4.29	13.31±3.03	12.56±2.35	66	0.24	0.79
Male	9.17±4.26	9.30±4.76	8.91±3.67	30	0.02	0.97
Preoviposition period						
APOP†	1.77±0.80	1.31±0.64	1.35±0.86	66	2.75	0.07
TPOP††	6.05±1.10	5.46±0.81	5.56±0.79	66	2.98	0.06
Lifetime fecundity	4.96±3.75	5.72±3.64	4.75±3.34	171	1.04	0.35
Lifetime longevity	10.61±4.73^{b}	14.21±5.92^{a}	12.06±3.44^{b}	66	3.47	0.04

Means within a row followed by the same letter are not significantly different at the 5% confidence level according to ANOVA test.

†APOP (Preoviposition period of female)

††TPOP (Total preoviposition period of female counted from birth)

Table 2. Mean ± SE of life table parameters of *Neoseiulus californicus* on different plant pollens and *Tetranychus urticae* eggs

Life table parameters	Plant pollens	Mean ± SE	CI Date pollen	 Walnut pollen
Intrinsic rate of increase (r) (day $^{-1}$)	Corn pollen	0.152±0.023	(8.324-0.142)*	(-5.821-2.621)$^{n.s.}$
Date pollen		0.201±0.032		(3.21-0.151)*
Walnut pollen	0.141±0.022			
Finite rate of increase (λ)(day^{-1})	Corn pollen	1.142±0.0006	(9.66-0.144)*	(-5.790-8.682)$^{n.s.}$
Date pollen		1.219±0.0006		
Walnut pollen	1.156±0.0007	(-8.628-0.134)$^{n.s.}$		
Net reproductive rate (R_0) (offspring/individual)	Corn pollen	3.68±0.546	(-0.216-4.91) $^{n.s.}$	(-2.012-2.207) $^{n.s.}$
Date pollen		3.132±1.073		
Walnut pollen	3.782±0.605	(-7.278-4.967) $^{n.s.}$		
Mean of generation time (T) (day)	Corn pollen	9.708±0.211	(-0.405-1.623)$^{n.s.}$	(-0.395-1.735)$^{n.s.}$
Date pollen		9.095±0.623		(-0.666-0.812)$^{n.s.}$
Walnut pollen	9.872±0.5234			

Multiple comparison tests among treatments were conducted in Kruskalmc program. When there is zero in data range (*CI*), two treatments were not significantly different.

IV. Discussion:

Neoseiulus californicus completed it's development on when fed on corn pollen, date pollen and walnut pollen. Ragusa *et al*. (2009) showed that 84% of egg of *N. californicus* reached the adulthood when feed on pollen of *Carpobrotus edulis* (L.) and *Scrophularia peregrine* L. [9]. In this study 71%, 74% and 76% of egg of the predatory mites reached the adulthood when feed on corn pollen, date pollen and walnut pollen respectively. In another study, the total immature mortality on different treated strawberry cultivars ranged between 21-37% [27]. This difference might be due to differences in laboratory condition, host plant structure or prey species.

Our study showed the egg incubation, immature period and adult (female and male) varied from 1.84-1.89, 2.23-2.40, 12.56-13.31 and 8.91-9.30 days respectively, which was similar to what obtained by Maroufpour *et al* (2013) [28] and Rezaie *et al* (2017)[28], but was lower than the study of Tohdi *et al* (2013) who reported the average of 5.69 and 5.35 days for female and male, respectively[29].

Ragusa *et al* (1995) was reported that female usually lay eggs only on food considered adequate for postembryonic development of the progeny [30]. Croft *et al* (1998) [31] reported that the number of egg production per day by *N. californicus* was 3.45 egg/day when fed on *T. urticae*. In another study, the total fecundity of *N. californicus* on seven strawberry cultivars ranged between 6.90 to 13.29 eggs/ female [27]. In the present study, the life time fecundity of *N. californicus* on different plant pollens ranged between 10.61 to 14.31 eggs / female.

The *r*-value is the most important population growth parameter [32]. The population growth parameters of *N. californicus* in present study varied in response to changing in plant pollens. The *r*- value of *N. californicus* in the present study show significant difference on the tested plant pollens and the highest value were observed when the predator fed on date pollen. The intrinsic rate of increase (*r*) of *N. californicus* was reported 0.27 day^{-1} at 25ºC [33]. Saber (2012) reported that the value of *r* when the predatory mite reared on *T. urticae* eggs and maize pollen was 0.17 and 0.23 day $^{-1}$ respectively [34]. The *r*-value of *N. californicus* fed on immature of *T. urticae* (0.154 day^{-1}) was lower than that obtained on the almond pollen (0.232 day^{-1}) or maize pollen (0.179 day^{-1}) [35].

Tohdi *et al* (2013) [29] recorded 0.151 day^{-1} for this predatory mite. The *r*-value of *N. californicus* on different strawberry cultivars ranged between 0.100-0.202 day^{-1}. Some phytoseiid mites require pollen require pollen for successful development and reproduction [36].

Pollen is utilized as an easy food source to rear phytoseiid mites [37]. The nutritional value of pollen varies across plant species and the developmental and reproductive response of phytoseiid to different pollen was also be variable [38]-[40].

With attention to observed results, *N. californicus* is a general predator and can play an important role in the biological control of *T. urticae.* The predatory mite with feeding on corn pollen, date pollen and walnut pollen can complete the developmental stages and can oviposit. Corn pollen, date pollen and walnut pollen were suitable alternative food for the mass rearing of this predator and between these pollens, date pollen was better than the others.

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