

Suitability of webworm *Loxostege sticticalis* L. (Lepidoptera: Crambidae) eggs for consumption by immature and adults of the predatory mite *Neoseiulus pseudolongispinosus* (Xin, Liang and Ke) (Acarina: Phytoseiidae)

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Abstract

The genus *Loxostege* has a worldwide distribution and includes an economically important group of insect pests of different crops. The effectiveness of predator *Neoseiulus pseudolongispinosus* (Xin, Liang and Ke) as a potential bio-control agent of webworm *Loxostege sticticalis* L., was investigated by measuring rates of prey consumption and destruction by the different life stages of mite, duration and viability of immature, pre-oviposition and oviposition periods, total oviposition capacity, and longevity of adults. When eggs food was offered in similar amounts, there were variations in consumption tendency among the different life stages of predator. Mean development period was shortest for egg-fed larvae, whereas, longest in deutonymph followed by egg and protonymph, and total life cycle was completed in a mean of 12.75 days for male or female. A mean pre-oviposition period of 4.28 days was recorded in female and period of oviposition lasted for 8.71 days. The mean number of eggs recorded was 1.42 day⁻¹ female⁻¹. Mortality was recorded in all life stages and percent viability was best in egg stage, adult females and males, and slightly less in larvae, protonymphs and deutonymphs. Further, predatory activity of mites, such as their feeding habits, number of eggs damaged, how they were damaged and oviposition were observed. It is concluded that *N. pseudolongispinosus* can be successfully reared on *L. sticticalis* eggs, which proved a good food for adults and nymphs. Laboratory data indicated that this predatory mite has the potential to act as a biological control agent of *L. sticticalis* in crops.

Additional key words: biological control; life parameters; predation.

Resumen

Aptitud de los huevos de *Loxostege sticticalis* L. (Lepidoptera: Crambidae) para su consumo por individuos inmaduros y adultos del ácaro depredador *Neoseiulus pseudolongispinosus* (Xin, Liang y Ke) (Acarina: Phytoseiidae)

El género *Loxostege* está distribuido por todo el mundo e incluye un grupo de plagas de insectos de importancia económica en diferentes cultivos. Se ha investigado el potencial del depredador *Neoseiulus pseudolongispinosus* como agente de control biológico de *Loxostege sticticalis*, midiendo la tasa de consumo de presa y el efecto deletéreo total para las diferentes fases de desarrollo del ácaro, la duración y viabilidad de los estados inmaduros, los periodos de pre-oviposición y de oviposición, la fecundidad y la longevidad de los adultos. Cuando se alimentaron con huevos en cantidades similares, hubo variaciones en la tendencia de consumo entre las diferentes fases de desarrollo del fitoseido. La duración media del desarrollo más corta se dio en larvas alimentadas con huevos, mientras que la más larga tuvo lugar en deutoninfas, seguidas por huevos y protoninfas; el ciclo de vida se completó en una media de 12,75 días. El período de preoviposición medio fue 4,28 días y la oviposición se prolongó durante 8,71 días. El número medio de huevos puestos fue de 1,42 día⁻¹ hembra⁻¹. Los porcentajes de supervivencia fueron mejores en el estado de huevo, seguido por los adultos. Se observó la actividad depredadora de los ácaros (hábitos de alimentación, número de huevos dañados, la forma en que fueron dañados y oviposición). Se concluye que *N. pseudolongispinosus* puede ser criado con éxito utilizando huevos de *L. sticticalis* como alimento de adultos y ninfas. Los datos de laboratorio obtenidos indican que este ácaro depredador tiene potencial para ser utilizado como agente de control biológico de *L. sticticalis* en campo.

Palabras clave adicionales: control biológico; depredación; parámetros vitales.

