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Biology and Predatory potential of *Neoseiulus longispinosus* Evans on *Tetranychus urticae* Koch

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ABSTRACT: *Tetranychus urticae* Koch is a polyphagous mite pest infests various agricultural and horticultural crops. *Neoseiulus longispinosus* (Evans) is a potential predator on *Tetranychus urticae.* Experiments were carried out on the biology and to evaluate the predatory potential of *N. longispinosus* on *T. urticae* reared on lablab under laboratory. The developmental duration from egg to adult of *N. longispinosus* was 4.625±0.1874 days. The mean developmental duration of female predatory mite was 4.88±0.09 days and male predatory mite was 4.75±0.06 days respectively. The ovipositional period and longevity of the female and male predatory mite was 10.05±0.436 days, 16.35± 0.9988 days and 19.91±0.5286 days respectively. The total fecundity of *N. longispinosus* was about 16.2±1.0678 numbers respectively. The predatory mite mostly preferred larval stages of *T. urticae* when compared to nymphs and adults. The total number of prey consumed by *N. longispinosus* was 166.01±12.23. The prey consumption rate was higher at temperature 30ºC when compared with 28ºC. Maximum predation was observed at 30˚C *i.e.* 13.38±0.10 for nymphs and 9.50±0.27 for adults when prey density was 40 nymphs and 40 adults respectively. This present study would help to identify the effectiveness and performance of *N. longispinosus* against red spider mite, *T. urticae*.

Keywords: Biology, Predatory potential, *Neoseiulus longispinosus, Tetranychus urticae,* functional and numerical response.

INTRODUCTION

Phytophagous mites cause considerable yield loss among the non-insect pests and it was observed that red spider mite, *Tetranychus* sp. (Tetranychidae: Acarina) represents one of the most important groups of phytophagous mites. It attacks agricultural and horticultural crops under open and protected conditions. It is highly polyphagous non insect pest attacks cotton, tomato, okra, chillies, gingelly and distributed throughout world and often severely affected under dry conditions. To control these mites excess use of chemicals should not be encouraged since it causes resistance, resurgence and environmental pollution. An alternative method is needed for managing these mites. Natural enemies *viz.,* predatory mites can be used for managing these phytophagous mites. Predatory mites play a leading role in commercial augmentative biological control. Many species of Phytoseiids are mass cultured and released in the field as a bio-control agent, among which *Neoseiulus longispinosus* (Evans) holds a key position due to its immense potential of predation (Bhowmik and Yadav 2021). Because of their high predatory potential ability in controlling mite pests in field they are considered as an important biocontrol agents.Mallik and Channabasavanna (1983), reported that *N. longispinosus* (Evans) is most potential obligate predator of tetranychid mites. Hence, the present studies were undertaken to explore the biology and predatory potential of *Neoseiulus longispinosus* against *Tetranychus urticae.*

MATERIALS AND METHODS

A. Stock culture of T. urticae

The red spider mite, *T. urticae* was collected from field, mass reared and maintained in the Acarology glass house at insectary by the method developed by Krishnamoorthy (1989). Host plants were raised in pots for culturing *T. urticae*. Thirty days old potted lablab plants (*Phaseolus vulgaris* L.) were infested with *T. urticae* with the help of camel hair brush or by keeping the already infested leaves on fresh plants in order to transfer the mites. Then, fresh potted plants were transferred besides the older plants at periodical intervals to transfer the mites from older one to fresh so as to maintain the continuous culture of *T. urticae.* The mites from the culture were used for various experiments.

B. Stock culture of predatory mite, N. longispinosus

The predatory mite adults were collected from the glass house along with prey mites. They were transferred to the mulberry leaves which are placed on plastic trays. The plastic tray containing sponge of 1.5cm thickness layered with the moist cotton pad. It was regularly monitored and water was added to the rearing unit whenever necessary to prevent the drying of leaves and to keep the cotton pad in moist condition. The Gravid females of *N. longispinosus* along with prey mites were monitored regularly and examined for every day.

C. Biology of N. longispinosus on T. urticae

Life cycle of *N. longispinosus* was studied on *T. urticae* cultured on lablab plants. Leaf bits of selected host plants were placed on rubber foam layered with moist absorbent cotton in individual rearing cells. Water was added to the rearing cells to prevent drying of leaf bits and keep the cotton moist. Leaf bits were supplied with eggs of prey mite using camel hair brush and one female deutonymph and active males of *N. longispinosus* was released on each leaf bit. Eggs of prey mite were supplemented and observations were made at 12 hours interval for pre-oviposition, fecundity and longevity using a stereo zoom microscope in the laboratory at 28±2ºC and 75±10 per cent RH. Longevity and fecundity of *N. longispinosus* was studied.