Introduction

The genus *Loxostege* has a worldwide, but largely northern temperate distribution and includes several economically important pest species of different crops. The beet or meadow webworm *Loxostege sticticalis* L. (Lepidoptera: Crambidae), is a major Holarctic (cold and temperate zones of the northern hemisphere) pest and has been recorded from a variety of plants (Hepner, 1975). It is capable to feed on more than 200 species of plants including cereals, oilseeds, beans, fiber crops and vegetable plants (Alekhin & Kuznetsova, 2003). Its high-altitude wind-borne migration, flight behavior, and short-distance dispersal were studied in northern China (Feng *et al.*, 2004). Females of the beet webworm had a pre-oviposition period of 3 days, and continued to lay eggs for up to 20 days post-emergence (Shirai, 2006). This insect pest is controlled especially by insecticide treatments of plants during the period of larval development, which impose environmental threat. The current experiment aims to provide safe biological alternatives to the use of agrochemicals for *L. sticticalis* pest management as the use of toxic chemicals is far too pervasive in the world today, and harmful to our health, environment and fauna.

Earlier researchers explored the possibility of arthropods egg consumption by certain predatory mites. A detailed study by Haines (1981) on the biology of the predatory mite *Blattisocius tarsalis* (Berlese) (Ascidae) demonstrated that this species can develop on alternative prey, *i.e.* eggs of *Tribolium* species, but, when offered eggs of the flour moth *Ephestia cautella* (Walker) and flour beetle *Tribolium castaneum* (Herbst), *B. tarsalis* displayed a strong preference for moth eggs. Hafez *et al.* (1988) studied the biology of the predatory mite *B. tarsalis* using newly deposited eggs of the tenebrionid *T. castaneum* and the silvanid *Oryzaephilus surinamensis* (L.) as prey; whereby all stages of the predator, except the larval stage, fed on the eggs. Abou-Awad *et al.* (1989) found housefly *Musca domestica* (L.), eggs as the most suitable diet for the mite *Hypoaspis vacuus* (Michael) from larval to adult stages. El-Laithy & El-Sawi (1998) studied the life span, life-table parameters, and predation rate of *Neoseiulus californicus* (McGregor) fed on different diets, adult females had a shorter life cycle on *Eriophyes dioscoridis* Soliman & Abou-Awad, and *Tetranychus urticae* Koch (Tetranychidae) eggs. Nielsen (1999) investigated food consumption rates of adult

female *B. tarsalis* by offering young eggs of the flour moth *Ephestia kuehniella* Zeller. Ali & Brennan (2000) described the predatory mite *Hypoaspis miles* (Berlese) feeding on *Lycoriella solani* (Winnertz), and Gotoh *et al.* (2004) determined the daily prey consumption rate of the immature stages (nymphs) and adult female of *N. californicus* on *T. urticae* eggs.

Knowledge on the species of natural enemies that co-occur with pests is essential when searching for indigenous candidates as biological control agents (Abad-Moyano *et al.*, 2009). The *Neoseiulus* (= *Amblyseius*) *pseudolongispinosus* (Xin, Liang and Ke) (Acarina: Phytoseiidae) has been found the most proficient and steadfast predator in controlling thrips and whitefly (Sarwar *et al.*, 2011a), and spider mite (Sarwar *et al.*, 2011b) populations. No information regarding the biology of *N. pseudolongispinosus* has been reported as a predator for webworm, though investigated on a diet of *Tyrophagus putrescentiae* (Schrank) (Sarwar *et al.*, 2010). For its possible use in biological control programs against *L. sticticalis*, it is important to know the effect of the host on the life cycle of this predator. Our objective was to evaluate the biological parameters of different *N. pseudolongispinosus* life stages under laboratory conditions using *L. sticticalis* eggs. Comparative investigation of the characteristics related to prey consumption and reproductive parameters among immature and adults of the predator *N. pseudolongispinosus*, which remained basically unexplored on this prey, could yield important information for selection of novel control agents to use in the field.

Material and methods

Stock culture

The stock culture of *N. pseudolongispinosus* was initially created from field-collected adults and culture maintained for about one year before the experimentation. To maintain genetic diversity, new *N. pseudolongispinosus* individuals were introduced to stock culture at different times. To avoid contamination of test mites' by other species, these were reviewed periodically by microscopic observation considering specific morphological characters of the species being studied. The stock was maintained at $25 \pm 2^\circ\text{C}$, $65 \pm 5\%$ relative humidity and 16: 8 h light: dark photoperiod. Mites were reserved on lima beans *Phaseolus lunatus* L., that were infested with ample spider mites *Tetranychus*

urticae Koch, and new colonies were established in cages. When the mites reached the intended densities in the rearing units, the required stages for experiments were obtained from these cages.

The larvae of the webworm moth were cultured on lima bean leaves in plastic pots. Newly hatched adults were fed on 5% sucrose solution using a small piece of sponge dipped in liquid. To obtain moth eggs, adult females mated with males were collected from stock cultures and allowed to oviposit on paper strips. Stock cultures were examined daily for the existence of all stages of predatory mite (egg, six-legged larva, protonymph, deutonymph and adult). During investigation, individually active mites were taken from culture and placed in a container. They were left for 3 min and then observed for 2 min to verify their activity as either inactive or active showing movement of legs or walking. This procedure was performed for a total of seven individual mites of each four postembryonic life stages, which were identified and classified by their size and shape; in addition, the ventral shield was checked under magnification before the experiments to confirm their identification as an adult female or male.

Prey consumption (number of prey consumed) and oviposition (laying eggs) of adult predatory mite

Before commencing feeding experiments, and to ensure mating, freshly emerged male and female predators (one of each) were selected at random from the stock culture and introduced into a small plastic Petri dish (2.5-cm diameter and 1-cm height). The Petri dish was contained fresh eggs of *L. sticticalis* mounted on a paper strip placed over a piece of filter paper at the bottom of the dish. After 24 h mite pairs were separated. For feeding experiments, the mite was allowed to feed only on eggs of host at the constant prey density of 15 eggs per individual. The Petri dishes in seven replicates were sealed with Parafilm (Pechiney Plastic Packaging Company, Chicago, IL, USA) and maintained at $25 \pm 2^\circ\text{C}$, $65 \pm 5\%$ relative humidity, with 16: 8 h light: dark cycles for 24 h. Later, the numbers of prey eggs consumed and left unconsumed in the unit were counted. Consumption rate was identified as the number of prey eggs consumed by predatory mite within 24 h, and the numbers of entirely or incompletely damaged eggs were also recorded. In addition,

the eggs produced by predators within the 24-h period were also counted. In the case of female mites, eggs laid were removed with a fine brush and transferred to new Petri dishes every day to ensure that they only consumed prey eggs and not their own. Seven replicates of adult males and females were maintained for studying different life parameters. The culture was placed in a regulated environmental chamber at 25°C , 70% relative humidity, and a photoperiod of 16: 8 h light: dark and mites were supplied with only moth eggs to maintain their populations. The observations on feeding habits and oviposition of adult mites in a small chamber were conducted with a microscope. Only adult female and male mites were used in the study to observe their activities on food consumption. The behavior of the predatory mite with the prey was also studied. Predatory activities, such as egg damaged and how they were damaged, were further recorded. Seven females were examined during pre-oviposition and oviposition periods. Pre-oviposition period was calculated as the time between the emergence of the adult stage female and the start of egg laying (oviposition). The oviposition rate was depicted as the number of eggs laid by a predatory mite in 24-h recorded under a microscope. Observations on predation rates (detection of prey, attack, capture and finally consumption) of both mite sexes, and fecundity for each female were continued daily and transformed to a per day basis.