D. Predatory potential of N. longispinosus.

Functional response of gravid female, *N. longispinonus* was studied on different densities of nymphs and adults of *T. urticae* at 28 and 30ºC in Biochemical Oxygen Demand (BOD) incubator as per the methodology adopted by Rahman *et al.,* (2013) and also in laboratory temperature. Experiments were conducted as per methodologies given by Rahman *et al.,* (2012a, 2012b, 2013); Zhang *et al.* (1999). Daily feeding potential of predatory mite was also examined. Number of eggs, nymphs and adults consumed daily by the predatory mite were observed and recorded.

E. Functional response of predatory mite on the nymphs and adults of prey at 28 and 30º C

Mulberry leaf bits of 2 cm² were placed individually on rearing cells containing rubber foam layered with moist absorbed cotton. Each leaf bit was infested with 1, 5, 10, 20, 30, and 40 nymphs and adults of *T. urticae* and 12 hours starved single gravid female of *N. longispinonus* was introduced to each prey density separately. Adequate water was added to the rearing cells to avoid drying of leaf bits. The number of prey nymphs and adults consumed by single predator was recorded for every 24 h. Experiment was repeated for two days.

E. Numerical response of predator on prey density at 28 and 30º C

The numerical response of *N. longispinonus* to various densities of *T. urticae* was examined in terms of oviposition of an individual predator to the rate of predation. A gravid female predatory mite was starved for 12 hours and confined on experiment leaf bits with adult females of *T. urticae* at a density of 3, 6, 9 and 12. The number of preys consumed and number of eggs laid by predator was recorded 24 hours after the start of the experiment for three consecutive days.

F. Statistical analysis

For biology studies, differences in the duration of developmental stages of *N. longispinosus* on *T. urticae* and different reproduction parameters were analysed by one-way analysis of variance (ANOVA) followed by the least significant difference test and means were classified by Tukey's HSD test. The computations were furnished in Microsoft Excel and SPSS (SPSS 22.0) software.

RESULTS AND DISCUSSION

A. Biology of Neoseiulus longispinosus on Tetranychus urticae

Biology of *Neoseiulus longispinosus* was examined in the laboratory at room temperature on lablab leaves infested with *T. urticae.* Mean development of *N. longispinosus* (Female and Male) is presented in Table 1. At laboratory temperature *N. longispinosus* completed the total development in a period of 4.625±0.1874 days, with incubation, larval, protonymphal and deutonymphal duration of 1.938±0.143, 0.515±0.0106, 0.993±0.0171 and 1.179±0.0167 days respectively. The total developmental period from egg to adult of *N. longispinosus* at laboratory temperature (4.625±0.1874) recorded in the present study are compared to the total development period recorded by Ibrahim and Palacio (1994) 102.50h (4.2708 days) for both sexes at 25-28ºC. Thongtab *et al.* (2001) observed that the total developmental period of *N. longispinosus*, fed on *Eotetranychus cendanai* Rimando was 4.79 ± 0.61 days from egg to adult compared to 4.625±0.187 days recorded in the present study. Due to the prey mite species used in these studies the difference in the developmental period was observed. Chauhan *et al.* (2011) found that the developmental duration of *N. longispinosus* was 8.8 days from egg to adult stages on rose under laboratory condition at 18.4-22.7°C & 20-91% Kolodochka (1985) recorded the mean total developmental time of 4.60 days and 4.50 days for female and male *N. longispinosus*, respectively on *T. urticae*, which is lower compared to the present results. The total developmental time of *N. longispinosus* on *T. urticae* recorded in the present study is comparable with the developmental time of 4.9- 5.9 days recorded by Lo and Ho (1979) and 5.1-5.7 days observed by Shih and Sheh (1979). The study by Ullah and Gotoh (2014) revealed that *N. womersleyi* when reared on *T.*

truncatus prey, took 4.64-4.65 days to complete its overall development close to the present record.

Observations recorded on the duration of the life stages of *N. longispinosus* female on lablab are represented in Table 2. At laboratory temperature, the time for incubation, larval, protonymphal and deutonymphal stages was $2.24±0.09^d$, $0.61±0.03^a$, $0.87±0.02^b$ and $1.16±0.03^c$ respectively. The total days taken for the development from egg to adult by female of *N. longispinosus* was 4.88±0.09 days at laboratory temperature. The total development period for females (117.12 h) recorded in the present study is slightly higher than the developmental time reported by Mallik and Channabasavanna (1983) who recorded 99h for females.

The data recorded on the duration of the life stages of *N. longispinosus* male on lablab are represented in Table 2. At laboratory temperature (28ºC), the time for incubation, larval, protonymphal and deutonymphal stages was $2.37±0.02^d$, $0.54±0.02^a$, $0.78±0.04^b$ and $1.07±0.01^c$ respectively. The total days taken by male of *N. longispinosus* for the development from egg to adult was 4.75±0.06 days at laboratory temperature. The total development period for males (114 h) recorded in the present study is slightly higher than the developmental time reported by Mallik and Channabasavanna (1983) who recorded 95h 30min for males. The difference is attributed to the host plant french beans and prey mite species (*T. ludeni*) used by them. Hariyappa and Kulkarni (1988) conducted studies on the biology of *A. (=N.) longispinosus* on *Polyphagotarsonemus latus* (Banks) at 23-27°C and 65-70% RH and recorded that the mean durations of the egg, larval, protonymphal and deutonymphal stages were 45.67h (1.894 days), 14.27h (0.595 days), 23.18h (0.966 days) and 24.41h (1.017days), respectively in females and the respective durations in males were 46.45h (1.936 days), 14.10h (0.588 days), 2.78h (0.116 days) and 22.71h (0.947 days). The female and male developmental duration recorded in the present study was almost comparable with the results of this study.

The data of different reproduction parameters of female *N. longispinosus* reared on *T. urticae* are presented in Table 3. The pre ovipositional period recorded was 2.053±0.0555 days and the oviposition period of *N. longispinosus* on *T. urticae* was 10.05±0.436 days respectively. The post oviposition period observed was 2.3166±0.0368 days. The total eggs laid (total fecundity) by a female predator recorded was 16.2±1.0678 as its fertility rate. The longevity of female and male was recorded as 16.35± 0.9988 days and 19.91±0.5286 days respectively. Abhilash and Sudharma (2002) reported a slightly lower female longevity (13.2±3.7 days) but higher fertility rate (25.2±3.83 eggs/ female) and daily oviposition rate (2.02±0.59 eggs/female/day) of *A. longispinosus* on *T. ludeni* compared to the corresponding values in the present study. Investigations carried out by Sanchit and Shukla (2016) revealed higher oviposition (18.60±2.61 days), post oviposition period (3.50±1.01 days) and fertility rate (38.04±4.63 eggs/female) but lower pre oviposition period (1.61±0.03 days) of *A. longispinosus* reared on *T. urticae*. The deviations in the values from present study may be due to the higher rearing temperature (28-32ºC) and relative humidity (78-83%).

B. Predatory potential of N. longispinosus

In earlier research the non-feeding behavior of *N. longispinosus* larva on life stages of *T. urticae* was observed. Hence, studies were conducted on the nymphal and adult stages only. Results shown in Table 4 revealed that tested predatory mite stages preferred larvae of *T. urticae* followed by nymphal and egg stages. Adult stage was least preferred by predatory mite stages. As the stage progressed from protonymph to adult stage, prey intake gradually increased. In comparison to earlier phases of the predatory mite, the adult female was a voracious feeder. Ibrahim and Palacio (1994) reported that *N. longispinosus* preferred more of larval and nymphal stages and the adult prey was least preferred. The results of the above studies support the present findings as the adult predatory mite consumed more number of prey eggs followed by larvae and nymphs. Table 5, reveals the total feeding potential of the predatory mite, *N. longispinosus* on *T. urticae.* The mean consumption rate by the protonymph, deutonymph and adult was 3.86±0.36, 11.86±0.9 and 150.29±10.97 respectively. The total number of preys consumed by *N. longispinosus* was 166.01±12.23. Ibrahim and Palacio (1994) stated that the protonymph and deutonymph of the predatory mite, *Amblyseius longispinosus* (=*Neoseiulus longispinosus*) consumed 3.94±0.16 and 3.99±0.22 eggs of the prey mite, *T. urticae*. The present findings are in little deviation to this study, wherein, the predatory protonymph consumed a smaller number of prey eggs (1.7±0.30) than reported by them, while the deutonymph consumed more or less the same number of prey eggs (3.7±0.65). Moghadasi *et al.* (2013) found that the predatory mite, *Typhlodromus bagdasarjani* significantly preferred the eggs, followed by larvae and protonymphs of its prey, *T. urticae* on rose.