Prey consumption and development of immature predatory mites

Under the same laboratory conditions, only one of all the eggs laid per replicate was placed in each dish to observe incubation period and the others were redundant. To study the effect of an egg diet on the postembryonic development and feeding behavior, newly hatched larvae and nymphs were kept singly in experimental cells (seven for every stage) with perforations in the lid and sealed carefully with Parafilm to create a mite-tight enclosure. Predatory larvae and nymphs were supplied with a suitable number of preys (15 eggs per individual) and observed for eggs feeding in each developmental stage. Egg feeding, consumption and destruction (egg damaged) rates by predatory immature were assessed. The Petri dishes were checked every day, and the food consumption and development of immature were observed on a regular basis. Observations on development and prey consumption were

carried out after every 6-h. The other parameters estimated were the effect of host eggs as prey on survival of all life stages, and the longevities of both male and female adult mites. In addition, the predators were examined daily to ensure that whether they were alive, the male and female longevity, and development period of the immature in each Petri dish were recorded. Similarly, the total duration for development from egg to adult was recorded.

Data analysis

Data analysis involved calculating the means of each parameter to measure the statistical effects of variables for comparative analyses using SPSS (SPSS, 2005). Differences between different life stages and sexes for development time, adult longevity, egg consumption and egg destruction were calculated by analysis of variance. Multiple comparisons were made using least significant difference (0.05). Pre-oviposition, oviposition, fecundity and total life duration were calculated using the standard methodology of descriptive statistics.

Results

During the present study the suitability of *L. sticticalis* eggs as prey for the immature and adult stages of the predatory mite, *N. pseudolongispinosus* was recognized. Development of the different life stages and longevity of the adults' predator were favored when mites were supplied with *L. sticticalis* eggs as prey. Tables 1 and 2 summarize the average developmental rates, food consumption and survival in different stages of the mite on the eggs diet.

Oviposition and development

The oviposition, pre-oviposition and oviposition periods of the predatory mites are shown in Table 1.

Mean pre-oviposition and oviposition periods of 4.28 and 8.71 days, respectively, were recorded for the egg-fed females. On an average, the number of eggs laid after single or multiple mating was 1.42 female⁻¹ day⁻¹ (Table 1). The duration of egg and immature developmental period, and the longevity of the adults indicated that this predator, successfully completed its development within 3.29 days in an average; protonymphs developed in a mean of 3.10 days, but results were not significantly different between the egg developmental time and that of the protonymph. The developmental time of the larval and deutonymph stages was 2.21 and 4.07 days, respectively. All the life stages from egg to deutonymph matured and developed to the next stage successfully (12.75 days for male or female). The total length of the developmental period of egg and immature stages was 12.75 days in an average (Tables 1 and 2).

Prey consumption

Daily (per day) food consumption rates for the different life stages of predatory mites are presented in Table 2. The larval stages of the predatory mite destroyed low number of the eggs offered. The nymphs fed on the eggs, but predation was too low compared with that of adults. Among different life stages, variations in feeding resulted in the death of some individuals during development. For male and female adult mites, there were significant differences in predation. Females showed the highest prey consumption day⁻¹, followed by male, deutonymph, protonymph, and no predation was recorded for larvae. The highest eggs destruction rate was recorded for females (3 or 4 day⁻¹) followed by male, and the lowest determined for immature stages (larva, protonymph, deutonymph). The total consumption capacity of the predator was highest in the female (3.57 prey predator⁻¹ day⁻¹) followed by male (2.85 prey predator⁻¹ day⁻¹). Very few eggs out of the 15 eggs offered were observed to be eaten by the immature stages. Among immature stages, no egg con-

Table 1. Analysis of variance for different life parameters and mean performance of mite predator *N. pseudolongispinosus*

Serial No.	Life parameter	Minimum	Maximum	Mean	Standard deviation
1	Preoviposition (days)	3.5	5.0	4.28	0.585
2	Oviposition (days)	7.0	12.0	8.71	2.058
3	Fecundity (number of eggs laid female ⁻¹ day ⁻¹)	1.0	2.0	1.42	0.534
4	Total development period (days)	12.0	13.50	12.75	0.540

Table 2. Food consumption and development rates in different growth stages of mite predator *N. pseudolongispinosus* (Mean $\pm$ Standard error)

Serial No.	Life stage	Prey consumption		Immature development/ adult longevity (days)	Survival of different life stages (%)
		Mean number of eggs consumed	Mean number of eggs destroyed		
1	Egg	0.00	0.00	3.29 $\pm$ 0.17 b	95
2	Larva	0.00	0.28 $\pm$ 0.18 a	2.21 $\pm$ 0.10 a	80
3	Protonymph	1.14 $\pm$ 0.14 a	1.42 $\pm$ 0.20 b	3.10 $\pm$ 0.17 b	85
4	Deutonymph	2.14 $\pm$ 0.26 b	1.42 $\pm$ 0.20 b	4.07 $\pm$ 0.10 c	85
5	Adult male	2.85 $\pm$ 0.20 c	2.57 $\pm$ 0.20 c	14.42 $\pm$ 1.15*	90
6	Adult female	3.57 $\pm$ 0.26 d	3.57 $\pm$ 0.29 d	19.42 $\pm$ 1.15*	92

Parameters (different life stages) followed by the same letters were not significantly different at the 5% level, while the symbol * shows significant differences.

sumption was recorded for the larvae, while, the daily food consumption rate was lowest in protonymph, and greater in deutonymph. Although the food consumed by all predatory stages was variable, yet they accepted eggs as prey, and the highest predation rate was recorded in female adults. Mean number of eggs killed, collapsed (wholly and partially), or deflated, when presented with *L. sticticalis* eggs, was the highest for female adult mite (3.57 day⁻¹) which was more than the mean number (2.57) of destroyed eggs in male and nymphs. The mean numbers of destroyed eggs were 1.42 day⁻¹ in both deutonymph and protonymph, this value was significantly different from the value obtained for the larval stage (0.28 day⁻¹) emerging a suitable diet for rearing of this predatory mite.

Predation and oviposition habits

Adult mites showed no attraction towards the eggs when first placed in the Petri dishes containing eggs; however, after 2-3 h, the mites began to move towards the prey and initiated activities on or very near to the prey eggs. All mobile stages of the mite were able to locate the host eggs in the container, after which these either climbed over the eggs and fed, or initiated feeding at the base of an egg. Predation on eggs did not generally commence until 3-4 h after transfer to the Petri dishes, after that the predator broke a minute hole in the egg shell to feed. The mites then fed on the egg's contents leaving the broken egg shell on the surface of paper strip. As soon as the contents of eggs were completely consumed, the mites then moved around or away from the feeding area. Larvae were only observed to damage eggs, and nymphs focused primarily on

freshly-laid, soft eggs and eggs that had been previously damaged by larvae at the base. Neither the larvae nor the nymphs were observed to enter the shell of an egg damaged by them. None of the feeding stages of predatory mite was observed to feed on any of the larval instars of *L. sticticalis*, if the egg offered hatched. In regards to oviposition habits, the majority of predator eggs were laid near to, or directly on the prey eggs, with more eggs being oviposited on damaged prey.

Survivorship and longevity

The survival or hatching rate of the mite eggs was 95%, while, survival rate of larvae was 80% compared with 85% each in protonymph and deutonymph instars. Survival rate was higher in females (92%) than males (90%). Longevity of 14.42 and 19.42 days was recorded for males and females, respectively, indicating that female mites are more voracious (high predation on *L. sticticalis* eggs) than those of the other immature and reproductive stage (male).

Discussion

It is an interesting finding which describes the possibility of using the eggs of webworm *L. sticticalis* as prey for the immature and adult stage of the predatory mite *N. pseudolongispinosus*. The ability of predator to feed on the different prey types is one of the most important characteristics to any biological control agents. Although Xin *et al.* (1981) described this predatory mite species as *Amblyseius pseudolongispinosus* collected on numerous plants in China, yet

there are no reports of its preying upon *L. sticticalis* eggs either in field or laboratory, even though this webworm is among one of the most damaging pests in crops. The present work investigated the possibility that *N. pseudolongispinosus* could feed on *L. sticticalis* eggs and be able to contribute to the biological control of this injurious pest. By studying the feeding behavior, reproductive response and developmental rate of the predator, the significant results were obtained in the laboratory. The predator food used favored the adult longevity and life span, but also appeared suitable for the predator's development. However, there were differences in the amount of food consumed between adult and the immature stages. The reasonable egg consumption rate (1.14-2.14) of the immature stages may be attributed to their requirements for energy during the active growth periods, and for energy reserves to be used during quiescent phases. Females consumed more food than the immature stages and adult males. The highest consumption rate of female mites may be because of their food requirement for egg production. The adult male showed moderate egg consumption, which was higher than the immature stages, but lower in regards to the adult female consumption rate.