Fig. 1. Adult female predatory mite, *N. longispinosus* and its egg.

C. Functional response of predator on nymphs and adults of prey

The results reported in Table 6 showed that the prey density changed gradually. A high rate of predation was seen when there were 40 nymphs and adults of prey in each leaf bit. Predation rate was significantly influenced by temperature, and it rises as the temperature does.

Both nymphs and adults experienced higher rates of predation at 30°C rather than at 28°C. Maximum predation was observed at 30ºC *i.e.* 13.38±0.10[e] for nymphs and 9.50±0.27for adults when prey density was 40 nymphs and 40 adults per rearing cell. Among the predatory mite developmental stages, non feeding behavior of larva on *T. urticae* was observed, shorter developmental period and lower searching efficiency of the larva might be the reasons for its nonfeeding behaviour. This is in agreement with Ibrahim and Palacio (1994); Sharma and Chauhan (2013). Predatory mite efficiency increased with advancement of developmental stage and the order of potency viz., adult female > deutonymph > protonymphs > adult male, according to Rao *et al.* (2017a). Adult female was able feed on more number of prey for oviposition requirement. It was found that adult male was fast moving than other stages and spent most of the time in searching the prey mite.

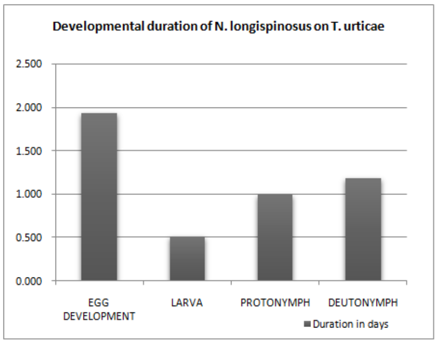
Fig. 2. *N. longispinosus,* predatory mitefeeding *T. urticae,* adult prey mite.

D. Numerical response of predator on T. urticae

Results shown in Table 7 revealed that rate of predation had influenced on rate of oviposition in relation to prey uptake. The rate of predation was 1.00±0.18, 1.92±0.32, 3.5±0.34 and 4.17±0.5 numbers of prey mite for prey density of 3, 6, 9 and 12 and the corresponding values for rate of oviposition were 1.08±0.28, 1.92±0.22, 2.5±0.26 and 3.25±0.37 respectively.

Table 1: Development of predatory mite, *N. longispinosus* on prey species of *T. urticae*

Predatory mite stages	Duration of development (days) on prey (Mean±S.E.)*
Egg development	1.938±0.143
Larva	0.515±0.0106
Protonymph	0.993±0.0171
Deutonymph	1.179±0.0167
Total development	4.625±0.1874
SE(d)	0.1028
CD(P=0.05)	0.2145



*Mean of six replications

Table 2: Development of Male and female predatory mite, *N. longispinosus* on *T. urticae*

Life stages of Predatory mite	Developmental duration of Female (days)	Developmental duration of Male (days)
Egg	2.24±0.09[d]	2.37±0.02[d]
Larva	0.61±0.03[a]	0.54±0.02[a]
Protonymph	0.87±0.02[b]	0.78±0.04[b]
Deutonymph	1.16±0.03[c]	1.07±0.01[c]
Total development	4.88±0.09[e]	4.75±0.06[e]
SE(d)	0.0721	0.0301
CD(P=0.05)	0.1664	0.0694

*Mean of four replications

Table 3: Reproduction attributes of predator *N. longispinosus* on *T. urticae.*

Reproduction attributes	Duration in days
Pre ovipositional period	2.053±0.0555
Oviposition period	10.05±0.436
Post ovipositional period	2.3166±0.0368
Total no. of eggs/female (fecundity)	16.2±1.0678
Female longevity	16.35± 0.9988
Male longevity	19.91± 0.5286

*Mean of five replications

Table 4: Feeding potential of adult predatory mite, *N. longispinosus* on life stages of the prey mite, *T. urticae.*