Many authors have noted that several predatory mite species are very active predators of other mites, insect pests and their eggs. Haines (1981) worked with fresh eggs of *Ephestia cautella* (*Cadra cautella*) (Walker) and found that a mean number of 2.4 eggs mite⁻¹ day⁻¹ were consumed by *B. tarsalis*. Maria *et al.* (2001) noted a maximum daily oviposition of 3.9 eggs by *Neoseiulus* day⁻¹ and a consumption rate of 40 eggs of the mite *Mononychellus tanajoa* (Bondar) (Acarina: Tetranychidae) over its lifetime, suggesting that mites of this genus comprise some of the most important eggs predators of pest species. The mean number of eggs consumed by mites in our study was 3.57 female⁻¹ day⁻¹. This value was slightly lower than the fully-consumed eggs per day by an ovipositing *Neoseiulus* female as reported by Maria *et al.* (2001), but higher than an egg predator *B. tarsalis* as shown by Haines (1981), who reported that most eggs were fully ingested; as a consequence, the mean number of totally destroyed eggs in that study was only slightly greater than the mean number of fully ingested. In our study, however, the mean number of incompletely consumed eggs per adult female mite (3.57 day⁻¹) was similar to that of the destroyed eggs. Gotoh *et al.* (2004) determined the daily prey consumption rate of the immature stages and adult females of *N. californicus* on eggs of

T. urticae. Females consumed more eggs (13.4 eggs female⁻¹ day⁻¹) than males, and the total number of eggs consumed during the immature stages did not differ significantly from each other.

Further, in our study, the mites raised on *L. sticticalis* eggs completed their life cycle on an average of 12.75 days; the mean number of eggs laid was per female 1.42 eggs day⁻¹, and longevity averaged 14.42 and 19.42 days for male and female mites, respectively. Zhou & Chang (1989) studied the biology of *Amblyseius pseudolongispinosus* at five different temperatures (from 18°C to 34°C); the mean generation times were 32.63 to 12.67 days. In contrast, El-Laithy & El-Sawi (1998) studied the life span, life-table parameters, and predation rate of *N. californicus* and reported that the adult females had a shorter life cycle on *E. dioscoridis* eggs (7.35 days) than on *T. urticae* eggs (9.76 days) or nymphs (8.05 days). Adult female longevity was 39.2 days on *E. dioscoridis*, but 31.58 and 35.7 days on *T. urticae* eggs and nymphs, respectively. Females fed on *T. urticae* nymphs had the highest fecundity rate. Each female laid an average of 64.7 eggs; whereas, the females that fed on *E. dioscoridis* laid an average of 32.95 eggs.

Our study found that the mean number of eggs destroyed was higher for females (3.57 day⁻¹) than for males and nymphs, such misuse of food by predator may be desirable to decrease the population of the pest and mitigate the damage it causes. One explanation for this response could be that, at relatively high prey densities, the remaining gut capacity of predator does not allow full ingestion of the prey, as proposed by Sabelis (1990; 1992). Nielsen (1999) found that the mean number of destroyed moth eggs per *B. tarsalis* female ranged from 3 to 5 eggs day⁻¹. The large amount of partially ingested eggs seemed to be an excessive waste of food, which may be a typical characteristic of predatory arthropods (Sabelis, 1992). Nielsen (2003) recorded a mean predation rate of 2.2-7.0 eggs of *E. kuehniella* destroyed in 24 h, reflecting that a large proportion of the available prey was destroyed. However, in this study, very young eggs were used, which could have influenced the predation rate, because eggs may become less attractive as they mature. We observed that the mites' break a small hole in the eggshell to create an opening for feeding and then ate the inside contents of the egg, leaving the eggshell on the surface of the paper. Under experimental conditions most eggs were incompletely consumed, confirming the general assumption that predatory mites leave most of the food