Feeding period	Number of prey consumed by *N. longispinosus*				Mean consumption
	Egg	Larva	Nymph	Adult	
D1	0.00	0.29	0.43	0.00	0.71(7)
D2	0.43	1.14	1.29	0.29	3.15(7)
D3	0.57	2.43	1.57	0.57	5.14(7)
D4	1.00	2.71	2.14	0.86	6.72(7)
D5	0.71	3.43	2.57	1.29	8.00(7)
D6	0.86	4.14	3.57	1.14	9.71(7)
D7	1.43	4.00	3.00	1.29	9.72(7)
D8	1.71	3.57	3.71	1.00	10.00(7)
D9	2.29	3.71	4.00	1.14	11.14(7)
D10	2.57	5.14	4.57	0.71	13.00(7)
D11	3.86	4.29	2.57	1.00	11.71(7)
D12	3.00	3.57	2.43	0.57	9.57(7)
D13	3.43	4.00	2.71	1.00	11.14(7)
D14	1.86	3.14	2.43	0.57	8.00(7)
D15	2.00	2.14	2.14	0.86	7.15(7)
D16	1.43	2.00	2.14	1.00	6.57(7)
D17	0.57	2.71	1.86	0.86	6.00(7)
D18	0.86	1.43	1.71	0.71	4.71(7)
D19	0.14	2.00	2.14	0.86	5.15(7)
D20	0.43	1.43	2.43	0.71	5.00(6)
D21	0.14	0.86	1.86	0.29	3.15(6)
D22	0.43	1.71	2.57	0.29	5.00(6)
D23	0.29	0.57	2.00	0.14	3.00(5)
D24	0.14	0.43	1.00	0.00	1.57(4)
D25	0.14	0.14	0.43	0.00	0.71(3)
D26	0.00	0.14	0.14	0.00	0.29(1)
D27	0.00	0.00	0.00	0.00	0.00(0)
D28	0.00	0.00	0.00	0.00	0.00(0)
D29	0.00	0.00	0.00	0.00	0.00(0)
D30	0.00	0.00	0.00	0.00	0.00(0)

*Figures in parentheses indicate the total number of alive female predatory mites out of 7 replicates over time; D- Day

Table 5: Feeding potential of adult predatory mite, *N. longispinosus* on life stages of *T. urticae*.

Feeding stages of predatory mite	Number of Prey consumed (Mean±S.E.)
Larva	Non feeding stage
Protonymph	3.86±0.36
Deutonymph	11.86±0.9
Adult	150.29±10.97
Total	166.01±12.23
SE(d)	0.6907
CD(P=0.05)	1.3722

Table 6: Functional response of adult predatory mite, *N. longispinosus* on *T. urticae* at 28 and 30°C.

Prey Density*	Temperature at 28°C		Temperature at 30°C	
	No. of adults consumed	No. of nymphs consumed	No. of adults consumed	No. of nymphs consumed
1	0.50±0.21[a]	0.50±0.21[a]	0.63±0.10[a]	0.50±0.16[a]
5	1.63±0.32[a]	2.50±0.29[b]	2.38±0.51[ab]	3.75±0.37[b]
10	3.63±0.24[b]	4.13±0.38[c]	4.00±0.35[bc]	5.75±0.34[c]
15	4.00±0.62[b]	5.00±0.36[c]	4.75±0.49[c]	6.38±0.53[c]
20	5.63±0.24[c]	6.88±0.52[d]	6.13±0.93[cd]	10.25±0.34[d]
30	7.00±0.87[c]	7.88±0.52[d]	7.63±0.90[de]	11.38±0.29[d]
40	8.63±0.75[d]	10.5±0.5[e]	9.50±0.27[e]	13.38±0.10[e]
SE(d)	0.7440	0.5786	1.0635	0.6038
CD(P=0.05)	1.55	1.21	2.22	1.26

*Mean of four replications in each treatment density

In a column, means followed by common letter(s) are not significantly different by LSD

Table 7: Numerical response of adult predatory mite, *N. longispinosus* on *T. urticae*.

Prey density*	Rate of predation	Rate of oviposition
3	1.00±0.18	1.08±0.28
6	1.92±0.32	1.92±0.22
9	3.5±0.34	2.5±0.26
12	4.17±0.5	3.25±0.37
SE(d)	0.6107	0.4714
CD(P=0.05)	1.01897	1.0047

*Each density with four replications

CONCLUSIONS

The results of the study revealed that, *N. longispinosus* was an effective biocontrol agent of *T. urticae*. It shown higher predation rates at temperatures 30ºC. Overall performance of *N. longispinosus* satisfy the main requirements for a biological control program to be success. Hence, there is a need to focus on successful mass culturing techniques and field efficacy studies of *N. longispinosus* for utilising this species in integrated mite management programmes. Further, predatory mites could be used as an alternative to acaricides which helps in reducing the hazards and pollution caused these chemicals.

FUTURE SCOPE

This current study can be a step for the future researchers in the aspects of biological control and Integrated pest management studies for the control of mites in cultivated crops.

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Conflict of Interest. None.

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