content unused. This feeding behavior substantiates the findings of Ali & Brennan (2000) that the predatory mite *Hypoaspis miles* (Womersley) feeds on *Lycoriella solani* (Diptera: Sciaridae) and *Acarus siro* (Acari: Acaridae) immature stages by using its chelicerae to cut into the cuticle of its prey. Portions of soft material in a semi-liquid state are extracted from the prey after which they are sucked into the alimentary canal.

Predators sometimes would kill several preys before consuming any of them. A diet of eggs caused the mature mite stages to feed more rapidly than other life stages. These observations are in accordance with those of Abou-Awad *et al.* (1989) who reported that the predacious mite *Hypoaspis vacua* (Michael) successfully developed from larva to adult stage when fed on eggs of housefly, *Musca domestica* (L.). Eggs of housefly were the most suitable diet, as it prolonged adult longevity and increased female fecundity. It was found that housefly eggs were an adequate diet for *Lasioseius athiasae* Nawar & Nasr (Acarina: Ascidae), promoting an oviposition rate which was nearly equal to, or greater than, those obtained with other mesostigmatid predators (Shereef *et al.*, 1980). Ascid mites have been reported to be voracious predators on nematodes (Walter, 1987); however, the oviposition rate of *L. athiasae* females that had fed on eggs of the root knot nematode *Meloidogyne incognita* (Kofoid and White) was very low (0.35 eggs female⁻¹ day⁻¹). Hafez *et al.* (1988) studied all life stages of the predator mite, *B. tarsalis* fed on the eggs of stored food mite, and the females consumed more eggs and reached maturity earlier than males. We found that the larval stage of the predatory mites did not consume the eggs of *L. sticticalis*, but some larvae caused the collapse of the egg surface through slight feeding or walking on the eggs. The nymphs fed on the eggs, but predation was low, resulting in comparatively higher mortality in the nymph stage. Adults of the predatory mite fed and accepted this prey very well. These findings are similar to those of Blaeser & Sengonca (2001), and Sarwar *et al.* (2009), who studied predation of *Amblyseius* predatory mites species on *Frankliniella occidentalis* (Perigande) (Thysanoptera: Thripidae), *T. putrescentiae* and *T. urticae*, and other soft-bodied arthropod pests (Sarwar *et al.*, 2011a; 2011b). Their studies showed significant differences in the level of predation and prey preference by the immature and adult stages of the predatory mites. In addition, female mites consumed more eggs than the male and immature life stages. The maximum number of eggs was consumed by adult

females, which consumed an average of 3.57 eggs day⁻¹. The feeding capacity of the male was always less than that of the female, irrespective of the type of food (Abou-Awad *et al.*, 1989).

A small degree of mortality of the mites in our study occurred indicating the suitability of the prey for predator development. Comparatively higher rate of mortality occurred in the immature stages than in adults. The main cause of mortality of immature mites may be due to their susceptibility during the development period or a failure to trace prey at earlier instars. Based on these studies, the predatory mite *N. pseudolongispinosus* seemed to be an efficient predator of the prey used here. The ability of a predator to feed on prey species other than its usual prey is an advantage because it may be able to survive on other insect and/or acarine prey when the target pest is scarce. As adults female and male predators generally displayed enhanced survival and longevity compared to that of larvae, protonymphs, and deutonymphs, thus, an estimation of both these parameters is of importance in determining the survival of any sexes. With the present knowledge of *N. pseudolongispinosus*, it can be further assessed the effectiveness of this mite under field conditions and its use in a biological control program of *L. sticticalis*. Nevertheless, the number of eggs of *L. sticticalis* consumed and destroyed by both adults and nymphs of this predatory mite implies that the species may have the ability to reduce pest populations under field conditions.

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